FilterBoxx Wastewater Treatment Plant Upgrade Report

NuTangent Technologies
May 18, 2020

Prepared for Weslease

Current System Overview

DESIGN CRITERIA

Treatment Plant Capacity

The system was designed to treat up to 750 m^3 of domestic sewage with the following influent characteristics.

Average Influent BOD 350 mg/L

Average Influent TSS 350 mg/L

Effluent Discharge Criteria

The system was originally intended to meet the Alberta secondary treatment objectives as defined in the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems

CBOD <25mg/L

TSS <25mg/L

Because of the system configuration as an extended aeration activated sludge process, the system was expected to remove ammonia by nitrification conversion to nitrate although this was not a requirement within the original project terms of reference.

PROCESS DESCRIPTION

The existing Filterboxx wastewater treatment plant is an extended aeration activated sludge plant. The system consists of the following unit operations:

- Headworks/Equalization,
- Activated Sludge Bioreactors
- Effluent Polishing Microstrainers
- Solids Dewatering

Headworks/Equalization

The headworks of the wastewater treatment plant consists of a rotary drum screen with a screened solids screw compactor. The purpose of the headworks equipment is to screen out coarse solids especially plastics, paper or other inorganic solids present in the influent wastewater that cannot be biologically treated by the wastewater treatment plant and/or may cause damage or operational problems with downstream process equipment.

The rotary drum screen is an IPEC Model IFM 4872 Rotary Drum screen with stainless steel drum and frame construction and a 2mm nominal screen size. The IFM 4872 drum screen with a 2mm screen is rated for an inlet flow of 250 m^3/hr with average inlet suspended solids content of 350 mg/L.

The equalization tank volume is approximately 190 m^3. This provides approximately 6 hours hydraulic retention time at the design average flow. This allows for a Peak Hour factor of 6 to 7 which is typical for flows from workcamps for which the treatment was designed. If the treatment plant is repurposed for a more municipal application Peak Hour factor is more likely to be 3 to 4. It is therefore unlikely the headworks or equalization tank will be a limiting factor in this application should there be a desire to increase the design flow of the treatment plant.

Bioreactor Feed/Transfer Pumps

The wastewater treatment plant is equipped with three Bioreactor Feed Pumps, one for each biological treatment process train. The Bioreactor Feed pumps are connected by a header system that allows for flow to all three process trains even when one of the feed pumps is out of service for maintenance. The Bioreactor Feed pumps are Gorman-Rupp Series 10 Model 11-1/2 process pumps equipped with 3 hp electric motors. The pumps have a rated capacity in excess of 100 usgpm @ 25 psi. The pumps are equipped with variable frequency drives to adjust the flow rate of each pump to the flow rate required.

Bioreactors

The treatment plant is equipped with three bioreactor tanks each designed to be operated in parallel process trains. Each bioreactor has a volume of 158 m^3 which allows for a nominal hydraulic retention time of 14 hours at the name plate flow rate of 250 m^3/day for each process train (750 m^3/day total).

As mentioned above, the bioreactors were designed to be nominally operated in an activated sludge process variant called extended aeration. The extended aeration process mode operates with a nominal hydraulic retention time of more than 12 hours (often 18-12 hrs) and a relatively high mixed liquor suspended solids (MLSS) which is a measure of the biomass within the bioreactor. The extended aeration process mode generally allows for excellent process stability and reduced excess sludge generation. The system is generally resistant to shock loads and can be very forgiving with respect to operational parameters.

The bioreactors as designed will provide nitrification (conversion of ammonia nitrogen to nitrate) but are not configured to provide denitrification (conversion of nitrate to nitrogen gas) for nitrogen removal.

Process Air Blowers

The process air blowers provide oxygen for the biological process within the bioreactors as well as mixing energy to keep the biomass suspended and mixed within the bioreactors.

The process air for each bioreactor is supplied by a Kaeser CB130 C rotary lobe blower with acoustic enclosure. Each blower is powered by a 15 hp electric motor and has a rated capacity of 300 CFM @ 6 PSI. Process air is supplied to the bioreactors via stainless steel piping and distributed via fine pore bubble diffusers. The dissolved oxygen level within each bioreactor is monitored by a HACH SC100 Controller with LDO Oxygen Probe. The operating speed of the aeration blower VFD is controlled by the PLC based on the indicated dissolved oxygen level. The aeration flow within the bioreactor tank is balanced via butterfly valves located on each drop-leg into the bioreactor tank

For extended aeration type processes, the aeration required for mixing tends to be rate limiting rather than dissolved oxygen being limiting. The process air blowers are not therefore not expected to be a rate limiting component for future upgrades of the plant unless there is a conversion to a high rate membrane bioreactor (MBR) at which time oxygen and mixing would need to be modelled to determine if larger process air blowers would be required.

Secondary Clarifiers

The secondary clarifiers are used to separate the biosolids from the effluent of the bioreactors to allow the sludge return pumps to send the biosolids back to each of the bioreactors or waste the sludge to the aerobic digester.

There is one secondary clarifier for each of the bioreactors. The clarifiers are 13' in diameter and are constructed of stainless steel. Each clarifier is equipped with a SEW Eurodrive gear motor that operates the skimmer/sludge rake for each clarifier.

There is one sludge return pump for each clarifier. The sludge return pumps are Gorman-Rupp Model T2A3 self-priming solids handling pumps with 3 hp TEFC motors. The pumps are equipped with variable frequency drives to control the return flow rate to the bioreactors via the main control panel. The flowrate is monitored by Rosemount magnetic flow meters. In order to maintain the proper amount of biosolids in the bioreactor, the return sludge is periodically sent to the digester for removal and dewatering through a process called wasting. The wasting process for each clarifier is controlled by a pair of automated valves with electric actuators that direct flow to the bioreactor or to the digester. The operation of these valves is set at the main control panel.

The secondary clarifiers are likely the hydraulically rate limiting process within the wastewater treatment plant if expansion is contemplated. The clarifiers have a surface overflow rate of 500 gpd/ft^2 at average daily flow conditions. This is a relatively high surface overflow rate given the relatively shallow sidewall depths the clarifiers were limited to given the mobile/skid based nature of the wastewater treatment plant and one of the primary reasons for including the tertiary microstainers as part of the process train. If additional flow capacity is desired within the wastewater treatment plant, the effluent microstrainers would likely have to be replaced with some form of more robust tertiary filtration such as a pressurized ultrafiltration (UF) system or conversion of the process to MBR.

Effluent Polishing Micro-strainers

The effluent polishing micro-strainers receive the effluent from the secondary clarifiers. There is one micro-strainer for each process train. The micro-strainers pass the effluent through a 40-micron mesh rotary filter to assist in removing solids that may have not settled in the secondary clarifier. The original design intent of the micro-strainer wasn't to provide tertiary level solids treatment but rather to polish the secondary effluent from the microstrainers to compensate for mild upset conditions in the bioreactor and the shallow sidewall depth of the secondary clarifiers.

The microstrainer tanks also have a separate compartment that receives the scum removed from the surface of the secondary clarifiers by the surface skimmers. The removed scum is pumped to equalization tank.

Solids Handling/Dewatering

The sludge digester receives the biosolids (sludge) wasted from all three bioreactor trains and has a total volume of 36.5 m^3. The sludge digester is an aerobic digester and the process air is provided by two rotary lobe blowers (one service/one standby). The purpose of the digester is to age and reduce the volume of the wasted biosolids prior to dewatering. The digester is equipped with a decant pump. Periodically, the process air to the digester is ceased and the biosolids are allowed to settle to the bottom. The supernatant is then discharged back to the equalization tank for reprocessing. This process helps thicken the sludge prior to dewatering.

The sludge digester was originally sized based on hydraulic and organic loading assumptions to the bioreactors as well as the extended aeration process scheme. The amount of excess biosolids produced was modelled and provided the input to the sizing calculations for the digester. If the influent organic loading varies from the original design or if the operational scheme changes from the original parameters, the design of the digester would need to be revisited and possible a supplemental external sludge holding tank may be required.

As discussed in the site visit report, the wastewater treatment plant was originally equipped with a centrifuge dewatering package that included a Peiralisi Baby centrifuge, Polymaster polymer make-up system, polymer dosing, pump, progressing cavity type centrifuge feed pump and main control panel but with the exception of the main control panel the entire dewatering package is missing.

The purpose of the dewatering centrifuge was to remove the excess liquid from the digester biosolids to allow them to be converted to a solid state for easier disposal. The original purchaser of the treatment plant had intended to incorporate the dewatered biosolids into a compost to form a soil amendment for later use in onsite reclamation.

Depending upon the final placement location for the wastewater treatment plant it may be cost effective to periodically truck away the digested biosolids for disposal at a municipal wastewater treatment plant.

Disinfection

Based on the process drawings the current wastewater treatment plant does not appear to have any form of final effluent disinfection system. However, as mentioned in the site visit report, the presence or absence of a UV disinfection system was not possible due to the building being inaccessible.

SYSTEM TURN-DOWN CAPABILITES

During scoping discussions for this report, questions were made regarding the potential turn-down of the plant for lower flow conditions. The wastewater treatment plant has three independent biological treatment trains each with a nominal capacity of 250 m^3/day based on a nominal 14 -hour hydraulic retention time within the bioreactors. The operating parameters of extended aeration activated sludge process, however, allow for hydraulic retention times in excess of 24 hours (some references list 36hrs). The minimum recommended average flow for a single process train would then be 100 to 125 m^3/day. Operating at flows lower than this range may require some additional modification of operating parameters such as the mixed liquor suspended solids levels and/or additional carbon supplementation.

Alberta Municipal Treatment Plant Guidelines

In order to operate a wastewater treatment facility in the province of Alberta with a design flow of more than 25 m^3/day, an operating approval and permit must be obtained from Alberta Environment and Parks. The operating approval will dictate the required effluent quality that must be maintained from the treatment plan. The required effluent quality criteria will be based on the Alberta Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems for the expected type and location of discharge.

Discharge to Surface Water Standards

Required effluent quality from a secondary treatment plant are governed under the Alberta Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. Under the Guidelines, discharges from wastewater treatment plants discharging to a surface water course shall be based at a minimum on the more stringent of the quality resulting from the "Best Practicable Technology" or the quality required based on receiving water assessments

The treated effluent quality for wastewater treatment facilities serving populations under 20,000 people need to meet secondary effluents standards given as follows:

Carbonaceous Biochemical Oxygen Demand (CBOD)	<25 mg/L
Total Suspended Solids (TSS)	<25 mg/L

The above standards are based on monthly average of composite samples. Basic secondary treatment requirement does not include discharge criteria for disinfection. This is the absolute minimum standard allowed with the exception of lagoons. The standard is largely designed to allow small municipalities with mechanical treatment plants to be bound to reasonable effluent treatment targets without forcing overly elaborate treatment systems except in cases where the receiving watercourse is particularly sensitive.

For facilities serving more than 20,000 people the more stringent tertiary treatment requirements apply. Which are as follows:

Carbonaceous Biochemical Oxygen Demand (CBOD)	<20 mg/L
Total Suspended Solids (TSS)	<20 mg/L
Total Phosphorus (TP)	< 1 mg/L
Ammonia Nitrogen (NH_3-N)	Assessed on Site Specific Basis (most commonly 5 mg/L Summer, 10 mg/L Winter)
Total Coliforms	<1000/100 mL

Fecal Coliforms	<200/100 mL

The above standards are viewed as minimum acceptable treatment requirements. The 'Best Practicable Technology' is really the best practicable technology from the 1970's. It is maintained within the current regulations to avoid having older systems being out of compliance with the standards. In practice, Alberta Environment approvals personnel will set criteria based on modern available technology and the specific water body to which the final effluent will be discharged and will include consideration for parameters as downstream water use, overall contaminant loading to the water course and other parameters. Even though the above standards are supposed to be for effluents directly or indirectly (ie via wetlands or infiltration gallery) to a surface water body, they are often also applied to operating licenses where effluent is discharged via ground disposal.

Preliminary discussions with Alberta Environment (for example) have indicated that for discharges to the Bow River Basin there is a particular focus on phosphorus loading. It is expected that to obtain a new discharge license, total phosphorus in final effluent will need to be below 0.5 mg/L and it is quite likely that a 0.15 mg/L limit would be imposed.

Wastewater Irrigation Standard

There is a further anomaly to the Standards and that is for discharge of treated wastewater for irrigation. Prior to the latest (2015) edition of the standards, irrigation with treated wastewater only anticipated agricultural crop irrigation. BOD and TSS standards were quite relaxed (100 mg/L) and there were no disinfection criteria. The main stipulations were minimum set-back limits and stipulations on when irrigation was allowed based on growing season. Under the old standards the only way to get a permit for use of treated effluent for golf course or parkland irrigation was via an exception approved by the director. The new (2015) edition of the standard was updated to require a minimum of secondary treatment or lagoon treatment with minimum nine months of storage, requirement for disinfection for parkland and golf courses, and additional criteria related to salinity, sodium absorption ratio and pH. Oddly however, the latest edition of the standard maintained the released BOD and TSS standards even though they are not consistent with secondary or lagoon effluent standards. The parkland and golf course irrigation standards are also very lax compared to other jurisdictions such as British Columbia.

Water Reuse Standards

With the exception of reuse for irrigation, the Province of Alberta does not have a legislative framework in place for water reuse. There are nationally implemented guidelines to facilitate reuse such as updates to the National Building Code as well as Canadian Standards Association document CSA B128.1-06/B128.2-06 Design and Installation of Non-Potable Water Systems/Maintenance and Field Testing of Non-Potable Water Systems and publication of Canadian Guidelines for Domestic Reclaimed Water for

Use in Toilet and Urinal Flushing. Canadian National Plumbing Code only allows the use of non-potable water for flush toilets, urinals and subsurface irrigation systems.

Alberta Environment recognizes the need for the development of appropriate regulations and water quality standards to facilitate the safe use of reclaimed wastewater but current official standards state that 'reclaimed wastewater from any source cannot be used inside buildings or for other domestic applications in Alberta.

For stakeholders interested in implementing a reclaimed water reuse plan, an alternative solutions proposal and request for a variance must be prepared and submitted. The Harmony community in Springbank for example was successful in obtaining a set-back variance to allow for more widespread use of reclaimed water for irrigation.

Final Effluent Disposal Options

SURFACE WATER DISCHARGE

Based on the conversations with Weslease, one proposed location for the wastewater treatment plant will be on land situated west of the City of Calgary between the Bow and Elbow Rivers. It is understood that the location is more readily accessible to the Elbow River but that there may be access to the Bow river via an existing outfall located downstream of the Bearspaw water treatment plant.

Obtaining discharge permits to either the Bow River or Elbow River will likely be a complicated and lengthy process. Consultations with the City of Calgary and Alberta Environment will need to be undertaken. The Bow River watershed is under strict scrutiny by Alberta Environment with a particular focus on nutrient contaminants. At a minimum, a receiving water assessment will be required based on the Water Quality Based Effluent Limits Procedures Manual. Discharges to the Elbow River would also require a receiving water assessment and because of its being a primary source of drinking water for the City of Calgary, extremely tight effluent limits including a high level of disinfection will be required.

Preliminary (unofficial) discussions with Alberta Environment yielded the following information.

1) It will be easier to obtain a permit for a discharge to the Bow River than the Elbow River
2) The outfall location downstream of the Bearspaw water treatment plant is known to Alberta Environment and would be the preferred discharge location.
3) As mentioned above any new discharges to the Bow River will be subject to strict limits on phosphorus. Most likely limited to 0.15 mg/L

4) Alberta Environment would look more favorably on an application for regional treatment facility.
5) There is no need to completely rule out discharge to the Elbow River as an option. Although it is likely that effluent discharge requirements will be very strict, there has been recent approvals for discharge to the Elbow including for the community of Bragg Creek. This approval, granted in 2010, required

Carbonaceous Biochemical Oxygen Demand (CBOD)	<5 mg/L
Total Suspended Solids (TSS)	<5 mg/L
Total Phosphorus (TP)	< 0.15 mg/L
Ammonia Nitrogen (NH_3-N)	< 3.0 mg/L
Total Nitrogen	<10.0 mg/L
Total Coliforms	<1000/100 mL
Total Fecal Coliforms	<200/100 mL

The same effluent discharge criteria was also applied to a recent (2018) approval for Foothills County for the Highwood Regional Wastewater Facility discharging into the Highwood River.

IN-GROUND DISPOSAL

In-ground disposal is much more common for private sewage treatment plants although the majority of these have capacities below 25 m^3/day and are governed under the Alberta Private Sewage Systems Standards of Practice (2015). Although systems with a capacity larger than 25 m^3/day are governed by Alberta Environment, the design criteria regarding suitability of soil conditions, design and installation of disposal field laterals and equipment etc from the Alberta Private Sewage Systems Standards of Practice will still be maintained. The expected effluent quality from the wastewater treatment plant is a determining variable for the design of the effluent disposal field. The large treatment facilities supplied by FilterBoxx all used ground disposal as the method of discharge.

For large treatment facilities, such as the one obtained by Weslease, these disposal fields can become very large and expensive ($500k-$1MM) but often represent the easiest pathway for licensing approval.

RECLAIMED WATER REUSE

As mentioned above, the Province of Alberta lags many jurisdictions in putting in place appropriate water reuse standards and guidelines. However, parkland and golf course irrigation as well as in-ground drip irrigation systems do have a regulatory framework in place. It is unknown at the time of writing if the final location of the wastewater treatment plant will include a golf course/parkland area or if a golf course is in the vicinity that would be willing to accept treated effluent from the treatment plant for irrigation purposes. Average golf course irrigation requirements are approximately 500 m^3/day during the active season which would consume the majority of the effluent from the treatment plant during the season.

Regulations however do require that the capability to either dispose of or store the treated effluent volumes from the plant be put in place regardless of intention for beneficial reuse.

Upgrade Options

NUTRIENT REMOVAL

Phosphorus Removal

If expectation is to dispose of final effluent from the wastewater treatment plant to a surface water course, it is expected that phosphorus removal will be required even though this system falls under the small system secondary treatment standard.

The most common phosphorus removal method is chemical precipitation. This process involves the addition of a metal salt to convert the dissolved phosphorus to and insoluble chemical species. Chemical phosphorus removal is common because of its operational simplicity but does result in an increase in sludge production. Metal salts (most commonly aluminum salts) are added to the wastewater stream at a well-mixed location. Most commonly within the bioreactor. The precipitated phosphorus is then removed by the secondary clarifier. Effluent phosphorus levels below 1 mg/L can be achieved with secondary clarification alone but levels below 0.1 mg/L can be achieved with tertiary filtration. Achieving effluent phosphorus levels below 0.5 mg/L also requires overdosing of metal salts well in excess of stoichiometric requirements. The increase in sludge volume generated also requires an increase in sludge wasting volume and increased requirements for sludge dewatering and disposal.

Implementation of chemical phosphorus removal to the wastewater treatment plant would involve the installation of chemical dosing pumps to each of the secondary treatment trains. There is sufficient area available on each bioreactor skid to install the required dosing pump and chemical storage tank. Additional electrical work would be required to connect the dosing pumps and to interlock them with the effluent feed pumps for each treatment train.

As discussed above, it may also be necessary to upgrade any solids dewatering system or provide a separate sludge storage tank to handle the increase in the amount of sludge that would be produced by the system.

Equipment costs for this upgrade should be less than $10,000 per train. Total budgetary cost for the chemical dosing system should be under $50,000. The cost for the upgraded solids handling system should be under $50,000. As noted in the site visit report the current system is missing the centrifuge originally supplied for the system. When ordering a replacement, moving to the next larger size from the same manufacturer should be adequate for the increase in sludge volumes from the chemical phosphorus removal system.

Nitrogen Removal

The treatment system as designed will provide effectively complete nitrification ie conversion of ammonia nitrogen to nitrate. The system could be modified to provide a degree of nitrogen removal by implementing processes to convert nitrate to nitrogen gas. This can be as simple as programming changes to the operating PLC software to cycle the process air blowers on and off to provide periods where anoxic conditions occur within the bioreactors to the addition of mixers within the bioreactor to provide additional sludge circulation within the bioreactor during periods when the process air blowers are off.

Preliminary discussion with Alberta Environment indicates that ammonia is the primary form of nitrogen of concern and that nitrogen removal would not likely be necessary except in very specific circumstances. (Note: as indicated above, the recent approvals for Rockyview Counts (Bragg Creek) and Foothills County (Highwood) both had Total Nitrogen limits)

EFFLUENT DISINFECTION

Ultraviolet Disinfection

Ultraviolet (UV) light is a form of light that is invisible to the human eye. It occupies the portion of the electromagnetic spectrum between X-rays and visible light. A unique characteristic of UV light is that a specific range of its wavelengths, those between 200 and 300 nanometers (billionths of a meter), are categorized as germicidal – meaning they are capable of inactivating microorganisms, such as bacteria, viruses and protozoa. This capability has allowed widespread adoption of UV light as a chemical-free and highly effective way to disinfect and safeguard water against harmful microorganisms.

UV disinfection systems are sized based design flow, UV transmissivity of the wastewater (how effectively the UV is able to penetrate the wastewater) and required disinfection level. The two most common disinfection levels are <200 CFU/100 mL and ,<2 CFU/100 mL. The <200 CFU/100 mL is the most common standard required and is the standard used in Alberta for tertiary level treatment/discharge to surface water and for irrigation of parks and golf courses (with standard set-back requirements). The <2 CFU/100mL standard is the adopted standard in other jurisdictions for less restricted reclaimed water reuse and may be used as the required standard if a variance is requested for less restrictive reclaimed water reuse.

There are two main types of wastewater UV disinfection systems, in-channel systems and pressurized systems. In-channel systems are the most common type employed for municipal wastewater disinfection. This is because most municipal wastewater treatment plants overflow by gravity to their final outfall locations and installation of flow channels in these facilities are common. The in-channel systems tend to be somewhat less expensive than pressurized systems and tend to have lower UV transmissivity requirements. Pressurized systems are more commonly employed in membrane bioreactor and tertiary filtration applications because the effluent is already under pressure rather than in a gravity channel. FilterBoxx packaged plants that included UV disinfection used pressurized UV disinfection.

Upgrading the existing wastewater treatment plant to provide UV disinfection would be relatively easy. The final effluent piping from each of the process trains would be modified to add a pressurized UV module prior to final discharge. The effluent piping for all three process trains can be access from the microstrainer building. There is adequate room to accommodate 3 parallel UV disinfection systems within the process building. Electrical changes would be required to provide a power feed for the UV units. It is expected that a single main power feed could be routed from the main panel in the dewatering skid to the subpanel on the distribution from the subpanel to the individual UV units. Alarm wiring would need to be routed back to the main control panel and programming changes would be required to include the UV units in the PLC control system.

Budgetary pricing for the UV treatment units from a leading UV manufacturer was $36,000 for each train. Including installation, piping and electrical changes total budgetary cost for this upgrade should be under $200,000.

FINAL EFFLUENT POLISHING

If final wastewater effluent standards require low phosphorus levels for surface water discharge, or high levels of disinfection for less restrictive reuse, final effluent polishing beyond that provided by the existing microstrainers will be required.

Cloth Disk Filtration Polishing

Cloth Disk Filtration emerged in the 1990's as method to provide tertiary filtration for existing secondary treatment facilities. Most cloth disk filters are capable of providing treated effluent with less than 5 mg/L total suspended solids.

The cloth media filter is made up of a series of filter discs mounted on a central hollow shaft. The filtration is done by gravity and uses the level difference between the input and output of the machine. The discs operate almost completely immersed in the water to be treated.

During the filtration phase, the solids are held back by the specialized cloth. The minimum water level in the tank containing the filter is controlled by a weir placed on the side of the clean water outlet. With the increase of deposit of solids on the cloth, the hydraulic resistance increases in passing and therefore the difference between the levels of entry and exit.

When a set difference between these levels is reached, it automatically activates the cleaning process of the cloth.

To clean the cloth the disks are rotated slowly. The solids are removed from the surface of the cloth either through a backwash process or by suction from the cloth surface (or a combination of the two. For backwashing, filtered effluent is used. It is typically recommended that a chlorine dosing pump be added to the backwash tank so that chlorinated water could be used for backwash. This will help control bio-growth in the filter vessels. Backwash water from the filters would be directed back to the equalization tank.

Budgetary cost for this upgrade should be under $300,000.

Ultrafiltration (UF) Polishing

Ultrafiltration provides effluent polishing by passing the effluent through an ultrafiltration membrane that has a pore size range from 0.01 to 0.1 microns (most commonly 0.02-0.05 microns). Ultrafiltration is more typically selected for reclaimed water use because the pore size of the membranes allows for 90-100% pathogen removal. This, in combination with chemical or UV disinfection, allows for the multi-barrier approach required for less restrictive reuse of reclaimed water. There are several types of ultrafiltration membranes but the most common for tertiary effluent polishing are hollow fiber (outside in configuration) and tubular membrane configurations.

Effluent would be pumped from the existing microstrainer tank through an array of membrane modules. The treated effluent would pass through the membrane (and through the downstream UV disinfection unit if selected) and into a permeate tank from which it is pumped to discharge. The permeate tank provides a reservoir for the periodic back pulsing of treated effluent to clean foulants from the membrane surface. In the case of tubular membranes a recirculation pump is also employed to provide a specific crossflow velocity across the membrane surface to prevent fouling.

Periodically, the membranes will need to undergo a chemical clean. A stand alone clean-in-place (CIP) system is used to make up the cleaning solution and pump it into the membrane modules. During the clean the wastewater train being cleaned will be offline.

Budgetary cost for an upgrade to ultrafiltration polishing will vary depending on the type of membrane selected but will likely be in the range of $500,000-750,000.

Unless there is a desire to apply for a variance to allow for less restrictive reuse of the treated effluent from the treatment plant, an upgrade to ultrafiltration polishing is not likely required.

MEMBRANE BIOREACTOR CONVERSION

Conversion of the existing treatment plant to a membrane bioreactor (MBR) is the most aggressive and costly upgrade option. A membrane bioreactor uses membranes as the main form of separation of treated effluent from the active biomass in the bioreactor. The option to convert the treatment plant to an MBR process would entail removal of the existing secondary clarifiers and replacing them with membrane tanks equipped with immersed membranes. The membranes selected may be hollowfiber or flat-sheet. However, hollowfiber membranes tend to have a higher packing density and are more likely to fit the available footprint.

The MBR conversion could have a two-fold benefit. First of all it would provide effluent quality equivalent to the ultrafiltration polishing option above, providing initial disinfection barrier for the treated effluent. Second, it could significantly increase the flow capacity of the wastewater treatment plant.

As discussed above, the current treatment plant is designed around a 14 hour hydraulic retention time in the bioreactor. A typical MBR facility is designed around a 4-6 hour hydraulic retention time and operates at a high mixed liquor suspended solids (MLSS) than the current treatment plant design. The treatment capacity of the current treatment plant could therefore be upgraded by a factor of 2.5-3.5 times by converting to an MBR.

Order of magnitude budgetary estimate for full MBR conversion would be $1 million-$2 million. Unless there is an option to fully utilize the increased capacity of the treatment plant due to MBR conversion such an upgrade is not warranted.

SUMMARY:

The existing treatment plant is capable of treating an average daily flow of 750 m^3/day and meeting the provincial standards for secondary effluent. This is sufficient for ground disposal options and may be sufficient for discharge into some surface waters (but not the Bow or Elbow Rivers). Discharge guidelines for specific waterbodies will need to be determined once the target surface water body is known.

Discharge into the Bow or Elbow River will at a minimum require upgrades to remove phosphorus down to below 0.15 mg/L thus requiring the upgrade for chemical phosphorus removal and some form of tertiary filtration. Discharge to the Elbow will also likely require upgrade for multibarrier disinfection.

If there is a desire for any form of beneficial reuse (including parkland or golf course irrigation but exempting some crop irrigation) an upgrade to add effluent disinfection will be required. The province is lagging other jurisdictions in implementing broad standards for beneficial reuse of reclaimed water but proposals applying for a variance from existing standards preventing reuse can be submitted to the appropriate governing body.

It may be possible to expand the treatment plant capacity by a factor of 2.5-3.5 times by converting the treatment plant from an extended aeration activated sludge plant to a membrane bioreactor.

UPGRADE COST SUMMARY

Upgrade Description	Total
Chemical Phosphorus Removal	$50,000.00
Ultraviolet Effluent Disinfection	$200,000.00
Cloth Disk Filter Tertiary Polishing	$300,000.00
Pressurized Ultrafiltration Tertiary Polishing	$500,000 - 750,000.00
Membrane Bioreactor Conversion	$1,000,000 - 2,000,000.00