Technical Memo

SENT:	17 August 2023	5:07 PM
BY:	Nyamaa Jalbuu, Manager of Municipal Services	**PROJECT:** **#23-3150**
RE:	3150 – Water Treatment Plant Upgrade Study, Radisson, SK Desktop Study & Conceptual Options Analysis Technical Memo - Draft	

INTRODUCTION

The Town of Radisson (the Town, the Client) retained PINTER & Associates Ltd. (PINTER) to provide engineering services to investigate the Town's potential need to upgrade their existing water treatment plant (WTP).

The Town reportedly has encountered issues with the pump injecting liquid chlorine for disinfection purposes and is unable to adequately control the current chlorine injection system causing long stabilization periods. The Town also typically exceeds the maximum use level (MUL) for injected sodium hypochlorite to achieve breakpoint chlorination.

The Town is interested in replacing the current liquid chlorine injection with gas chlorine in hopes to mitigate this problem. Other upgrades the Town are considering include:

- Additional chemical storage room inside the plant;
- Upgrade to variable frequency drive (VFD) pumps and controls; and
- Installation of one (1) outdoor backup generator for the WTP.

PINTER was commissioned to conduct a review and assessment of the current water treatment system, identify the core issue, and recommend alternative solutions for mitigation.

BACKGROUND INFORMATION

The current water treatment system was upgraded in 2013-2014, treating water from a raw water source previously recorded to have high concentrations of Iron, Total Dissolved Solids (TDS), and Manganese. The WTP process utilizes a Manganese Greensand Filtering system and consists of aeration, pH adjustment, detention/sedimentation, filtration and disinfection processes.

Raw water enters the WTP and is oxygenated before it enters the first chamber, where it dissolves and oxidizes soluble iron and manganese. Potassium Permanganate is then added to raise the pH level of the water to assist with the removal of manganese and iron. Through the two greensand filter chambers working in parallel, the water is pressure-filtered through BIRM media, which are aluminum silicate sand coated with manganese oxide causing iron to oxidize. Sodium hypochlorite (NaOCl) is injected into the treated water before it enters the storage reservoir for long-term disinfection.

Backwash water is retrieved from the reservoir, pushed through the filters, and is released into a sump within the plant which is directly connected to the gravity wastewater pipe system.

PROJECT OBJECTIVES

The purpose of this memo is to provide a review and assessment of the current treatment system, identify the core issue, recommend alternative solutions to mitigate the issues as well as to explore optimizing the system design and operational procedures and provide alternatives both to improve water quality and increase WTP operational efficiency. Additionally, PINTER conducted a brief review of the current lagoon, power, and gas capacity to ensure that the recommended upgrades can be compatible with the current Town's existing infrastructures.

RAW WATER AND TREATMENT PROCESS ASSESSMENT

On 07 July 2023, three (3) water samples at various locations were collected to test the raw water composition, pre-treated water, and distributed water to measure and determine water characterization. Collected water samples were submitted to Saskatchewan Research Council (SRC) Laboratories located in Saskatoon, SK. Laboratory analysis reports are presented in Appendix A.

Laboratory analysis results show that the treatment process is achieving the design targets and fulfilling required water quality standards, guidelines, and objectives for the treated and distributed water. Treated water quality results show no exceedances of the Canadian Water Quality Guidelines (2002), as shown in Table 1. The full water quality analysis results are attached in Appendix A.

Table 1. Selected Water Quality Parameters Laboratory Results

Parameter	Raw Water	Treated Water	Distributed Water	C/SDWQS&O*
Iron	**0.82**	0.0035	0.01	0.3
Manganese	**0.24**	0.016	0.016	0.05
Copper	<0.0002	0.02	0.21	1
Zinc	<0.0005	0.0054	0.028	5
Ammonia as nitrogen	1.2	<0.01	<0.01	NG
Nitrate	<0.04	<0.04	<0.04	45
Nitrate as nitrogen	<0.01	<0.01	<0.01	10
Total Kjeldahl nitrogen	1.3	0.11	0.11	NG
Total nitrogen	1.3	0.11	0.11	NG
Organic carbon	2.4	2.3	2.2	NG
pH [pH units]	7.93	7.9	7.98	7.0 - 10.5
Turbidity [NTU]	**8**	0.6	0.5	<1.0
Total Dissolved Solids	418	430	460	1500
Specific Conductivity [us/cm]	712	740	743	NG

*Canadian/Saskatchewan Drinking Water Quality Standards and Objectives (2022)
All results in mg/L unless otherwise specified
NG - No Guideline
Bold - Exceeds regulatory limit

As can be seen in Table 1, the raw water coming into the system is naturally high in Iron, Manganese, and Ammonia. The current treatment system utilizes manganese greensand filters to mitigate the high Iron and Manganese content, working at 99.6% efficiency at removing iron and 93.3% efficient at removing manganese. However, manganese greensand filters do not affect ammonia in the water.

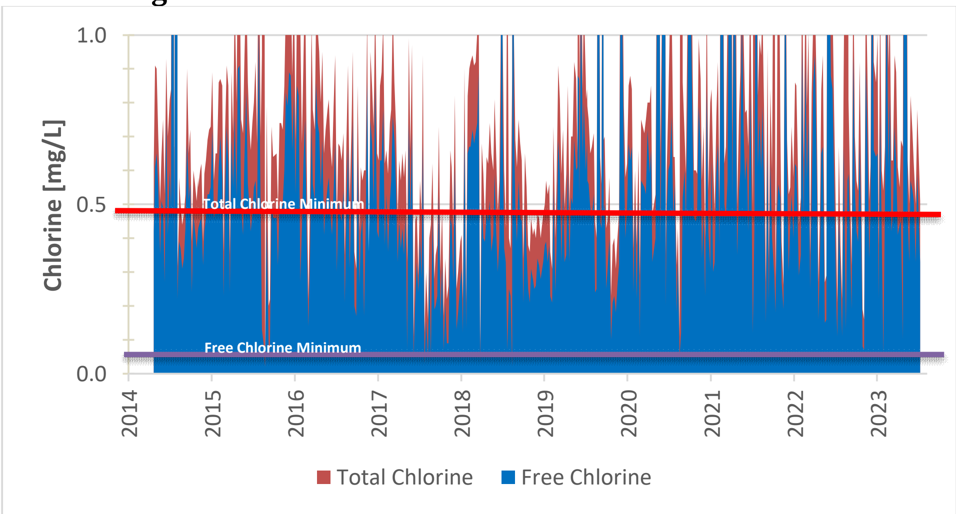
Achieving breakpoint chlorination in the system will require more chlorine due to the presence of ammonia in the water impacting the disinfection process. Chlorine first reacts with ammonia until the chlorine demand has been satisfied, where it is typical to require a chlorine dose of up to eight to ten times the ammonia concentration. Additional dosage of chlorine past the breakpoint results in free chlorine residual.

High ammonia presence in the water also risks nitrification, which is a health risk and is regulated by the Canadian and Saskatchewan Drinking Water Quality Standards and Objectives (C&SDWQSO). From Table 1, nitrite and nitrate amounts do not seem to fluctuate in the water therefore it is not expected to be a concern at this time.

HISTORICAL WATER TESTING

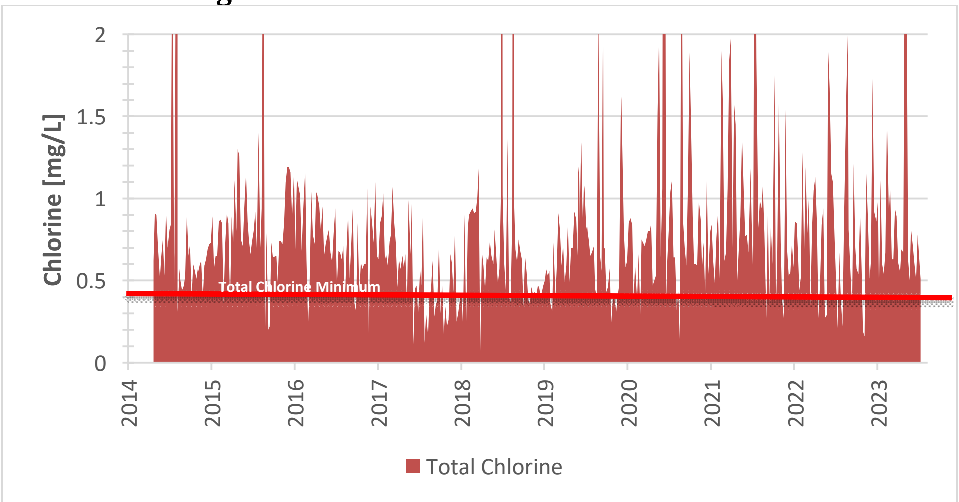
A review of historical inspections and water quality testing in the water treatment plant show that there was a constant wave of issues with reaching the required total and free chlorine residual in the treated water as can be seen on Figure 1. The required free chlorine residual is 0.1 mg/L entering the distribution system, and the required total chlorine residual is 0.5 mg/L.

Figure 1: Historical Free and Total Chlorine Results



Exceedances of chemical use were not noted until the June 2018 inspection. Notably, total chlorine residuals were below minimum requirements for 74% of the time between June 2017 to February 2018 based on weekly water sampling results, more clearly represented in Figure 2.

Figure 2: Historical Total Chlorine Results



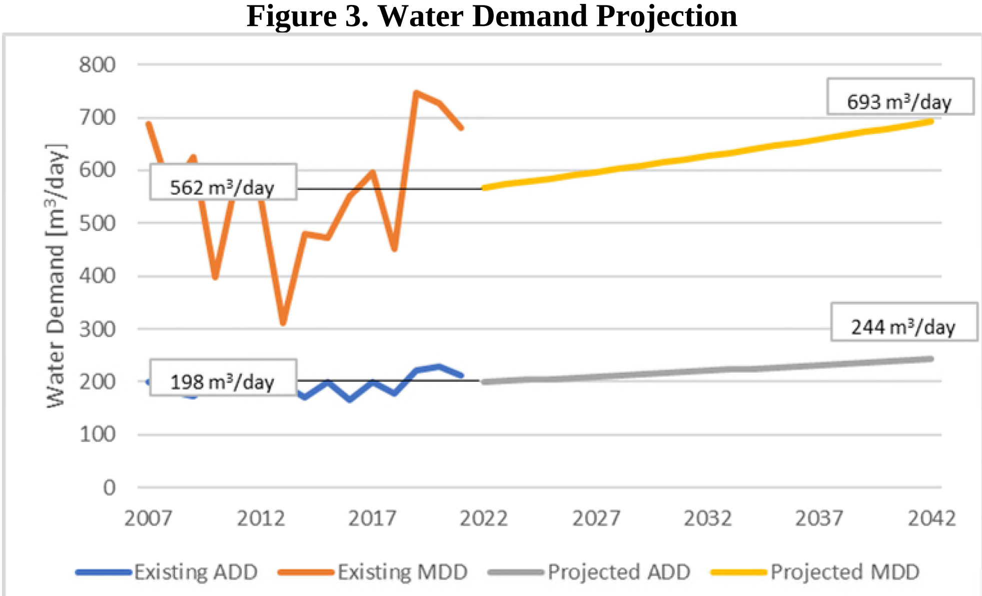
PINTER suspects that the system is having issues reaching breakpoint chlorination because of the ammonia which is interfering with the injected chlorine, pushing chlorine dosage requirements up past the MUL. Additional parameters that may affect the disinfection process include Dissolved Organic Carbons (DOCs) and the formation of Trihalomethanes (THMs) which are by-products of chorine disinfection.

No historical sampling of ammonia, DOCs, or THMs in the raw or treated water could be found; therefore, it is not certain if the raw water has always contained ammonia concentration, or it fluctuates seasonally. The susceptibility to impacts and disturbances of the well aquifer is unknown. Further water sampling analysis should be completed to determine disinfection by-product presence in the treated water.

PROJECTED WATER DEMAND AND LAGOON CAPACITY

Historical water demand data is shown in Figure 3, obtained from the Saskatchewan Community Water Use Records. Assuming a 1% growth rate based on the Saskatchewan average growth rate, the Average Day Demand (ADD) and the Maximum Day Demand (MDD) were projected to the year 2042. Based on the information presented, the production capacity of the water treatment system should be equal to the projected MDD, which is 693 m^3/day.

Figure 3. Water Demand Projection



PINTER also conducted a desktop review of the existing lagoon capacity in addition to the projected lagoon capacity requirements based on the Town's water use by 2042 of the projected population. The estimated capacity requirements are based on the current water treatment system, assuming 8% of wastewater is generated from a routine backwashing of the filters. Table 2 outlines the current and expected requirements to the Town of Radisson's wastewater lagoon.

Table 2. Lagoon Capacity Projected Requirements 2023-2042

	Existing	2023	2027	2032	2037	2042
Population (1% growth)		475	495	520	546	574
Lagoon:						
Primary* (ha)	1.11	1.46	1.52	1.60	1.68	1.77
Secondary** (m3)	15,031	32,566	33,938	35,562	37,434	39,374

*25 kg/ha/day BOD loading and 0.077kg/BOD_5 treatment
**220-day storage

As can be seen in Table 2, the lagoon is currently undersized, and will require further expansion in the future to accommodate the projected population growth.

IMPROVEMENT OPTIONS

The current water treatment system is performing as designed. However, current disinfection process is not sustainable, and the liquid chlorine usage should be reduced. Based on the water quality analysis, enhancing the raw water treatment system to limit the ammonia concentration entering the distribution system, ensuring compliance with MUL and maintaining water quality within the guidelines for drinking water. The following options should be considered to limit the chlorine intake of the system.

1. Option 1 - Pre-Treatment of Existing Raw Water Supply

A variety of pre-treatment options are available to reduce Ammonia concentration. The following is a brief description of the available pre-treatment options that can be utilized in addition to the Town's current system.

1.1. Aeration

One option to reduce the ammonia content in the water is aeration via air stripping, or an aeration tower. Aeration is commonly used for removing ammonia in wastewater. Although it is highly effective in that field, it is less commonly used for water treatment as its efficiency is sensitive to the water's pH and temperature, and there are typically lower concentrations of ammonia in raw water versus wastewater and therefore less reactions.

Aeration requires an increase of the pH of the water above 10 and increase its temperature to boost effectivity. As a pH of 10 is not within standards, pH adjustment is also required after the aeration treatment. This increases the space requirement and cost of the system.

1.2. Ion exchange

Ion exchange is a process in which ions from the raw water are exchanged with ions within the solid phase of a resin. Multiple factors impact the performance of ion exchange which include ammonia concentration in the source water, water quality (competing anions such as calcium, magnesium, and potassium), resin properties (polymer composition, porosity and charged functional groups) and operational variables (resin dose, contact time, regeneration frequency). Appropriate disposal of the waste stream brine resulting from the process increases the costs of operating this system.

Some effective materials for ion exchange removal of ammonia include zeolites like clinoptilolite. Ion exchange is ideal if low cost minerals are effective specific to the plant's raw water source, as well as if the water hardness is low.

1.3. Conclusion

If the pre-treatment option is decided to be the preferred method of improvement, it is highly recommended that a raw supply treatability study be conducted to assess and compare pre-treatment options. Determining the feasibility of any potential pre-treatment process should be based on jar testing and disinfection by-products (DBP) formation. This study should include bench and/or pilot-scale testing to determine the DBP formation potential.

Aeration is a viable but not efficient option for the Town's water treatment system. Meanwhile, ion exchange is efficient but requires additional wastewater capacity, which is not currently viable for the Town.

2. Option 2 – Treatment System Replacement

2.1. Membrane Filtration

Four types of pressure-driven membranes are currently used in drinking water treatment: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). Membranes are generally classified by the type of substances they remove, operating pressure and pore size or molecular weight cut-off. MF and UF are referred to as low-pressure membranes and are used for particle/pathogen removal. Guidelines for Canadian Drinking Water Quality suggest that "RO and, to a lesser extent, NF, can be effective technologies for removing ammonia concentrations in drinking water." To install this system, appropriate disposal of reject water needs to be considered as it is rich in contaminants.

Although the installation of an RO system is highly effective in the removal of ammonia concentration in the water as well as other unwanted constituents, the high cost of the membrane filtration system limits the feasibility of this treatment option.

2.2. Biological treatment

Biological treatment involves targeting the removal of the Biodegradable organic matter (BOM) fraction that encourages biofilm growth in the distribution system and increases chlorine demand. The effectiveness of biological treatment depends on the amount of BOM that is present in the water to be treated, the microbial community consuming the BOM and the temperature. The main biological treatment processes are riverbank filtration, rapid granular media filtration and slow sand filtration.

Biological treatment processes typically require about 3 months for the growth of the necessary bacteria, and as it is a living treatment system, a high intake of oxygen and a long solids retention time are required. An additional tank is also required to store non-chlorinated water for backwashing purposes, as chlorine will kill the necessary bacteria on the filters.

2.3. Conclusion

If the replacement treatment system option is decided to be the preferred method of improvement, it is highly recommended to complete pilot testing. Piloting is utilized to reduce risk and uncertainty in the chosen treatment option. Piloting will help to confirm the number of tanks, efficiency of removal of constituents, subsequent membrane selection, as well as to confirm membrane performance, fouling potential and cleaning frequency for the chosen treatment option.

Both systems are very effective in reducing ammonia, however installation and replacement of the treatment system to an RO or biological treatment is expensive. Each option also requires a larger WTP footprint, requiring an expansion of the current plant facility, and further driving up the cost for installation.

3. Option 3 – Disinfection of Treated Water

3.1. Ultraviolet (UV) Radiation

Ultraviolet (UV) rays are effective at removing microorganisms, including bacteria, viruses, and protozoa, from water. The system is typically used for additional water disinfection to reduce reliance on chlorine for disinfection and, with increasing frequency, used to reduce ammonia in water. It is an effective solution to reducing chlorine use by lessening the system’s reliance on chlorine to achieve breakpoint chlorination.

Particles in the water can block the UV rays therefore filtration is required prior to the water entering the UV system. The system overall is easy to integrate into existing water treatment systems and can accommodate varying footprint availability in the plant. The number of units required is dependent on the water quality after filtering, disinfection target, as well as the required flow rate. Although it may be effective as a primary disinfection treatment, chlorine is still required for long-term disinfection.

3.2. Chlorine Gas

Chlorine gas is an alternative disinfection chemical used in water treatment plants when hypochlorite solutions at the recommended MUL cannot reach breakpoint chlorination. It is an effective disinfectant and has an MUL of up to 30 mg Cl_2/L depending on the manufacturer. As per WSA’s EPB261 – Chemical Use and Storage at Waterworks, the following safety equipment should be available wherever chlorine gas is stored or used:

- Shower and eye wash facility,
- Emergency breathing apparatus,
- Chlorine gas detector,
- Floor level vents, and
- Fans that maintain a positive air pressure in the storage facility.

Although the list above is not requirements, some of the recommendations do fall under *Occupational Health and Safety Regulations.* Gas cylinders are also recommended to be stored in an upright position secured by chain supports. Chlorine sensors and alarms should be installed in the storage room, which should be kept cool dry, and well-ventilated. Additional training for operators working with chlorine gas is also highly recommended, although not required. Specific storage instructions are typically specified by the manufacturers.

3.3. Conclusion

If the post-treatment system option is decided to be the preferred method of improvement, it is highly recommended that a pilot study be conducted to assess and compare disinfection options. To utilize UV installation, an onsite analysis of the treated water Ultraviolet Transmittance (UVT) is required to accurately design the system for the WTP.

The effectiveness of replacing the chlorine disinfection product with chlorine gas will require appropriate testing to determine the contact time (CT) required for the product to achieve breakpoint chlorination. Storage of the product will also require the installation of an enclosed storage room in the plant. As the current plant footprint is limited, an expansion of the facility may be required.

RECOMMENDATION AND BROAD COST ESTIMATE

Each option was evaluated based on their ease of connection to existing system, ease of operation and maintenance, and overall capital and operational cost of the optional treatment enhancement including materials and equipment, installation, engineering design. Based on the stated criteria, PINTER recommends the Town to integrate UV radiation disinfection to their existing treatment system to limit their chlorine use to achieve breakpoint chlorination.

The following broad cost estimate was developed based on the available information regarding water treatment and supply requirements. A broad cost estimate for expected engineering work has also been included. A breakdown of the broad cost estimate is presented in Table 3.

Table 3. Broad Cost Estimate for UV Disinfection Integration

Item	Includes:	Cost Estimate*
UV System	Equipment, Controls, Spare Parts, Startup, Training, Travel, Commissioning,	$200,000
	Installation, and Pipe and Electrical Modifications	$50,000
	Contingency 20%	$60,000
Engineering	Design, Permit Applications, Tendering, Construction Management, QA/QC, As-Builts	$35,000
	Total (excluding applicable taxes)	**$345,000**

***Excluding applicable taxes**

The proposed UV system is easy to integrate into the existing treatment system and can accommodate to the available floor or wall space in the plant. The disinfection system must intercept the current flow path of the treated water before it is chlorinated. The proposed UV array estimates the requirement of 12 units to obtain the desired UV transmittance and flow rate based on an MDD of 690 m^3/day.

A second option recommended by PINTER is the integration of a Reverse Osmosis/Nanofiltration System. This system also utilizes the existing manganese greensand filtration system, acting as a secondary treatment to additionally address issues with Ammonia, Hardness, Dissolved Organic Carbon (DOC), and Total Dissolved Solids (TDS).

Table 4. Broad Cost Estimate for RO/NF Integration

Item	Includes:	Cost Estimate*
RO/NF	Equipment, Membranes, Filters, Sensors, Tanks, Level Switches, Chemical Dosing System, Automation Controls,	$615,000
	Installation, Testing, and Pipe and Electrical Modifications	$100,000
	VFD pumps and controls	$80,000
	Contingency 20%	$159,000
Engineering	Design, Permit Applications, Tendering, Construction Management, QA/QC, As-Builts	$35,000
	Total (excluding applicable taxes)	**$989,000**

***Excluding applicable taxes**

The integration of an RO/NF system does increase the wastewater generated by the water treatment system. This option will require upgrades to the existing lagoon capacity in order to get approval from Water Security Agency.

ADDITIONAL IMPROVEMENTS

1. Chemical Storage

Proper chemical storage is specific for the type of chemical and chemical form for storage (solid, liquid, or gaseous). These are provided by manufacturers for each product. Chlorine should be kept in a cool, dry, well-ventilated, away from direct sunlight and heat or ignition sources, separate from incompatible materials and secure and separate from work areas, preferrable in an isolated, detached building.

The Town currently uses Sodium hypochlorite, which degrades over time and is typically recommended to not be stored for more than 3 months. The chemical's strength may also be adversely affected by temperature and light; therefore, it should be stored in a dark, cool, and dry place.

Appropriate spill control and fire protection equipment should be readily available. PINTER recommends the installation of secondary containment trays or pallets to contain potential spills. Highly hazardous materials should be stored within lock and key secured shelving. Additionally, safety measures including an eye wash station, appropriate floor drainage, and ventilation in the facility should be accommodated as required based on chemical use to ensure operator's health and safety.

Should chlorine gas be considered for use in the facility, floor level ventilation and installation of a separate storage room may be required. As the Town's water treatment plant has limited space, a separate chemical storage room will be difficult to install.

2. Standby Outdoor Generator

The installation of a standby outdoor generator will provide the water treatment plant with security to ensure that water production and treatment does not halt in the event of power outages or any breaks in power. Natural gas is readily available in the plant and will be utilized for the proposed generator.

The estimated cost for a natural gas standby outdoor generator is approximately $80,000 to $120,000.

3. VFD Pumps and Controls

Upgrading the pumps and controls with a Variable Frequency Drive (VFD) system will improve pump efficiency, minimize power costs, and extend pump life. However, it should be noted that the current pumps installed may need to be replaced if they are not compatible with the VFD control system. As well, different treatment options may require different pumps and controls.

Replacement of the pumps and controls will cost approximately $60,000-80,000, depending on the treatment system chosen.

4. Utility and Lagoon Upgrades

The recommended UV system requires approximately 320-amp breaker to be installed, therefore upgrades may be required of the current power breaker. The costs for upgrades to utilities are accounted for in the cost estimate previously presented for the recommended upgrade.

Natural gas is available in the facility. Power requirements will differ based on the chosen option.

The recommended UV system does not increase wastewater therefore no lagoon upgrades will be required. Should the second recommended option be chosen, the lagoon capacity will require expansion for approximately 0.66 ha surface treatment for the primary cell and approximately 35,000 m^3 storage for the secondary cell, with an estimated 30% wastewater generated from reject and backwash.

RECOMMENDATIONS FOR THE NEXT STEPS

It is recommended to start by carrying out a treatability study for the existing groundwater source. A small-scale pilot should be conducted to determine:

- UV disinfection suitability for the existing treatment system; and
- conceptual design and estimated cost of the treatment process.

Based on the estimated cost, the Town may decide to investigate the second recommended option by carrying out small-scale pilot testing.

The cost of small-scale pilot testing is dependent on the distributor and supplier chosen by the Client. For an RO/NF system, the range of costs for testing can vary from $30,000 to $50,0000.

CLOSURE

We, the undersigned, hereby declare that to the best of our knowledge, the information contained herein and the information in support of this submission as completed by us is complete and accurate in accordance with my obligations under The Engineering and Geoscience Professions Act (2011) and its regulations. We further declare that this submission has been prepared in accordance with the published standard for this submission.

PINTER & Associates Ltd.

Enkhnyamaa Jalbuu, P.Eng.	Joyce Galang
Manager of Municipal Services	Municipal Engineering Intern

Date: 17 August 2023

H:\2) Projects\3150 Radisson Water Treatment Plant Upgrade Study\3150 Report\Final\3150 - Water Quality Assessment Technical Memo 17Aug23 - FINAL.docx

Appendix A

Water Quality Analysis Results

SASKATCHEWAN RESEARCH COUNCIL

Environmental Analytical Laboratories
143-111 Research Drive, Saskatoon, SK Canada S7N 3R2
T: 306-933-6932 F: 306-933-7922
Toll-free: 1-800-240-8808
E: analytical@src.sk.ca
www.src.sk.ca/analytical

SRC Group # 2023-8399

Jul 14, 2023

Pinter and Associates
710A 48th St E
Saskatoon, SK S7K 5B4
Attn: Nyamaa Jalbuu

Date Samples Received: Jul-07-2023 Client P.O.:

All results have been reviewed and approved by a Qualified Person in accordance with the Saskatchewan Environmental Code, Corrective Action Plan Chapter, for the purposes of certifying a laboratory analysis

Results from Lab Section 1 approved by Gipman, Keith
Results from Lab Section 2 approved by Britton, Stephanie
Results from Lab Section 8 approved by Tse, Timothy

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* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as
    * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
    * Environment Canada
    * US EPA
    * CANMET

* The results reported relate only to the test samples as provided by the client. Results apply to the sample as received, unless otherwise indicated.

* Data marked as "by Client" has been provided by the client and may affect the validity of results.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

* Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

This is a final report.

SRC SASKATCHEWAN RESEARCH COUNCIL

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710A 48th St E
Saskatoon, SK S7K 5B4
Attn: Nyamaa Jalbuu

Date Samples Received: Jul-07-2023 Client P.O.:

21344 **07/07/2023 3150 - TO *WATER***
21345 **07/07/2023 3150 - TRTD *WATER***
21346 **07/07/2023 3150 - RAW *WATER***

Analyte	Units	21344	21345	21346
Lab Section 1				
Bicarbonate	mg/L	371	368	373
Carbonate	mg/L	<1	<1	<1
Chloride	mg/L	13	13	2
Hydroxide	mg/L	<1	<1	<1
P. alkalinity	mg/L	<1	<1	<1
pH	pH units	7.98	7.90	7.93
Specific conductivity	uS/cm	743	740	712
Sum of ions	mg/L	622	621	607
Total alkalinity	mg/L	304	302	306
Total hardness	mg/L	330	333	328
Ammonia as nitrogen	mg/L	<0.01	<0.01	1.2
Nitrate	mg/L	<0.04	<0.04	<0.04
Nitrate as nitrogen	mg/L	<0.01	<0.01	<0.01
Total Kjeldahl nitrogen	mg/L	0.11	0.11	1.3
Total nitrogen	mg/L	0.11	0.11	1.3
Organic carbon	mg/L	2.2	2.3	2.4
Fluoride	mg/L	0.26	0.26	0.26
Total dissolved solids	mg/L	460	430	418
Turbidity	NTU	0.5	0.6	8.0
Lab Section 2				
Calcium	mg/L	78	79	79
Magnesium	mg/L	33	33	32
Potassium	mg/L	5.8	5.8	5.3
Sodium	mg/L	32	32	25
Sulfate	mg/L	89	90	89
Aluminum	mg/L	0.0095	<0.0005	<0.0005
Antimony	mg/L	<0.0002	<0.0002	<0.0002
Arsenic	ug/L	0.8	0.8	7.1
Barium	mg/L	0.020	0.020	0.029
Boron	mg/L	0.16	0.16	0.16
Cadmium	mg/L	0.00001	<0.00001	<0.00001

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Jul 14, 2023

Pinter and Associates

21344 **07/07/2023 3150 - TO *WATER***
21345 **07/07/2023 3150 - TRTD *WATER***
21346 **07/07/2023 3150 - RAW *WATER***

Analyte	Units	21344	21345	21346
Lab Section 2				
Chromium	mg/L	<0.0005	<0.0005	<0.0005
Copper	mg/L	0.21	0.020	<0.0002
Iron	mg/L	0.010	0.0035	0.82
Lead	mg/L	0.0016	0.0009	<0.0001
Manganese	mg/L	0.016	0.016	0.24
Selenium	mg/L	<0.0001	<0.0001	<0.0001
Silver	mg/L	<0.00005	<0.00005	<0.00005
Uranium	ug/L	0.7	0.7	0.7
Zinc	mg/L	0.028	0.0054	<0.0005
Phosphorus	mg/L	<0.01	<0.01	0.03
Lab Section 8				
E. coli	MPN/100mL	Not Reported	Not Reported	Not Reported
Total coliform	MPN/100mL	<1	<1	<1

Symbol of "<" means "less than". This indicates that it was not detected at level stated above.
Most Probable Number (MPN) is equivalent to counts (CTS).

The temperature of the cooler was 11.8 °C upon receipt.

E. coli is not reported when Total coliform is not detected.

SRC SASKATCHEWAN RESEARCH COUNCIL

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SRC Group # 2023-8399

Jul 14, 2023

Pinter and Associates

Analyte Methods

Name	Units	Method
P. alkalinity	mg/L	Chm-211
Organic carbon	mg/L	Chm-380
Chloride	mg/L	Chm-115
Carbonate	mg/L	Chm-211
Fluoride	mg/L	Chm-211
Bicarbonate	mg/L	Chm-211
Ammonia as nitrogen	mg/L	Chm-123
Nitrate as nitrogen	mg/L	Chm-124
Total nitrogen	mg/L	Calculation
Total Kjeldahl nitrogen	mg/L	Chm-128
Nitrate	mg/L	Chm-124
Hydroxide	mg/L	Chm-211
pH	pH units	Chm-211
Total dissolved solids	mg/L	Chm-203
Specific conductivity	uS/cm	Chm-211
Sum of ions	mg/L	Calculation
Total hardness	mg/L	Calculation
Total alkalinity	mg/L	Chm-211
Turbidity	NTU	Chm-316
Silver	mg/L	Chm-522
Aluminum	mg/L	Chm-522
Arsenic	ug/L	Chm-522
Boron	mg/L	Chm-522
Barium	mg/L	Chm-522
Calcium	mg/L	Chm-508
Cadmium	mg/L	Chm-522
Chromium	mg/L	Chm-522
Copper	mg/L	Chm-522
Iron	mg/L	Chm-522
Potassium	mg/L	Chm-508
Magnesium	mg/L	Chm-508
Manganese	mg/L	Chm-522
Sodium	mg/L	Chm-508
Phosphorus	mg/L	Chm-522
Lead	mg/L	Chm-522
Antimony	mg/L	Chm-522
Selenium	mg/L	Chm-522
Sulfate	mg/L	Chm-508

Name	Units	Method
Uranium	ug/L	Chm-522
Zinc	mg/L	Chm-522
Total coliform	MPN/100mL	Chm-410
E. coli	MPN/100mL	Chm-410