File L220.12

R.M. of Brittania No. 502
Hamlet of Greenstreet

Water Treatment System Assessment
Lloydminster, SK

Clifton Associates

Clifton Associates

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Attention: Wanda Boon Administrator
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Water Treatment Systems Assessment
Hamlet of Greenstreet, SK

We are pleased to present to you our report regarding the above subject.

We thank you for the opportunity to work with you on this project. If you have any questions regarding this report, please contact me.

Yours truly,

Clifton Associates Ltd.

Bill Heywood BAdmin PEng
Senior Municipal Engineer
BH/hd

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1.0 Background

The Rural Municipality of Britannia owns and operates a water treatment plant (WTP) in the Hamlet of Greenstreet. In 2006 a new well and water treatment plant upgrade were placed in service. The facility has been successfully operating since that time and only recently began to identify capacity constraints and the occurrence of trihalomethanes (THM) at levels above provincial standards.

In addressing the capacity constraints, the Hamlet was planning to increase plant capacity by adding a second pressure filter. A second pressure filter is on standing order and can be installed at the WTP.

Chlorine based disinfection in Saskatchewan water treatment plants is widely practiced. At the Greenstreet WTP sodium hypochlorite (chlorine) is dosed into the potable water reservoir. The water plant operator monitors and ensures that a level of 0.1 milligrams per litre (mg/l) free chlorine or 0.5 mg/l of total chlorine in the distribution system.

Considering that laboratory tests have established elevated levels of Trihalomethane (THMs), as shown in Table 1.1, the presence of organic compounds or THM precursors in raw water are highly probable. Organic compounds react to the chlorine in the treated water and THM's are formed.

Table 1.1 - Trihalomethane

	06 Mar 2013	03 June 2013.	03 Sept 2013	16 Dec 2013	24 Nov 2014	16 Mar 2015
Total Trihalomethane	89.6	144	146	137	119	104
Chloroform	22.5	48.7	45.3	44.4	38.3	29.7
Bromodichloromethane	25.4	45.7	49.6	46.0	38.6	33.4
Dibromochloromethane	34.2	41.2	42.1	38.5	34.9	34.0
Bromoform	7.57	8.69	8.63	8.17	6.67	6.84

Notes:

- According to Saskatchewan Ministry of Health, the long term total Trihalomethane concentration should be less than 100 mg/L based on an annual average of seasonal samples (winter, spring, summer and fall).
- Seasons are as follows: Spring – April, May and June; summer – July, August and September; fall – October, November and December; winter – January, February and March.
- Since March 6, 2013 the Greenstreet WTP has recorded THM at levels exceeding Saskatchewan Standards.

1.1 Water Treatment Plant

A schematic of the water treatment process is provided in Appendix A. The following bulleted points present operational aspects of the plant.

- The WTP doses incoming water with an oxidant that flows directly into the aerator. On 11 December 2014 the aerator unit was cleaned as it accumulated a mass within it. Up until that time, turbidity was reasonably stable. Since cleaning in the aerator, elevated levels of iron and manganese are occurring. The turbidity levels increase more readily especially when flow rise above 22,730 L per day.
- The plant is backwashed daily. Discharge from the backwash is a pale red color that fails to dissipate after one hour of backwashing. Typically, backwash is dark brown in color for 15-20 minutes and then clear.
- After the backwash is complete, flow is discharged to waste for another 15 minutes to ensure backwash water goes to waste and not into the potable reservoir.
- Backwash water is discharged into the sewer collection system.
- Three wells not in use are connected into the raw supply line. A valve is in the off position preventing water from being sucked into the raw supply. Those line should be severed from the active raw supply line to prevent any possible unknown source of inflow that might come from an abandoned well.
- The pressure filter is rated at 100,013 L per day. It performs well if flows are less than 22, 730 L gallons per day. As flow increases to 45,461 L gallons per day, the turbidity climbs up to 0.95 NTU.
- The filter is configured for manual backwashing.
- The potable reservoir was last cleaned in April 2012.
- When the first reaction chamber was cleaned, there was about 1 m of KM_n0_4 sludge in it.
- Mixing KM_n0_4 may not be occurring effectively. KM_n0_4 is added in the aerator.
- Chlorine is dosed into the pipe leaving the pressure filter. The disinfected treated water is then discharged into the potable reservoir. Distribution pump intakes at the bottom of the potable reservoir are a distance away from the chlorine dosing point.
- Three distribution pumps discharge into two distribution lines.
- Flow from the WTP is unmetered.
- A sanitary collection system consists of grinder pumps that discharge to the lift station.

The WTP footprint, storage capacity and available space for an RO are contained in the following table.

Table 1.2 - WTP Footprint, Storage Capacity and Available Space

	L (m)	Ft	W (m)	Ft	H (m)	Ft	Volume (m)	Ft³	Gallons
Building Extension	5.5	18	2.7	9	NA	NA	NA	NA	NA
WTP	6.4	21	7.0	23	3.3	10.8	NA	NA	NA
Reaction Chamber 1	2.9	9.5	2.6	8.5	2.3	7.5	17.3	612	3,810
Reaction Chamber 2	2.9	9.5	2.6	8.5	2.3	7.5	17.3	612	3,810
Wet Well	7.2	23.6	3.2	10.5	2.3	7.5	53.0	1,871	11,650
Available Footprint for RO	3.5	11.5	4.5	14.8	3.3	10.8	NA	NA	NA

2.0 Raw Water Supply

Well No. 6 is located in SE ¼-1-52-27- W3 and supplies raw water via a 75 mm HDPE DR17 water line to the WTP. The well is fitted with a 140 mm steel casing equipped with a 100 mm stainless steel 3.04 m long screen, 0.51 mm slot size with a bottom depth of 31.7 m.

The well site is approximately 20 m from a surface water body and 2.5 m above the water surface. While the well depth and sub-surface stratigraphy would suggest the groundwater source is truly groundwater, THM data confirms the presence of organics in the raw water. Groundwater under direct influence (GUDI) of surface water requires that such raw water be treated as surface water to become compliant with regulatory standards.

Water well reports dating back to 2006 are provided in Appendix D.

The operator identified a monitor well 20 m south of the production well. The monitoring well is observed to be artesian. If so, this could suggest the aquifer well pump house contains the well pump and supply line to the WTP and also electrical and controls. The well case is 25 mm. An extra line to a local farm is also installed but according to the meter, has zero discharge. The pump house is approximately 2.5 m above Greenstreet Lake water level.

The 75 mm raw supply line to the WTP can be accessed in order to launch a swab. This was done in the last few years.

The Pump house is a plastic building with a spray in foam liner. Heaters are run in it during winter.

2.1 Water Supply Alternatives

At this time the, source of organic matter causing the presence of the THMs is unknown. The driller's report form provided by the client indicated the presence of coal at the depth of the screen installation. This coal may be the source of the organic material responsible for the presence of the THMs. It has also been suggested that gaps in the well seal may be allowing organic material from other sources to infiltrate the well.

If additional water testing for the presence of tannins and THM precursors be undertaken, the following steps are required.

- Sample well water.
- Sample well water after pumping 3 well volumes.
- Sample nearby observation piezometer after pumping 3 well volumes.

If testing indicates tannins are present in the production well and the piezometer, this would indicate that the organics in the well water are coming from the water bearing formation. If testing indicates that tannins and THM precursors are present in the well water but not the observation piezometer, this would indicate the organics in the well water are coming from somewhere other than the water bearing formation.

2.1.1 Replacement Well at the Same Site

If the organics causing the THMs are not derived from the water producing formation installing a new production well at the site of the old well is an option. McAllister Drilling Inc. was contacted and an estimated cost of $20,000 was provided for installing a new 127 mm well to a depth of 37 m and for a 24 hour pump test (Add $10,000 for Clifton Supervision and Licencing Report). Tie-in of this well to the existing pump house (Add $15,000). However, if the water bearing formation the well is currently completed in is the source of the organics, this will not help. Should this be an option the Hamlet wishes to pursue a detailed cost estimate for drilling and engineering services will be provided.

2.1.2 Exploration Program and Production Well at a New Location

If the water bearing formation the current well is completed in is the source of the organics responsible for the THMs the Hamlet may wish to consider sourcing a new water supply. The Rex Valley Aquifer has been mapped in close proximity to the Hamlet at an approximate depth of 85 m below ground surface. A drilling estimate was obtained from McAllister Drilling Inc. for conducting a test drilling program. The estimate was based on drilling and installing three test wells (piezometers) and one 127 mm production well to a depth of 85 m, as well as a 24 hour pump test. The estimated cost for drilling was $40,000 (Add $15,000 for Clifton services). Should this be an option the Hamlet wishes to pursue, a detailed cost estimate for drilling and engineering services will be provided.

3.0 Water Demand

The Hamlet is uncertain with respect to its future growth objectives and consequently historical water use data from the document "Saskatchewan Community Water Use Records, 1996 to 2011", Report No. 24 and recent WTP records were referred to achieve demand for treated water.

Table 3.1 - Historical Water Use

Year	Population	Total for Year m^3	Average Day m^3	Peak Day m^3	Treated Water	
					Peak Day Factor	Per Capita
2010	50	11,055	30	92	3.04	605
2009	50	11,529	32	110	3.48	631
2008	50	7,003	19	49	2.55	384
2007	50	7,918	22	NA	NA	433
2006	50	9,632	26	59	2.24	527

Note: NA = Not available

Table 3.1 – Historical Water Use - presents data from the above records. For the years 2006 to 2010 population is assumed to be 50 residents. During this timeframe average data water use had steadily increased to 11,055 m^3 per year. At this level of water demand the per capita water use is 605 litres per capita day (LPCD). For communities of comparable population, LPCD consumption is about half of the Hamlet. Since the Hamlet does not meter its users, the high LPCD may explain why water use is double.

The Hamlet reports that 43 water bills are sent out monthly. Further, the Hamlet estimates its population at 120 residents. Assuming an annual flow of 12,000 m^3, and using a population of 120 residents, the per capita consumption of 273 is more reasonable.

4.0 Water Quality

Water quality data is shown in Table 4.1 with supporting documentation in Appendix B. Two types of water are identified: raw water and treated water. The two data sets are almost identical even though separated by almost nine years. It is possible the 2006 data is actually "treated". If this is the case, then the treatment process is remarkably similar given the span of time between the tests.

Table 4.1 Water Quality

Description Analysis	Units	Raw Water	Distributed Water		Saskatchewan		
		6-Jan-06 Results	16-Mar-15 Results	16-Dec-13 Results	MAC (mg/L)	IMAC (mg/L)	AO (mg/L)
Bicarbonate	mg/L	866	848	837			No Guideline
Calcium	mg/L	77	76	77			No Guideline
Carbonate	mg/L	<1	0	0			No Guideline
Chloride	mg/L	81	72.7	89			250
Hydroxide	mg/L	<1	0	0			No Guideline
Magnesium	mg/L	36	37	37			200
pH	pH units	8.18	8.1	8.1			6.5 to 9.0
Potassium	mg/L	7.5	7.0	8.0			No Guideline
Sodium	mg/L	258	250	278			300
Specific conductivity	uS/cm	1400	1562	1629			No Guideline
Sulfate	mg/L	100	107.7	106			500
Total Alkalinity	mg/L	710	695	686			500
Total Hardness	mg/L	340	342	345			800
Nitrate	mg/L	0.26	<0.2	2.4	45		
Aluminum	mg/L	0.0031	0.0044		No Guideline		
Arsenic	ug/L	2.5	2.4	3.4		0.025	
Barium	mg/L	0.075	0.057	0.020			
Boron	mg/L	0.37	0.4	0.4		5	
Cadmium	mg/L	<0.0005	<0.00056	0.00056	0.005		
Chromium	mg/L	<0.005	<0.0001	<0.0001	0.05		
Copper	mg/L	<0.0002	0.00271	0.0098	No Guideline		

Table 4.1 - Water Quality (Continued)

Description Analysis	Units	Raw Water	Distributed Water		Saskatchewan		
		6-Jan-06 Results	16-Mar-15 Results	16-Dec-13 Results	MAC (mg/L)	IMAC (mg/L)	AO (mg/L)
Iron	mg/L	3.1	2.5	0.1	No Guideline		
Lead	mg/L	0.0001	0.0009	0.0001	0.01		
Manganese	mg/L	0.07	0.06	0.02			0.05
Selenium	mg/L	<0.0001	0.00096	0.00096			0.01
Uranium	ug/L	0.2	0.3	0.3	20		
Zinc	mg/L	<0.005	0.0176	0.0045			5
Floride	mg/L	0.34	0.28		15		
Total Dissolved Solids	mg/L	993	1399				1500

Note:

MAC = Maximum Acceptable Concentration

IMAC = Interim Maximum Acceptable Concentration

AO = Aesthetic Objectives

Data from the WTP records for iron and manganese are recorded in Table 4.2.

Table 4.2 - Iron and Manganese

	2014 (mg/L)	2015 (mg/L)
Iron	0.01 – 0.21	0.11 – 0.23
Manganese	0.037 – 0.94	0.044 – 0.16

5.0 Alternative Disinfection

Sodium Hypochlorite (chlorine disinfection) is the most simple, reliable and common approach to disinfection in Saskatchewan. WTP operators have access to training and maintenance resources and are well positioned to source support for sodium hypochlorite dosing systems. Other disinfection options exist in Saskatchewan.

5.1 Chlorine Dioxide

Chlorine dioxide has been used as a drinking water disinfectant around the world. It is a proven and effective disinfectant for ***Giardia Lamblia*** and ***Cryptosporidium*** parasites, for bacteria and viruses and performs in a manner to reduce formation of harmful halogenated disinfection by-products such as trihalomethomes and halogenated acetic acids. At the same time chlorine dioxide for drinking water can form by-products chlorite and chlorate introducing the requirement for their monitoring.

Should consideration be given to adopting Chlorine Dioxide into the WTP, considerations should be given to the following:

- An engineer stamped plan is required to identifying minimum and maximum dose rates with estimated chlorite and chlorate levels, a Concentration-Time calculation and start up plan describing chemical adjustments needed and routine requirements as per Section 1 of "A Guide to Water Works Design EPB201".
- Small scale trials are required before installing chlorine dioxide. The interaction of chlorine dioxide is to include evaluation of oxidizails like iron and manganese. Not all water supplies are a suitable candidate for chlorine dioxide.
- Switching from chlorine to chlorine dioxide can result in discolored water, taste and odor issues. Gradual introduction of chlorine dioxide is recommended.
- Occupational Health and Safety (OH&S) issues with chlorine dioxide must be addressed. The Saskatchewan workplace contamination limit for chlorine dioxide in air is 0.28 mg/m^3 for an 8 hour average and 0.83 mg/m^3 for a 15 minute average. The owner, designer and operator must ensure OH&S requirements are met.

5.2 Ozone

Ozone is used in drinking water for disinfection as well as taste and odor control. Ozone is a strong oxidant that can inactivate microorganisms including Cryptosporidium, Gardia and viruses, and also oxidize ad break down organic matter. Ozone reacts quickly with organic and inorganic constituents and does not maintain a residual in water for a significant period of time. For this reason disinfection by ozone must be followed by a secondary disinfectant such as chlorine, chloramine or chlorine dioxide.

6.0 Existing Water Treatment Plant - Compliance

The existing WTP process flow diagram is provided in Appendix A. The process flow diagram (PFD) illustrates raw water entering the facility, dosing with an oxidant, potassium permanganate (KM_nO_4), aeration, filtration and disinfection with another oxidant, sodium hypochlorite (NaClO).

Presently the WTP is in compliance with drinking water standards (other than THM levels).

The operating data shown in Appendix B (see handwritten records) identifies raw water use, oxidant dosing, disinfectant dosing, free and total chlorine, and turbidity readings. Operating data for the WTP (other than THM levels) or turbidity and disinfection levels are in compliance with regulatory standards.

One operational note identified during the plant visit and identified in the operating data, is the unexplained consequence of cleaning the aerator. On 09 December 2014, the aerator was taken out-of-service and cleaned of extraneous matter. The aerator has functioned as an aerator and dosing point for KM_nO_4. After clean-up of the aerator turbidity levels increased from a range of 0.32-0.61 NTU, September 2014 to 0.50-84 NTU February 2015, and 0.51-0.96 March 2015. While this data is very preliminary and lacks month to month comparison, it may demonstrate [as per plant data for two years data] a consequence of the aerator cleaning.

Turbidity is an important indicator of water treatment process efficiency from a health and aesthetic consideration. Compliance with turbidity standards is a requirement for permitted operation. For groundwater plants turbidity levels must be less than 1.0 NTU in 95% of discrete measurements.

Backwashing the filter more frequently since December 2014 is identified as another shift in operating practise. The pressure filter discharges for an extended period of time (up to one hour) and does not run fully clear. Typical backwash duration is 15-20 minutes during which initial flow is very dark in color with the final flow lacking color.

7.0 Plant Upgrade

The new plant introduces an opportunity to design for future growth. According to the Hamlet, 43 water bills are provided to residents each month. It is considered that 120 residents receive treated water from the Greenstreet plant. Accepting the suppliers design flow of 333 litres per capita per day (LPCD), the following water demand is presented.

Users	LCPD	Average Day Demand (m^3)	Peak Day	Annual Average Demand (m^3)
120	333	40	110	14,600

The supplier providing the budget quotation used an average day of 40 m^3 and peak day of 100 m^3.

Clifton recognizes the supplier's report as part of the assessment and findings are to indicate an order of magnitude cost. For example, a projection of 10 year population growth is required to adequately establish water demand for design.

Wastewater disposal costs should be considered in the plant pre-design. Depending upon the design flow up to 30% of flow from a membrane water treatment plant enters the wastewater distribution system.

The supplier's quotation is provided by Anderson Pump House Ltd. (APH) and included in Appendix C. Their staff is familiar with the Greenstreet water treatment system. Three documents from APH are attached describing an initial site visit, costs for piloting pre-treatment systems and a membrane system upgrade.

The quotation dated 23 July 2015 provides a comprehensive upgrade of the water system from the existing supply well (using raw water combining THM precursors), through pre-treatment and treatment and finally post treatment with pH adjustment. APH base their quotation on its knowledge of the existing water treatment plant. Their quotation is a budget quotation.

An engineering pre-design of the system will introduce a greater level of detail and invite an updated submission of APH's revised quotation should the Hamlet proceed with this upgrade.

8.0 Options to Address THM Levels

As identified earlier, the Greenstreet raw water supply is subject to a THM precursor that when disinfected with chlorine produce THMs in the potable water distributed to the Hamlet.

In the following paragraphs three options are discussed with respect to re-establishing regulatory compliance: upgrade water supply, employ other disinfectants and thirdly replace the existing treatment equipment with membrane technology. In the next section costs attributed to each activity are stated.

8.1 Upgrade Water Supply

As identified earlier in this report, the Greenstreet raw water supply is subject to a THM precursor that when disinfected with chlorine produce THMs in the potable water distributed to the Hamlet.

8.1.1 Upgrade Water Supply – New Well at Site

Based on our field investigation and background review of well information, the first action is to test water at the existing supply well and observation well. If the supply well is found to be free of THM precursors then testing may not be identifying THM precursors and further testing abandoned.

If a THM precursor is not identified in the observation well, a new well could be drilled and supply the plant and be expected to operate within regulatory standards.

Operating and Maintenance costs are anticipated to remain constant. Operator Certification is not anticipated. Risk to this approach is that the new well may be fine at first but with time be THM precursors could migrate into the water bearing strata.

8.1.2 Upgrade Water Supply – New Well at Site to be Determined

If THM precursors are found at the existing supply well and observation well, a new raw water supply is an option. Locating a new well site involves an exploratory effort and the uncertainty and cost of establishing a new location. Should a new site be identified, testing for THM precursors is recommended. Upon confirming raw water quality and supply new well infrastructure and tie-in to the water treatment plant follows. Because the site is selected based upon water quality and available quantity, the distance to the water treatment plant is unknown.

When a new well site is determined, an accurate cost to develop the well, the well infrastructure and raw supply can be developed.

Operating and Maintenance costs are expected to increase slightly depending upon length of the raw supply line. Operator Certification upgrade is not required. Risk to this approach is the additional length and cost of the raw supply line. The presence of coal and potentially THM precursors must also be taken into account.

8.1.3 Other Disinfection

A study is required by regulatory authorities to establish viability and suitability for certain water treatment chemicals. Some chemicals require special storage and dosing equipment. Confirming the suitability, viability and functionality of a chemical system demands an engineering assessment and design.

In Saskatchewan very few communities employ special chemical dosing systems, in particular, with low water use needs.

Operations and Maintenance costs are anticipated to be greater than with the present system. More rigorous handling and safety practices are to be expected and possibly higher operator certification required.

Risk with proceeding ahead with studying and piloting of other chemical disinfectants is that monies expended may be lost if piloting results are negative.

8.1.4 Process Upgrade to RO – Pilot Pre-Treatment

Reverse osmosis membrane systems are proven in municipal application and used throughout Saskatchewan in recent years. Such systems produce high quality water yet require more maintenance and operation effort and therefore incur greater costs.

Protecting membranes and extending membrane life is to be considered. Piloting of the pre-treatment systems can increase knowledge of the raw water supply and equipment requirements. Appendix C includes supplier quotation for piloting the raw water with two pre-treatment scenarios: one using an anti-scalant system and one with a coagulant system.

Operator effort is required to support the piloting effort as it may require a month to gather data and assess each pre-treatment system.

The risk attributed to piloting may be expressed in the cost expenditure. If there is no piloting then there is no cost. The risk of not piloting is loss of opportunity to evaluate the optional pre-treatment system therein identifying the better system.

8.1.5 Process Upgrade to RO – System Upgrade

Upgrading the water treatment plant will introduce the requirement to provide water during construction. Demolition of the existing plant is required along with upgrade of the electrical system.

Once available for construction, the new system can be installed. Clifton and the supplier consider the proposed equipment upgrade to fit within the building footprint based upon water supply considerations developed in the supplier quotation.

The upgraded facility as outlined in the supplier quotation will provide 40 m^3 average day flows. Before proceeding, the Hamlet should complete a pre-design report. This document will establish a clear basis for the future plant.

Operations and Maintenance efforts will increase as will operating costs. Operator certification upgrade should be anticipated.

Risks attributed to installing an RO system are very manageable and therefore considered low given engineering design and control.

9.0 Capital

In this section conceptual costs for capital, operating and maintenance costs are developed, based on the findings in this assessment.

9.1 Upgraded Water Supply

9.1.1 New Well at Existing Site

Table 9.1 - New Well at Existing Site

Item	Cost ($)
Water Testing	3,000
Drill New Well	30,000
Tie-in New Well	15,000
Sub-Total	48,000
Engineering @ 15%	7,200
Contingency @ 30%	16,560
Total Estimate	72,000

9.1.2 New Well at Site to be Determined

- Tie-in new site to water treatment plant, estimated cost of $200,000 per km for new raw supply line.

Table 9.2 - New Well at Site to be Determined

Item	Cost ($)
Exploratory Drilling	45,000
New Supply Well	45,000
Water Testing	3,000
Tie-in New Well	200,000
Sub-Total	293,000
Engineering @ 15%	43,950
Contingency @ 30%	87,900
Total Estimate	425,000

9.2 Other Disinfection

Table 9.3 - Other Disinfection

Item	Cost ($)
Assess Alternative Chemical	10,000
Pilot	30,000
Regulatory Approval	5,000
Total Estimate	45,000

9.3 Process Upgrade to RO

9.3.1 Pilot Pre-Treatment

Table 9.4 - Pilot Pre-Treatment

Item	Cost ($)
Pilot	28,500
Engineering @ 5%	1,500
Contingency @ 5%	1,500
Total Estimate	32,000

9.3.2 RO Upgrade

Table 9.5 - RO Upgrade

Item	Cost ($)
New Water Treatment Process Upgrade	200,000
Demolition	20,000
Electrical	20,000
Sub-Total	240,000
Engineering @ 15%	36,000
Contingency @ 30%	82,800
Total Estimate	359,000

9.4 Assessment Matrix

Table 9.6 - Assessment Matrix

Item	Cost ($)	Risk	Recommended
New Well (Existing Site)	72,000	Moderate - If water quality initially okay, could be subject to coal bed effects with time.	No
New Well (New Site)	425,000	Moderate - Length of new supply line unknown. New well could be subject to coal bed effects with time.	No
Alternative Disinfectant	32,000	Alternative disinfectants very seldom used. Cost is for pilot only. Additional costs for equipment unknown.	No
RO Pre-Treatment Pilot	43,000	Low - Undertaking pilot will lower long term membrane replacement costs, lower pre-treatment if anti-scalant recommended.	Yes
RO Upgrade	359,000	Low - RO technology will provide high quality water	Yes

10.0 Conclusions

The following conclusions are provided to identify aspects of the report:

- The existing raw water supply contains THM precursors from undetermined sources.
- The organic matter is passing through the existing WTP and reacting with chlorine to produce THM's.
- Testing the existing well and observation well for THM precursors will confirm one or both wells have THM precursors.
- Relocating the raw water supply to another location will entail an exploratory program and additional supply line costs.
- Other disinfection methods such as ozone and chlorine dioxide can reduce THM formation, yet are not considered suitable for this situation.
- A membrane treatment system is a proven method for removal of organics that contribute to the formation of THM's.
- Lack of water meters in homes contributes to higher than average water use.

11.0 Recommendations

Clifton recommends that the Hamlet pursue the following:

- Install water meter in homes.
- Fully disconnect raw supply lines from three wells no longer in service but currently connected to WTP (valves in lines are closed).
- Undertake a Pilot Program to assess the pre-treatment regime.
- Retrofit of the existing WTP process with an RO Membrane system.

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Association of Professional
Engineers and Geoscientists of Saskatchewan
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