October 3, 2022
File #364.01-2

Elk Ridge Utility
Box 182
Waskesiu, SK
S0J 2Y0

Attention: Mr. Dennis Paddock, P.Eng., President

Re: Elk Ridge Utility
Water Treatment Plant Facility

As requested, BCL is pleased to provide the following assessment report for the Elk Ridge Utility's Water Treatment Plant facility. The intent of this report is to provide an assessment of the existing infrastructure and recommendations for addressing any issues identified.

1. BACKGROUND

Raw Water Supply

Raw water for the community is provided by two groundwater wells, located in close proximity to the treatment facility. The primary well (PW6-BHL) was installed in 2011, with a depth of 100 m and a typical pumping rate of 3.8 L/s. The well is equipped with a 7.5 hp submersible well pump and supplies water to the treatment plant through a dedicated 50 mm HDPE raw water supply line.

An additional well (PW7-BHL) was installed in 2014, with a similar depth and pumping rate as PW6. This well replaced the original well (PW5-BHL), which was installed in 2000, but now serves as an observation well. PW7 is equipped with a 7.5 hp submersible well pump and supplies water to the treatment plant through a dedicated raw water supply line ranging from 38 mm to 50 mm.

Operations personnel report that PW7 produces high quantities of fine silt and sediment, causing rapid buildup and plugging of the filters. In previous seasons, PW7 pumped over 10,000 m^3 to waste, in an unsuccessful effort to exhaust the sediment source. For this reason, the Utility has operated primarily with PW6, using PW7 as backup supply.

Additional testing was conducted by Beckie Hydrogeologists Ltd. (BHL) in summer of 2022 to determine the concentrations and pumping characteristics of the entrained sediment coming from PW7. The well was pumped at a rate of 3.8 L/s through filter socks to capture and measure sediment quantities over various time intervals. The testing results are summarized as follows.

PW7 Entrained Sediment Testing					
Pumping Time					
Interval Duration (minutes)	5	5	20	30	235
Total Elapsed Time (minutes)	5	10	30	60	295
Concentration					
Interval Average (mg/L)	107	138	114	17	2.6
Overall Average (mg/L)	107	123	117	67	16
Total Sediment					
Interval Amount (kg)	0.1	0.2	0.5	0.1	0.1
Total Amount (kg)	0.1	0.3	0.8	0.9	1.1

Over a 1 hour period, the well yielded an average sediment concentration of approximately 67 mg/L, for a total of 0.9 kg. Concentrations exceeded 100 mg/L for the first 30 minutes before declining to less than 20 mg/L the remainder of the test. The well was pumped for approximately 4 hours following the initial 1 hour period, yielding a concentration of 2.6 mg/L for this period, for a total of 1.1 kg.

Treatment

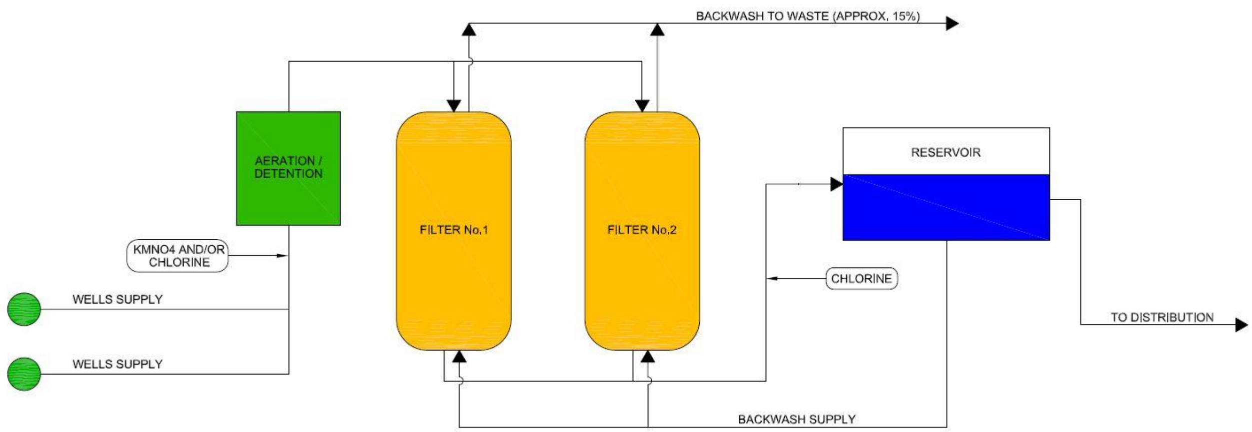
The water treatment facility was constructed in 2000, with mechanical upgrades completed in 2007.

Raw water entering the plant is metered and dosed with sodium hypochlorite prior to entering a detention tank. The tank is 1.22 m in diameter by 1.52 m in height, with an approximate volume of 1,800 L. The detention time is estimated to be in the order of 8 minutes. Due to the lengthy oxidization reaction time of manganese, the detention process is not likely to provide any significant improvement to the removal of this constituent.

Following detention, raw water flows through two manganese greensand pressure filters operated in parallel. The filters are 1.22 m in diameter by 2.13 m tall, operated at a rate of 1.9 L/s each (3.8 L/s total). For raw water of poor to fair quality, the recommended operating flux for manganese greensand filters is 1.0 - 1.6 L/s/m^2, which equates to 1.2 – 1.9 L/s each (2.4 – 3.8 L/s total). Therefore, the filters are operating at the high end of the recommended range, considering the raw water quality. Operations personnel report deteriorating treated water quality when operating above this rate.

The filters are backwashed based on pressure differential, typically producing approximately 180 m^3 of treated water between backwash cycles. The backwash process is conducted manually, with a dedicated backwash pump, consisting of 15 minutes per filter at a rate of 11 L/s. No air scour is provided. This equates to a backwash consumption rate in the order of 10% of total water use. The filters are regenerated every few months. The Operators avoid using well PW7, as the sediments from the source quickly build up in the filters and drastically reduce filtration rates.

Following filtration, clarified water is dosed with additional sodium hypochlorite for disinfection followed by deposition to the treated water storage reservoirs. The existing manganese greensand process schematic is shown below for reference.



MANGANESE GREENSAND

Chemical Dosage

The only chemical used for treatment is a 12% liquid sodium hypochlorite solution (Hypochlor-12 by ClearTech Industries), which is dosed prior to detention and following filtration. The Operators vary the dosing rates frequently in response to daily free chlorine residual levels. Based on the daily records, the dosing rates ranged from 7 - 15 mg/L prior to detention and 0.5 - 3 mg/L following filtration, for a total dosage rate in the order of 7.5 - 18 mg/L. This is below the maximum use rate of 103 mg/L for this product, as per NSF60 standards for drinking water chemical use. The frequent variability of the dosing rates suggests that a constituent in the raw water, such as ammonia or organic material, is reacting with the chemical.

Treated Water Storage

Storage of treated water is provided by two subgrade concrete reservoirs and a pump well. The pump well is located under the water treatment plant and has storage capacity of approximately 34,000 L. Reservoir #1 is also located under the water treatment plant building and has a storage capacity of approximately 155,000 L. Access to the pump well and reservoir #1 is provided by a raised hatch located within the building. Reservoir #2 is located immediately southwest of the plant and has a storage capacity of 222,000 L. A raised access hatch with lockable cover is provided. Total facility storage volume is 411,000 L.

As discussed in the following section, the plant uses submersible well pumps for distribution. Well pump assembly suspends the pump motor from the end of a drop pipe, below the suction inlet of the pump. Therefore, the suction inlet is approximately 1.2 m above the pump well floor, rendering all water below the inlet elevation unusable. For this reason, the effective storage volumes of the pump well and reservoirs are reduced to approximately 23,000 L, 103,000 L, and 138,000 L, respectively, for a total effective storage volume of 264,000 L. If the reservoirs are operated at a lower level in order to improve the circulation rate, the effective storage volume would be further reduced.

Under normal operation treated water is deposited to reservoir #2 and then flows via transfer pipe to reservoir #1, followed by the pump well for distribution.

Distribution

Distribution system pressure is provided by three submersible well pumps drawing from the pump well, each with a rated capacity of approximately 21 L/s at 46 m TDH. The pumps are driven by 20 hp, 600 V, 3 phase submersible motors, controlled by variable frequency drives to maintain a typical distribution pressure of 65 psi. Each pump has sufficient capacity to meet typical demand, with the lag pumps providing redundancy or additional flow in high demand scenarios.

Two distribution pumps draw from the pump well, while the third is installed in reservoir #1 to provide distribution in the event that the pump well is unavailable due to maintenance or other issues. The distribution header is equipped with valves for isolation and backflow prevention, a pressure relief valve that discharges to the pump well, and an electromagnetic flow meter. A pressure tank is connected to the system to mitigate excessive start and stop of the pumps during periods of low flow.

Controls and Electrical

The raw water supply, treatment, and distribution process all have automated components. The well pumps and chemical pumps are started and stopped based on level condition in the pump well, as monitored by an ultrasonic level transducer. The distribution pumps are controlled by a pressure transducer on the header, which communicates with the pump drives to maintain the set pressure. Manually controlled processes in the plant include filter backwash.

The plant is equipped with an autodialler call-out device, which notifies operations personnel of conditions such as low distribution pressure and low reservoir conditions.

Electrical service to the building is provided by a 600 V, three phase connection. Electrical components are typically individual surface mount type. The facility is equipped with a 100 kW, natural gas fuelled emergency power generator to maintain distribution in the event of a power outage. The generator is equipped with an automatic power transfer switch.

Facility

The water plant building is a timber-framed structure, totalling roughly 75 m^2 in area. The building is situated on top of the concrete reservoir foundation. The exterior finishes consist of stucco, wood and pre-finished metal trim, and asphalt shingles. The interior finishes consist of pre-finished metal cladding on the walls and ceiling, and exposed concrete floors.

The building is equipped with a small water heater and sink for domestic water use. Building heat is provided by a natural gas fired unit heater. Building ventilation is provided by a dedicated exhaust fan and intake damper. Lighting is provided by fluorescent fixtures.

2. EXISTING DEMAND

Annual water consumption records from 2007-2021 were reviewed to determine historical water consumption by the community. The following table provides a summary of treated water distribution since the inaugural development.

Year	Treated Distribution (m^3)	Operational Notes
2021	34,996	Leaking fixture in pavilion all summer.
2020	15,001	Resort closed April to November (Covid-19).
2019	29,496	
2018	32,524	Early fall.
2017	32,595	
2016	34,530	Cottages opened in late summer.
2015	31,753	Forest fires June and July.
2014	33,700	
2013	29,148	
2012	25,564	Early winter.
2011	29,040	
2010	26,989	
2009	23,892	Resort hotel opened.
2008	15,261	
2007	10,735	

With the exception of 2020, consumption has been relatively consistent since 2014, with an average annual distribution of approximately 32,800 m^3. Since the opening of the resort hotel, the consumption rate has increased intermittently, typically corresponding to further development within the community. Disregarding the years prior to the resort hotel opening, the average annual increase in consumption is in the order of 2.4%.

Daily water records from 2015 to 2021 were available and reviewed to determine more detailed usage data, as shown in the following table. Data from 2020 was discounted due to low facility use during the Covid-19 pandemic.

Year	Consumption (m^3)		Daily Peak Factor
	Avg day	Peak day	
2021	96	267	2.8
2020	-	-	-
2019	81	208	2.6
2018	89	304	3.4
2017	89	299	3.3
2016	95	271	2.9
2015	87	304	3.5
Average	**90**	**275**	**3.1**

The average daily consumption is in the order of 90 m^3 with a typical peak day of approximately three times that amount. It should be noted that this peak day factor is typical for communities of this size due to the seasonal nature of the community population.

It should be noted that total raw water consumption is recorded in addition to distributed water. The difference between the raw and treated totals typically provides an indication of backwash and waste volumes generated by the treatment process. Based on the raw water totals, backwash and waste amount to less than 5% of the total raw water usage. This is considered quite low for a manganese greensand process, particularly for treatment of lower quality raw water where backwash and waste rates in the order of 10 - 15% are typical. It is likely that the existing raw water meter readings contain some error. Treated distribution is metered by an electromagnetic flow meter which provide improved accuracy compared with older style meters. This should be taken into account when assessing total water consumption.

3. FUTURE DEMAND

The rate of water consumption varies widely during different periods of the year and hours of the day. However, two characteristic demand periods are normally recognized as being critical factors in the design and operation of a water system. These factors are the peak day (the day of highest consumption during any one year) and the peak hour (the hour of highest consumption during any one day) demand. A peak day factor of 3.1, as derived from the actual water consumption records, will be used for the peak day flow. A peak hour factor of 4.0 times the average day is typical for a community of this size and as such, will be used to determine water pumping capacities.

Applying the assumptions described, the following table summarizes the current and expected demand from the community.

Demand Projection 2022-2042					
Demand	**2022**	**2027**	**2032**	**2037**	**2042**
Average Day (raw; L/s)	1.22	1.38	1.55	1.74	1.96
Peak Day (raw; L/s; P.F. = 3.1)	3.79	4.27	4.80	5.41	6.08
Average Day (treated; L/s)	1.04	1.17	1.32	1.48	1.67
Peak Hour (treated; L/s; P.F. = 4.0)	4.16	4.68	5.27	5.93	6.67

Applying the future water demand projection, system component requirements for the current treatment process is shown in the following table below (bolded items highlight that there is a shortfall in capacity).

Infrastructure Requirements 2022 – 2042						
	Existing	**2022**	**2027**	**2035**	**2037**	**2042**
Raw Water Supply (L/s; P.F. = 3.1)	3.8	**3.8**	**4.3**	**4.8**	**5.4**	**6.1**
Water Treatment (L/s; P.F. = 3.1)	3.8	**3.8**	**4.3**	**4.8**	**5.4**	**6.1**
Distribution Pumping (L/s; P.F. = 4.0)	21.0	4.14	4.68	5.27	5.93	6.67
Treated Water Storage (L; 2 x avg. day)	264,000 / 411,000	210,470	237,941	**267,766**	**301,330**	**339,101**

As indicated, the current water treatment equipment has difficulty producing quality water at sufficient rate during peak periods. Increased treatment capacity will also require an increase to raw water supply. It is important to note that the existing water treatment facility is relatively small and does not have sufficient space for additional water treatment equipment.

The existing reservoir capacity is adequate to meet the 20 year projected requirements. However, the effective storage is reduced due to the current pumping arrangement and is anticipated to encounter a shortfall within 10 years. Therefore, it is recommended that an alternative pumping arrangement be explored prior to reaching this threshold.

It is understood that there is an RV Park in development that will increase demand within the next two years. Such development is accounted for by the long term growth rate applied to the annual water consumption. However, growth rates may be slightly higher in the short term due to this development. Therefore, the five year projected requirements may be realized more rapidly.

4. WATER QUALITY

The raw water source for the Elk Ridge Utility is classified as poor to fair, with high concentrations of ammonia, total dissolved solids, and moderate overall hardness. Metals are present in levels consistent with true groundwater, with arsenic, iron and manganese concentrations exceeding guidelines.

Treated water is sampled and tested for quality every two years. A brief summary of constituents of interest for the raw and treated water is summarized in the table below. Bolded values are those that are nearing or exceeding the Saskatchewan or Canadian Drinking Water Quality Guidelines.

Constituent	Raw Sept. 17, 2014	Treated Oct. 15, 2015	Treated July 7, 2017	Treated Feb. 5, 2019	Treated Feb. 22, 2021	SK Guideline	Canadian Guideline
Arsenic	**0.027**	0.0015	0.0025	0.0013	0.0016	0.01	0.01
Iron (mg/L)	**1.88**	-	0.107	0.03	0.017	0.3	0.3
Manganese (mg/L)	**0.13**	-	**0.0468**	0.0114	0.0008	0.05	0.02
Ammonia (mg/L)	0.71			0.75		-	-
Alkalinity (mg/L)	**538**	**501**	**497**	**486**	**494**	500	-
TDS (mg/L)	**848**	**842**	**530**	**519**	-	1,500	500
Hardness (mg/L)	446	434	450	440	432	800	200

A description of each of the raw and treated water constituents in excess of the Canadian or Saskatchewan Drinking Water Standards are as follows (unless noted as *, write ups are from SRC Analytical – *Water Analysis Information Sheet*):

Arsenic

Natural sources, such as the dissolution of arsenic-containing bedrock, often contribute significantly to the arsenic content of drinking water and groundwater. A number of disorders have been associated with the intake of arsenic in drinking water; however, there is no evidence of any specific illness related to the ingestion of water containing arsenic at the maximum acceptable concentration of 0.01 mg/L. Treated water test results have not approached the regulatory limits to date.

Iron

At levels above 0.3 mg/L, iron can stain laundry and plumbing fixtures, as well as cause an undesirable taste. The precipitation of excessive iron causes a reddish-brown colour in the water and may also encourage the growth of iron bacteria, leaving a slimy coating in piping. The presences of iron bacteria can also cause a rotten egg odour and a sheen on the surface of the water. The aesthetic objectives for both Saskatchewan and Canada are set at 0.3 mg/L.

Manganese
Manganese can cause staining of plumbing and laundry and undesirable tastes in beverages. Also, it may lead to the accumulation of bacterial growth in piping. The aesthetic objective for Saskatchewan is set at a maximum of 0.05 mg/L. Health Canada recently lowered the aesthetic objective to 0.02 mg/L and implemented a maximum acceptable concentration of 1.2 mg/L. Laboratory test results have exceeded the guidelines on one occasion. However, review of daily manganese testing conducted at the plant with a bench top unit indicated that manganese concentrations in the treated water routinely exceed 0.02 mg/L.

Ammonia*
Though not considered an immediate health or aesthetic concern, high ammonia in a raw water source can have deleterious affects on treatment processes. Ammonia reacts readily with sodium hypochlorite (chlorine), which is used for oxidization of iron and manganese, as well as for disinfection. This greatly increases chlorine consumption and inhibits the oxidization and disinfection processes, reducing the effectiveness of iron and manganese removal and potentially resulting in inadequately disinfected drinking water. The effects of ammonia on water treatment are well known and documented in the Water Security Agency's EPB 431. Recent testing indicates ammonia concentrations of 0.75 mg/L, which is considered moderately high.

Alkalinity
Alkalinity is a water's acid-neutralizing capacity and is primarily a function of carbonate, bicarbonate and hydroxide content. Excessive alkalinity levels may cause scale formation. The Saskatchewan aesthetic objective is set at a maximum of 500 mg/L. Recent testing results have approached and exceeded this limit.

Total Dissolved Solids or Specific Conductivity
Specific conductivity is a measure of the ability of water to carry an electric current. This ability depends on the presence of ions and therefore is an indication of the concentration of ions (i.e. dissolved solids) in the water. Waters with high dissolved solids generally are of inferior palatability and are likely to leave a white film on dishes, etc. The provincial aesthetic objective for total dissolved solids is 1,500 mg/L. The federal objective is more stringent, at 500 mg/L. Recent testing indicates concentrations exceeding 500 mg/L.

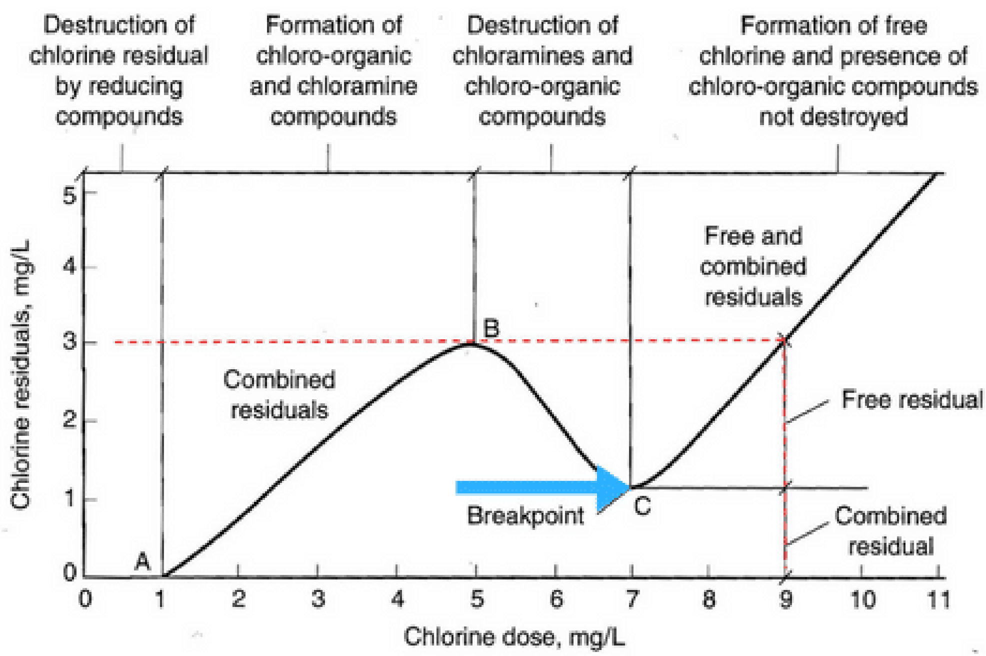
Total Hardness
Water hardness is mainly caused by the presence of calcium and magnesium and is expressed as the equivalent quantity of calcium carbonate. Scale formation and excessive soap consumption are the main concerns with hardness. When heated, hard waters have a tendency to form scale deposits. Depending on the interaction with other factors, such as pH and alkalinity, hardness levels between 80 and 100 mg/L are considered to provide an acceptable balance between corrosion and incrustation. Water supplies with a hardness greater than 200 mg/L are considered poor, but tolerable; those in excess of 500 mg/L are unacceptable for most domestic purposes. The aesthetic objective in Saskatchewan is 800 mg/L. Recent water quality records note total

hardness concentrations approaching 500 mg/L.

5. DISINFECTION

Disinfection is a critical part of the water treatment process, ensuring that water intended for human consumption is free of harmful viruses and pathogens. Chlorine is a powerful oxidant and is commonly used for disinfection of drinking water in Saskatchewan. To ensure adequate disinfection is achieved, free chlorine residuals are monitored daily at the water treatment plant. However, the presence of ammonia in the water interferes with the disinfection process by reacting with the available chlorine. To overcome this, chlorine dosage must be increased until all ammonia has reacted, and sufficient free chlorine residual is achieved. This process is referred to as 'breakpoint chlorination'.

A typical break point chlorination chart is shown below.



Fluctuating raw water ammonia levels require frequent adjustment to chlorine dosage rates and often result in over or under-dosage of the chemical. This is evidenced by the daily water plant records, which show highly variable free chlorine residuals, ranging from 0.15 to 1.5 mg/L. Operator notes indicate frequent dosage rate changes.

Review of sodium hypochlorite dosage indicates that the operation does not approach the NSF61 maximum use limit for use of this chemical in drinking water. However, the ammonia interference increases the overall chemical consumption at increased cost to the Utility. Further, ammonia can inactivate all available chlorine, reducing the effectiveness of the oxidization process, manganese greensand regeneration, and overall iron and manganese removal. This is likely a factor in the treatment process' difficulty in removing manganese below regulatory limits.

6. WATER TREATMENT CONSIDERATIONS

The existing manganese greensand filtration process is generally capable of meeting the regulatory requirements for arsenic, iron and manganese. However, the system must be operated at low flux rates to achieve adequate treatment. As indicated by the infrastructure requirement projections, the filters are currently operating at peak capacity and will not be capable of meeting peak demands of future development. Ammonia interference compounds the iron and manganese removal issues and results in excess chemical use. Further, the treatment system is not capable of achieving the recommended water quality objectives for the aesthetic constituents such as ammonia, alkalinity, hardness, and total dissolved solids.

Considering the characteristics of the raw water, several treatment considerations / processes may be required to meet the water quality objectives of the community. The following table highlights some of the key parameters and appropriate technologies for their removal.

Key Parameters and Appropriate Technologies		
Parameters	**Appropriate Technologies**	**Comments**
Arsenic	Greensand, Biological. Membrane.	The existing system is typically successful in removing arsenic.
Iron	Greensand, Biological, Membrane	The existing system is typically successful in removing iron.
Manganese	Greensand, Biological, Membrane	The existing system is often unsuccessful in removing manganese, due to filtration rate and ammonia interference.
Ammonia	Biological, Membrane	Greensand filtration will not remove ammonia. Biological filtration is very effective in ammonia removal. Membranes are typically effective, depending on the chemical state of the ammonia.
Alkalinity	Membrane	Greensand filtration and biological filtration by themselves do not reduce alkalinity. Membrane filtration is required to reduce alkalinity to below recommended limits.
TDS	Membrane	Greensand filtration and biological filtration, by themselves do not reduce TDS. Membrane filtration is required to reduce TDS to below regulated limits.
Hardness	Membrane	Greensand filtration and biological filtration, by themselves do not reduce hardness. Membrane filtration is required to reduce hardness to below recommended limits.

Both manganese greensand and biological filtration are considered suitable technologies for the removal of arsenic, iron and manganese. However, in order to meet all federal and provincial treatment regulations and aesthetic objectives, implementation of a membrane treatment system would be required. Membrane filtration consists of forcing water through a membrane barrier at high pressure. The use of membranes results in a treated water that is lower in all constituents, including organics, hardness, iron, manganese, and total dissolved solids. Membranes also provide a positive barrier against giardia and cryptosporidium.

It should be noted that a direct-feed membrane system is not recommended due to the high concentrations of iron and manganese. Though capable of iron and manganese removal, without a pre-treatment system the membranes would require frequent cleaning and replacement. The high ammonia concentrations present in the raw water suggest that a biological and membrane filtration combination would provide optimal treatment.

In addition to dissolved constituents, the treatment process also encounters entrained sediments in the source water when operating PW7. Conventional greensand filtration is capable of filtering out small concentrations (<10 mg/L) of suspended solids, expelling the sediments during the backwash process. However, the concentrations of entrained sediment observed during the recent testing far exceed this amount. Sediment buildup in the filters would be rapid and cause plugging, requiring frequent backwashing, reducing treatment effectiveness, and increasing maintenance requirements. Entrained sediments would present even greater issue for the biological filtration process, which typically uses a lesser backwash rate than conventional greensand filtration. Regardless of treatment process, additional measures will be required to mitigate this issue.

BCL ENGINEERING LTD.

7. TREATMENT OPTIONS

Overall, the existing water treatment facility is in good condition, but is presenting several issues regarding capacity and capability in meeting current standards and objectives for water treatment. It must be noted that most options for improving the treatment process require additional equipment, which is constrained by the physical size of the existing building. Considering this, the following options have been identified.

Option 1 – Manganese Greensand Media Replacement

The plant currently uses typical manganese greensand media, which is a silicate mineral coated with manganese dioxide. The greensand is topped with a layer of anthracite media which acts as a physical filter for precipitated iron, manganese, and other larger particulates. The anthracite material has been replenished periodically, as it is gradually lost during the backwash process. However, the greensand media is believed to be the original material. Over time, greensand material can degrade through abrasion (reduced surface area), physical loss of media during backwashing, and possibly reduced adsorption ability over time. Therefore, it is possible that replacing the greensand media could improve treatment performance. Estimated cost to replace the media is as follows:

Greensand Media Replacement	
Item	**Estimated Cost**
Greensand Media Replacement	$40,000

It is important to note that treatment issues, particularly regarding manganese removal, have been observed for more than 10 years and are not isolated to recent occurrences. There does not appear to be a discernable trend of reducing manganese removal within this timeframe. It is more likely that the treatment issues stem from the rate of operation and inadequate oxidization time than from media degradation or loss. Therefore, media replacement is not guaranteed to realize increased treatment performance.

Alternatively, modified media types are available that can reportedly increase the flux capacity of the existing tanks. Alternative media options typically include a variation of the type of mineral coated with greensand or a solid manganese dioxide mineral media. Manufacturers report improved iron and manganese adsorption rates; however, limited data is available by which to evaluate these claims. Estimated cost to replace with an alternative media is as follows:

Alternative Media Replacement	
Item	**Estimated Cost**
Alternative Media Replacement	$75,000

Chemically, the process for iron and manganese removal is the same for all media types using the greensand approach. Therefore, improved removal requires a substantial increase in oxidization and adsorption of dissolved iron and manganese. A large factor in successful oxidization, particularly for manganese, is the oxidization time and the pH level of the raw water. Manganese is typically harder to remove as the oxidization reaction time is significantly slower than that of iron, particularly at the pH level present in the raw water. It is important to note that alternative media will do nothing to increase the contact time with the oxidizing agent and media. By increasing filtration rates to meet demand, media contact time will actually be reduced. Further, the presence of elevated ammonia concentrations in the raw water is likely inhibiting the oxidization process. This too would not be mitigated by alternative media types.

For these reasons, the alternative media options are not guaranteed to achieve treatment at the filtration rates required to meet future growth in the community. Though some improvement may be realized at the current operating rate, it is anticipated that these returns will diminish at increased filtration rates. The better alternative for continued use of the manganese greensand process is to simply add more filters or replace the existing ones with larger tanks. Physically, it may be possible to accommodate the additional equipment but working space would be significantly reduced. An air scour process is also recommended. Such a project would require the following:

- replacement of existing media;
- installation of two additional filters;
- installation of air scour system and piping;
- plant and piping modifications.

Estimated costs to design, construct, and implement this work are as follows:

Greensand Process Expansion	
Item	**Estimated Cost**
Filter Media Replacement	$75,000
Additional Filters	150,000
Air Scour System	50,000
Existing Building / Reservoir Modifications	25,000
Process Piping Modifications	90,000
Instrumentation	20,000
Subtotal - Construction	**$410,000**
Contingency (15%)	60,000
Engineering (15%)	60,000
Total Estimated Cost	**$530,000**

Installing additional filters will increase production ability of the plant. However, some difficulty in manganese removal is likely to continue due to inadequate contact time and ammonia interference. Increasing the size of the detention tank would not be possible due to physical constraints of the plant.

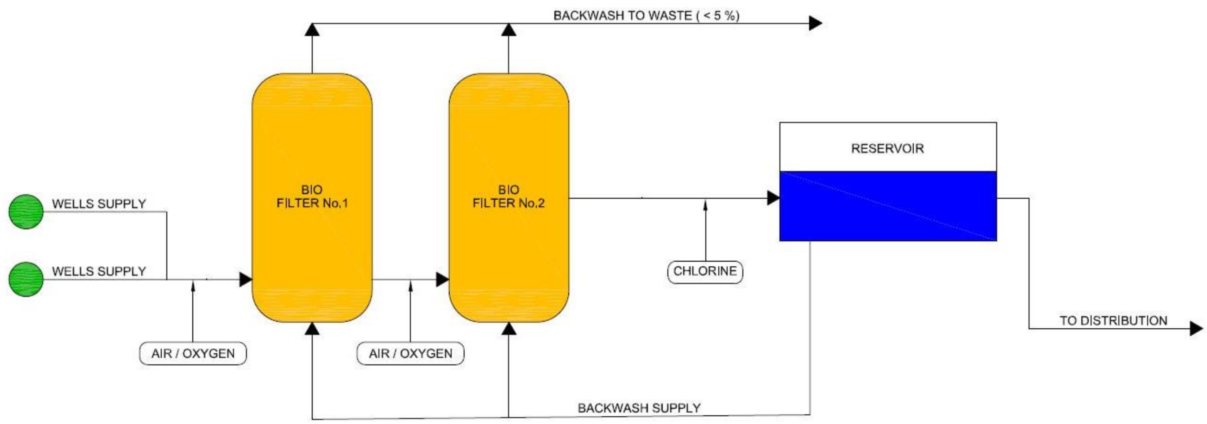
Option 2 – Biological Filtration Conversion

Biological filtration provides several advantages over conventional manganese greensand filtration. This process has been implemented at many locations throughout Saskatchewan over the last 10 years, replacing manganese greensand processes in many instances. Biological filtration typically realizes slightly improved iron removal and significantly improved manganese removal, compared to manganese greensand filtration. Biological filtration can also remove ammonia whereas manganese greensand has no ammonia removal ability. Due to the ability to remove ammonia and the elimination of oxidization prior to filtration, the biological process would greatly reduce chlorine usage at the plant. Backwash requirements would also be reduced.

The existing filter tanks are in good condition and are suitable for conversion to a biological process. Based on the filter sizing and projected demand, two additional tanks of equivalent size would likely be required. The existing detention tank could be removed for this process. Confirmation of filter sizing would be required by the treatment process vendor. Such a project would require the following:

- 4 to 6 week pilot testing process;
- replacement of the existing filter media;
- installation of additional filters;
- 4 week bio-seeding process;
- installation of compressor and blower system equipment;
- instrumentation equipment.

A typical biological filtration schematic is shown for reference:



BIOLOGICAL

It should be noted that the existing treatment process would not be available during the 4 week seeding process. Therefore, direct distribution of unfiltered water with chemical disinfection would be required during this time. It is possible that the bio-filters could begin use before the end of this period with gradually improving treatment.

Estimated costs to design, construct and implement this work are as follows:

Biological Filtration Conversion	
Item	**Estimated Cost**
Pilot Process	$25,000
Filter Media Replacement	40,000
New Filters	150,000
Air System	75,000
Existing Building / Reservoir Modifications	25,000
Process Piping Modifications	90,000
Instrumentation	25,000
Subtotal - Construction	**$430,000**
Contingency (15%)	65,000
Engineering (15%)	65,000
Total Estimated Cost	**$560,000**

The addition of biological filtration would provide benefit to operations by reducing chemical usage and backwash requirements. Water quality would be improved by reduced iron and manganese concentrations, as well as ammonia removal. However, as discussed herein, biological filtration will not remove other dissolved solids. Therefore, alkalinity, water hardness and total dissolved solid concentrations will not be improved. Additional treatment process equipment is required to address these constituents.

Option 3 – Membrane Filtration Addition

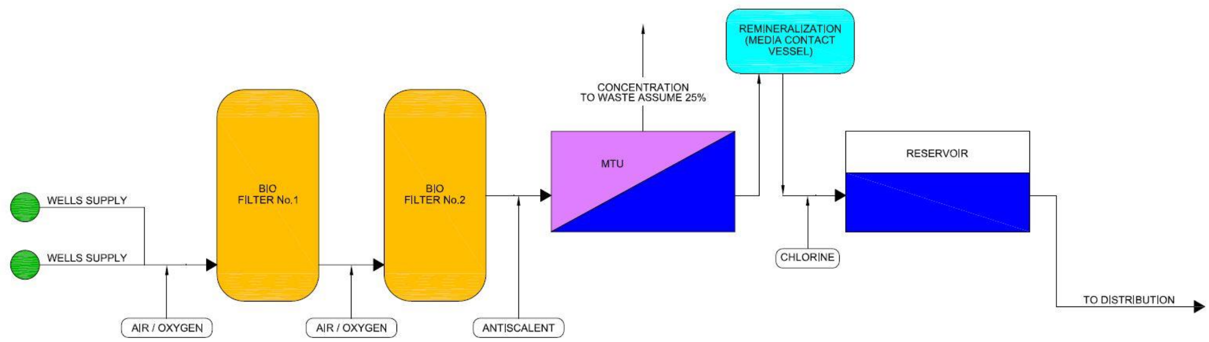
The manganese greensand and biological filtration processes are suitable for iron and manganese removal, but are incapable of removing other dissolved minerals and lowering hardness. It was reported that many residences employ water softeners and small-scale, point-of-use reverse osmosis filters to address this. Membrane filtration is capable of removing dissolved solids from water and can produce a 'bottled water' quality product. Should the Utility wish to remove these constituents to meet all regulations and aesthetic quality objectives, a membrane system would be required. However, due to the high concentrations of dissolved solids in the raw water at Elk Ridge, a 'direct-feed' membrane system would be prone to membrane fouling and frequent replacement at substantial cost. Therefore, a two stage treatment process would be recommended, consisting of greensand or biological filtration for iron, manganese and ammonia removal, followed by membrane filtration for removal of remaining constituents.

Therefore, Option 3 would be added to the greensand or biological filtration process as discussed in Options 1 and 2. Option 3 could be considered concurrently or for upgrade in the future.

Spatial constraints of the existing plant would require construction of a new space to house the additional equipment. This could likely be accomplished by construction of a new building using the existing external reservoir as a foundation. In general, the project would require the following:

- 4 to 6 week pilot testing process;
- construction of a new building;
- installation of membrane filtration equipment;
- modifications to the existing process piping and building;
- instrumentation and integration into controls and monitoring systems.

A typical biological membrane filtration schematic is shown for reference:



BIOLOGICAL / MEMBRANE

Estimated costs to design, construct and implement this work are as follows:

Membrane / Building Addition	
Item	**Estimated Cost**
Pilot Process	$25,000
Building Construction	475,000
Membrane Process Equipment	600,000
Process Piping	150,000
Existing Building / Reservoir Modifications	90,000
Existing Process Modifications	50,000
Instrumentation and Controls	250,000
Subtotal - Construction	**$1,640,000**
Contingency (15%)	245,000
Engineering (15%)	245,000
Total Estimated Cost	**$2,130,000**

It should be noted that these costs would be in addition to Option 1 or 2. Further, these estimates do not include upgrading the existing well capacity, should it be required to meet the additional water supply necessary for the membrane filtration option.

8. ADDITIONAL IMPROVEMENTS

In addition to the treated water quality and capacity issues, several other items were noted during the inspection of the facilities.

Raw Water Supply

The capacity of the existing raw water supply is approximately 3.8 L/s. Therefore, increased raw water pumping capacity will be required to realize any increase to the treatment capacity. This is most easily achieved by replacement of the existing well pumps with larger units. Preliminary well analysis suggests that the existing well construction and aquifer are sufficient for increased pumping rates.

Well Pump Replacement	
Item	**Estimated Cost**
Well Pump and Motors	$35,000
Total Estimated Cost	**$35,000**

In addition to capacity, PW7 also has issues with entrained sediment, which will pose a problem to any treatment process upgrades. As a result, PW7 has been operated as a back-up well, only used in case of issues with PW6. BHL suggested several options for mitigating this issue in their 2018 letter report. One option was to pump the well to waste in an effort to exhaust the source of the sediment, which was done without success in 2021.

Another option listed in the BHL report was to install a screen insert with smaller slot openings and finer screening sand within the well to prevent the sediment infiltration. A reduced screen opening size and the accumulation of fine sediment around the well will increase the drawdown level of the well, affecting pumping capacity. Therefore, a larger pump may be required for PW7 to achieve equivalent capacity to PW6. Additional analysis would be required to determine whether this assembly would be sufficient for increased pumping rates. It should be noted that the installation of a screen would also make it more difficult to service and rehabilitate the well in the future.

Well Screen Installation	
Item	**Estimated Cost**
Well Screen Installation	$70,000
Total Estimated Cost	**$70,000**

Rather than addressing the issue at the source, there is also an option to filter out and remove the entrained sediments as a part of the treatment process. This could be accomplished through addition of a self-cleaning filter within the plant, installed prior to the filter tanks. These units remove suspended solid particles, automatically flushing them to waste intermittently or continuously, without interrupting filter operation. This option would require piping modifications and additional floor space within the plant. The filter discharge would direct sediment to the sanitary sewer system, including the nearby pumping station and ultimately, the lagoon. The sediments observed to date have been relatively fine and are not anticipated to pose a problem to the sanitary sewer system but may increase wear on sewage pumping equipment.

Pre-Filter Installation	
Item	**Estimated Cost**
Pre-Filter Installation	$35,000
Piping Modifications	5,000
Electrical	5,000
Total Estimated Cost	**$45,000**

Long term, the best option would be design and installation of a new well with increased capacity and adjusted screen sizing to prevent infiltration of finer sediments. However, capital costs for well development are significant and would also include the cost of construction of a new supply main to connect well to treatment plant.

Estimated costs for the options discussed herein are as follows:

Well Development	
Item	**Estimated Cost**
Well Drilling	$170,000
Well Completion	50,000
Pump and Motor	40,000
Raw Water Supply Main	50,000
Total Estimated Cost	**$310,000**

Distribution Pumping

As discussed, the plant currently uses submersible well pumps for distribution of treated water. The pumps are of adequate capacity to meet current and future demands but present operational issues due to the installation arrangement. The pumps are installed vertically within the reservoir and consist of a motor and pump end suspended from a drop pipe. The motor hangs below the suction inlet of the pump, positioning the inlet approximately 1.2m above the reservoir floor. Therefore, the bottom 1.2 m of treated water are inaccessible, effectively reducing storage capacity by approximately 147,000 m^3.

The effective storage volume is sufficient to meet current demand rates but will realize a shortfall in approximately 10 years. However, if the utility reduces the operating level of the reservoirs during winter months, the effective storage may dip below current requirements.

Vertical turbine pumps are considered industry standard for treated water distribution and feature a suction inlet extending to the base of a reservoir to utilize the full storage volume. It is recommended that vertical turbine pumps be installed when storage capacity becomes critical. Estimated cost to replace the distribution pumps with vertical turbine pumps are as follows:

Distribution Pumping	
Item	**Estimated Cost**
Vertical Turbine Pumps	$180,000
Header Piping Modifications	10,000
Total Estimated Cost	**$190,000**

9. RECOMMENDATIONS AND CONCLUSION

As discussed, the ERU water treatment plant is currently faced with several immediate operational issues.

Water Treatment Quality / Capacity
Recommendation: Conversion to Biological Filtration System

The existing system requires media replacement and installation of additional filters to increase treatment capacity and quality. Even with additional filters, insufficient oxidization time may result in continued difficulty with removal of manganese. The presence of ammonia in the raw water would continue to interfere with the oxidization process and require excess chlorine dosage. Conversion of the filters to a biological filtration system would realize significantly improved manganese removal, as well as ammonia removal, with reduced chemical dosing. The bio process has no oxidization requirement and therefore would eliminate the detention tank, reducing spatial requirement of the process. Costs for these upgrades are not expected to differ significantly from greensand option.

Raw Water Supply Capacity
Recommendation: Well Pump Replacement

The wells are currently run at full, or near full, capacity during normal operation. Increasing treatment capacity will require increased supply capacity to suit. Preliminary well analysis suggests the well construction and aquifer should be sufficient for increased pumping rates. Therefore, installation of larger capacity well pumps would achieve the required supply increase.

PW7 Entrained Sediments
Recommendation: Pre-Filter Installation

The entrained sediment produced by PW7 pose a problem to the operation of the existing treatment process as well as the future process upgrades. Therefore, sediment removal is required by installation of a screen sleeve within the well or a self-cleaning pre-filter within the plant. Installation of a well screen would accomplish the task but may reduce well efficiency, which is problematic for increasing the aforementioned raw water supply capacity. The screen would also make rehabilitation work on PW7 impossible, effectively limiting the remaining lifespan of the well. A pre-filter unit within the plant would have a spatial requirement but would be more cost effective to install and easily serviceable. Further, the pre-filter could provide benefit to both existing wells as well as any future wells should further sediment issues crop up.

Immediate Recommendations Cost Summary	
Item	**Estimated Cost**
Biological Filtration Process Upgrade	$430,000
Well Pump Replacement	35,000
Sediment Pre-Filter Unit	45,000
Subtotal – Construction	**$510,000**
Contingency (15%)	75,000
Engineering (15%)	75,000
Total Estimated Cost	**$660,000**

Please note that all costs provided in this report are preliminary in nature and subject to change based on economic conditions, market timing, contractor and material availability.

Long term, the ERU should consider additional upgrades as discussed within this report, including:

- replacement of the existing distribution pumps with vertical turbine style pumps in order to realize full reservoir capacity;
- should the community wish to pursue further improvements to water treatment to meet all treatment guidelines and objectives, a membrane filter could be added to the proposed biofilter upgrades. This would require a building expansion to fit this equipment;
- the ERU should plan for new well construction in the event that PW7 experiences further issues.

We trust this information meets your needs at this time. If you have any questions or require further information, please do not hesitate to contact our office.

Yours truly,

BCL ENGINEERING LTD.

T. T. Braun, P. Eng.