City of Brandon

Water Utility Master Plan - FINAL

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

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60275081

Date:

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AECOM: 2012-01-06

AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com

204 477 5381 tel
204 284 2040 fax

October 27, 2015

Patrick Pulak, P. Eng.
Deputy Director of Engineering Services & Water Resources
City of Brandon
P.O. Box 960 410 – 9th Street

Dear Mr. Pulak

Project No: 60275081.500

Regarding: Water Utility Master Plan - FINALFinal

AECOM is pleased to submit our Final copy of the Water Utility Master Plan. This report was first issued as draft in October 2013. We have incorporated comments received from the City to the draft report and included recommendations obtained from the 2015 tour of on-site sodium hypochlorite systems.

We trust that you will find this in order and look forward to discussing any comments you may have.

Sincerely,
AECOM Canada Ltd.

Keith Sears

Keith Sears, Ph.D., P.Eng.
Project Manager

KS:CU:td
Encl.
cc:

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AECOM Signatures

Report Prepared By:

Keith Sears, Ph.D., P.Eng.
Project Manager

Report Reviewed By:

S.R.(Ray) Bilevicius, M.A.Sc., P.Eng.
Associate Vice-President, Operations Manager, Manitoba Water

List of Abbreviations

AB	Alberta
ADA	Assiniboine Delta Aquifer
ALARA	As low as reasonably possible
Alum	Aluminum sulphate
AO	Aesthetic objective
AOC	Assimilable organic carbon
ARVA	Assiniboine River Valley Aquifer
ASCF	Action Spectra Correction Factors
Avg	Average
BAC	Biologically activated carbon
BCA	Brandon Channel Aquifer
c	Capita
$CaCO_3$	Calcium carbonate
CDW	Committee of Drinking Water
CIP	Clean-in-place
cm^2	Square centimetre
CSA	Canadian Standards Association
d	Day
DBP(s)	Disinfection By-Product(s)
DOC	Dissolved organic carbon
DWI	Drinking Water Inspectorate
EC	European Commission
GAC	Granular activated carbon
GCDWQ	Guidelines for Canadian Drinking Water Quality
GUDI	Groundwater under the direct influence (of surface water)
GW	Groundwater
h	Hour
HAA(s)	Haloacetic Acids
hp	Horsepower
HVAC	Heating, ventilation and air conditioning
kg	Kilogram
km	Kilometre
$KMnO_4$	Potassium permanganate
kPa	Kilopascal
KPI(s)	Key Performance Indicator(s)
kW	Kilowatt
kWh	Kilowatt-hour
L	Litres
m	Metre
M	Million
m^2	Square metre
m^3	Cubic metre
MAC	Maximum acceptable concentration
Max	Maximum
MB	Manitoba
MCA	Multi-criteria analysis

MF	Microfiltration
mg	Milligram
Min	Minimum
mJ	Millijoule
ML	Megalitres per day
mm	Millimetres
Mt	Megatonne
MWWTP	Municipal Wastewater Treatment Plant
N	Nitrogen
N/A	Not available
NaOCl	Sodium Hypochlorite
NBCC	National Building Code of Canada
NDMA	*n*-Nitrosodimethylamine
NF	Nanofiltration
NH_4OH	Aqua ammonia
NOM	Natural organic matter
NTU	Nephelometric turbidity unit
O&M	Operation and Maintenance
OFWAT	Office of Water Services
OG	Operational guidance
ON	Ontario
PAC	Powdered activated carbon
RM	Rural municipality
RO	Reverse osmosis
RSSCTs	Rapid small-scale column tests
s	Second
SW	Surface water
TBL	Triple Bottom Line
TDS	Total dissolved solids
THM(s)	Trihalomethane(s)
TM	Technical Memorandum
TOC	Total organic carbon
TTHM	Total trihalomethanes
UF	Ultrafiltration
UK	United Kingdom
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
WHO	World Health Organization
WRF	Water Reclamation Facility
WTP	Water Treatment Plant
µg	Microgram

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1. Introduction

1.1 Overview

The City of Brandon retained AECOM to develop a Master Plan for its water utility, with the goal of developing a roadmap to guide operation, maintenance and upgrades, now and into the future.

While this Master Plan will outline a process to develop the City's water utility over the long-term, some of the existing infrastructure at the Water Treatment Plant (WTP) will be in need of replacement or major upgrade in the next five years. Selected upgrades will need to align with future water demands, which will drive the need to make decisions for the longer term. The Master Plan will therefore be used as a tool to address short-term needs while achieving long-term objectives.

1.1.1 Water Supply

Currently, the WTP obtains a majority of its water from the Assiniboine River, which has historically been able to meet water demands. As with many surface waters, the raw water exhibits a high level of organics, turbidity and colour throughout the year. During flooding events in 2011, the proximity of the WTP to the Assiniboine River also exposed potential vulnerabilities of the WTP to rising river levels.

Developing new water sources may enhance treated water quality and offer greater reliability on overall supply. Many of the long term upgrade decisions rely on the characteristics of the source water, such as the selection of treatment upgrades and siting of the future WTP. Development of new water supplies may include monitoring potential water sources and upgrading the existing intake structure. The potential for industrial facilities to utilize the City's highly treated wastewater effluent in exchange for groundwater rights will also be detailed in this Master Plan.

1.1.2 Water Treatment

Current treatment at the WTP consists of coagulation, softening, filtration, and disinfection processes. While the plant is operated effectively by the City, much of the existing infrastructure is in decline, requiring immediate repair or replacement. It may be no longer desirable or realistic to continue to maintain some of this equipment; changing treated water quality standards, technological developments, and economic considerations could help determine when that point is reached.

The existing plant has a number of issues that also affect operability and operator/community safety. These include the use of chlorine gas without air scrubbing, aging chemical feed systems and limited spill containment. Many of these issues will be addressed in the short-term through the construction of a chemical storage facility, streamlining chemical handling operations.

Existing treatment processes do not remove a sufficient amount of organic material from the raw water, resulting in the pronounced formation of Disinfection By-Products (DBPs) in the water supply. This may be addressed through use of alternative treatment technologies, or through the selection of raw water sources with low organics content.

New research and changing water quality regulations will also have an impact on the ultimate selection of treatment processes. Emerging contaminants of concern such as pharmaceuticals, pesticides and herbicides may necessitate the use of new treatment processes such as granular activated carbon filtration or membrane filtration. Ongoing studies suggest that current operational target of medium-pressure UV disinfection may not be sufficient to achieve sufficient *Cryptosporidium* removal, which may require reassessing the operation of the UV reactors installed at the WTP.

1.2 Objectives

This Master Plan is intended to provide the water utility a roadmap for the future upgrades and decisions that will be experienced in the short term (<5 years) and the long term (>5 years). This will allow the City to be in a good position to make decisions that will provide reliable water services and meet service requirements in an economically efficient manner.

As the future raw water quality is uncertain, the Master Plan must focus on the short-term needs. This is done with full recognition that in the near term, the major plant expansions decisions will be made. Short-term decisions will involve improving chemical handling and safety around the WTP, and implementing high priority code and condition improvements in the WTP. If Provincial/Federal funding becomes available, short term improvements will also address disinfection by-product related issues.

Other changes that will affect the long-term future of the water utility may include new regulatory requirements, changes in water consumption, changes in stakeholder expectations and new fiscal constraints. As such, the Master plan will serve as a living document that will be continually updated to meet the needs of the City.

2. Existing Water Treatment Plant

2.1 Overview

Raw water is drawn from the Assiniboine River by means of an intake and pumping station located on the river bank a few hundred metres from the WTP. An oval pipeline conveys raw water to a low lift pump station located within the WTP. Potassium permanganate ($KMnO_4$) and powdered activated carbon are added to the raw water to control tastes and odours that often develop during the summer months.

Aluminum sulphate and ferric sulphate are added to the water in the feed lines to before clarification to allow for turbidity removal. Lime, soda ash, and polymer are added in the clarifiers for water softening.

Settled water from the clarifiers passes through recarbonation chambers, where carbon dioxide is added to reduce the pH and stabilize the water. If necessary, powdered activated carbon may be added in the recarbonation chambers for additional taste and odour control.

Effluent from the recarbonation chambers is filtered, chlorinated, fluoridated then stored in treated water reservoirs before being pumped to the distribution system. Treated water is then subjected to UV disinfection processes as it leaves the WTP.

Backwash and blowdown wastes are discharged into a common sewer. A sludge pump station collects solids from this sewer and conveys them to a thickener in the WTP. Thickened solids are further dewatered via belt filter presses and then hauled to landfill/agricultural fields. Supernatant is discharged back into the Assiniboine River.

2.2 Existing Facilities

The existing Brandon WTP consists of three interconnected building units, commonly referred to as Plant 1, Plant 2, and Plant 3. The general layout of the WTP is shown in **Figure 2.1**.

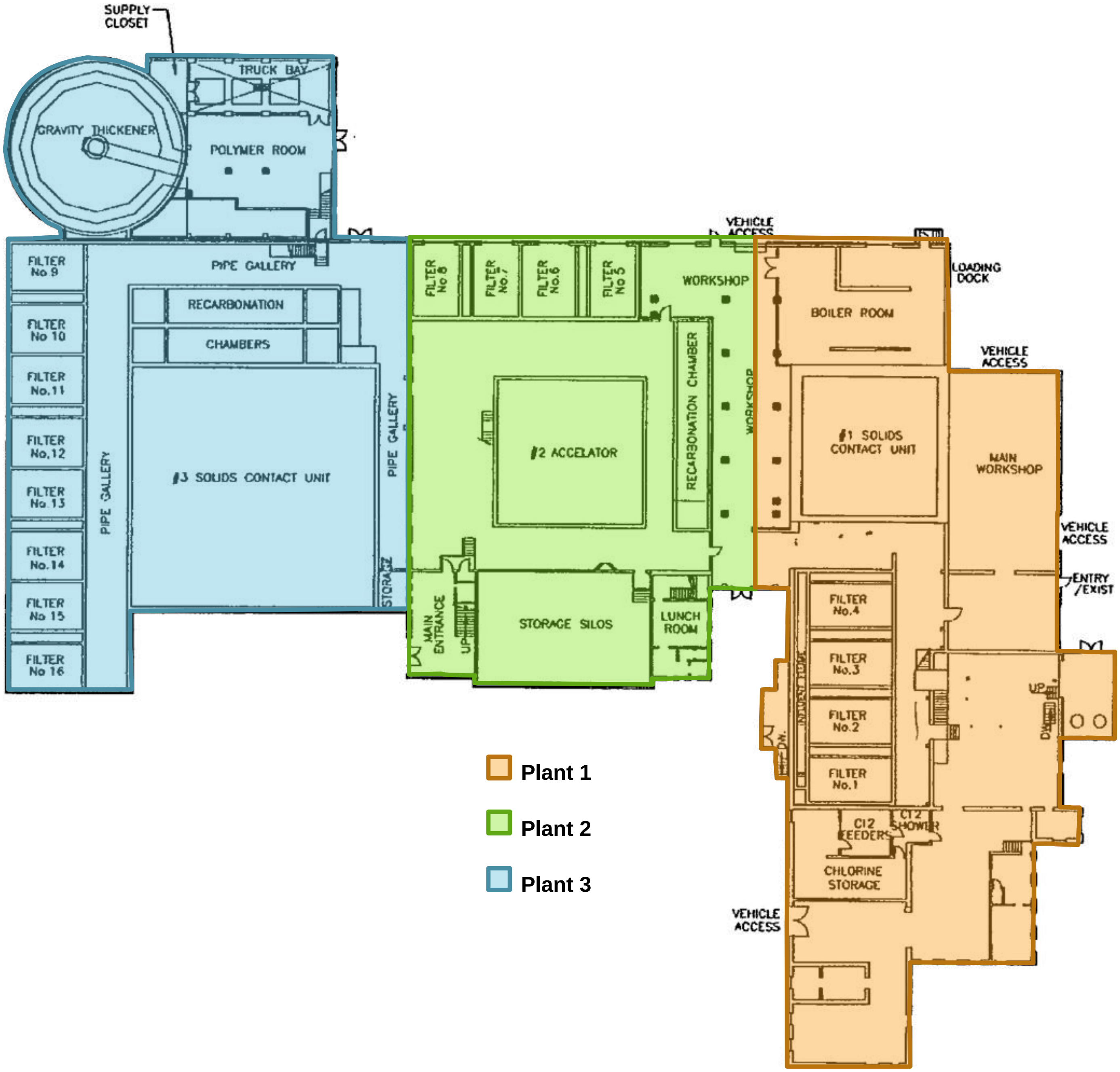


Figure 2.1: Existing WTP Layout (City of Brandon Engineering Department, 2000)

- **Plant 1** was constructed in the 1940's and has a nominal design capacity of 13.6 ML/d. The main components of the plant consist of a Hydrotreater solids contact clarifier, four rapid gravity filters, and auxiliary systems such as chemical feeders.
- **Plant 2** was constructed in the 1950's and has a nominal design capacity of 13.6 ML/d. Main process components include an Accelator solids contact clarifier, a recarbonation system (shared with Plant 1), additional chemical feed facilities, and four rapid gravity filters.

- **Plant 3**, was constructed in the 1970's and has a nominal design capacity of 27.2 ML/d. The main process components are a Graver solids contact clarifier, additional recarbonation facilities, eight rapid gravity filters, and additional chemical feed systems.

Under normal conditions, Plant 3 operates alone for most of the year and has sufficient capacity to meet the City's current treated water demands. Each year, Plant 3 is shut down for the month of January to allow routine maintenance procedures to be carried out. Plants 1 and 2 are used during that time, as well as during other times of the year if operation is disrupted in Plant 3.

2.2.1 System Capacity

Various definitions of the capacity of a water supply system exist. In general, a WTP must be able to supply the maximum average daily demand of the distribution system. Shorter-term peak demands such as the peak instantaneous rate are usually provided from treated water reservoir storage at the plant or in the distribution system.

A particularly important consideration in most situations is the *firm* or *reliable* capacity of a water supply system. Perhaps the most commonly-used definition of firm capacity is the capacity of the system with the largest unit out of service.

While the concept appears simple, if blindly applied it can lead to somewhat misleading interpretations. The firm capacity of the Brandon water supply system, for example, could be regarded as zero because only a single raw water line feeds the plant. However, the low probability of failure of this line should be taken into account when discussing the firm capacity of the water supply system as a whole. On the other hand, it could also indicate that consideration should be given to twinning the line. Clearly, the need for some discretion and common sense is needed; but the concept of firm capacity is a real and useful one. It will be used, with qualifying comments where appropriate, in the following discussion.

2.2.2 Raw Water System

The primary source of water for the City is the Assiniboine River. The Assiniboine River Valley Aquifer (ARVA) serves as a secondary raw water source when water quality in the river water is low.

The withdrawal from the River is governed by the Province of Manitoba which allows the City to divert up to 14,808,000 m^3 annually at a maximum withdrawal rate of 0.59 m^3/s. Supplemental raw groundwater supply comes from two wells that draw from the ARVA; the Turtle Crossing Park Well and the Canada Games Park Well. The Turtle Crossing Park Well was constructed in 1996 and has an estimated capacity of 190 L/s. The Canada Games Park well was constructed in the same year, and has a slightly lower estimated capacity of 189 L/s.

On average, the City's raw water consumption was relatively steady between 2000 and 2012. The average raw water use ranged between about 8,051,000 m^3 and 8,928,000 m^3 per year. Most years, all of this water was drawn from the Assiniboine River, with the exception of 2009, 2011, and 2012 when the raw water wells supplied 146,000 m^3, 443,000 m^3, and 1,485,640 m^3 respectively. **Figure 2.2** illustrates the total raw water consumption by the City of Brandon between 2000 and 2012. The use of the raw water wells has increased because the City has begun blending groundwater into the river water in an effort to help reduce DBPs.

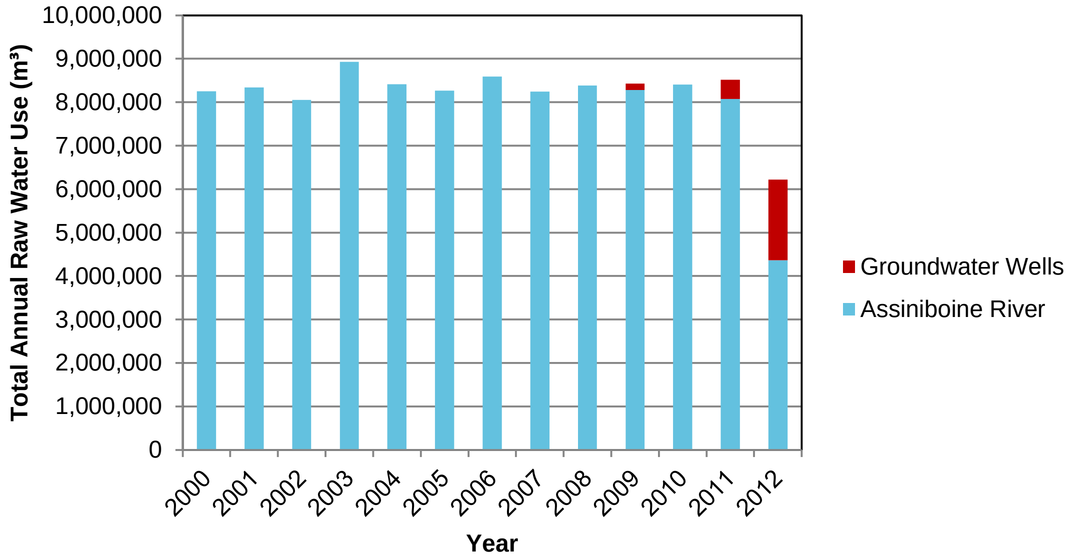


Figure 2.2: Raw Water Consumption (2000-2012)

The Assiniboine River level is controlled by the Shellmouth Dam, located north of Russell, Manitoba and the 3rd Street Dam located in the City. The City owns and maintains the 3rd Street Dam in order to set water levels at the intake structure based on the level in the river. The 3rd Street Dam forms a critical element in the water treatment process; without it, sufficient river water would not be able to be conveyed to the WTP. For this reason, the City upgraded the 3rd Street Dam in 2012, as it had been showing signs of structural defects.

The intake structure was constructed in the 1940's and is comprised of screens and gates that allow collection of water from varying depths in the Assiniboine River. As part of the City's commitment to provide long term and sustainable drinking water for its citizens, it initiated an assessment of the existing intake structure in 2012. The assessment determined that the intake structure had some immediate issues such as being located in a flood zone, where excess sediment buildup in and around the structure caused equipment damage and flow restriction (CH2M Hill, 2012a). Structural issues found with the intake and gates. The gates were also found to no longer seal properly. The assessment report made reference to the river depth as being shallow at the intake and ice cover (estimated to be 900 mm thick) or frazzle ice was found to develop around the structure, causing a flow restriction.

Raw water flows into the intake wells through four gates located in the intake structure on the river's edge. After the gates, water flows into two separate intake chambers and enters into a central wet well via 1.5 m diameter pipes. From the wet well, water is conveyed in a 290 m long oval reinforced concrete pipe to the low lift pump station at the WTP. The low lift pump station is comprised of five pumps rated between 227 L/s and 417 L/s. With the largest pump out of service, the firm pumping capacity is 1,098 L/s (95 ML/d), which is sufficient for the design year flows.

In 2012, the City initiated the development of various intake structure layouts for use in future detailed designs (CH2M Hill, 2012b). The recommended intake design involving the use of a settling pond that would retain raw water collected from Assiniboine River for a period of about 3 days. The 3-day retention time would help reduce the amount of sediment entering the WTP and also provide emergency water storage during low river levels. Water from the settling pond would be conveyed to the WTP through gravity drainage.

2.2.3 Clarifiers

2.2.3.1 Clarifier Parameters

At the Brandon WTP, the most significant process units to consider when determining the overall plant capacity are the clarifiers and the filters. The primary dimensions and main operating parameters for the clarifiers are shown in **Table 2.1**.

Table 2.1: Clarifier Parameters

Description	Plant 1	Plant 2	Plant 3
Nominal rated flow, ML/d	13.6	13.6	27.2
Nominal rated flow, m^3/h	568	568	1135
Clarifier top dimensions, m	12.19 x 12.19	12.80 x 12.80	21.34 x 21.34
Centre baffle dimensions, m	0.91 dia.	4.88 x 4.88	7.62 dia.
Total surface area, m	148.6	163.8	455.2
Centre baffle area, m^2	0.65	23.8	45.6
Net settling area, m^2	148.0	140.0	409.6
Hydraulic loading rate, m/h	3.8	4.1	2.8

The basic function of a clarifier is to remove the solids formed during coagulation, softening, or other treatment processes. The WTP uses solids contact-type clarifiers. In this type of design, the water flows through a bed of previously-formed solids in the bottom of the unit. This assists in removal of fine solid particles, so a somewhat higher treatment capacity can be achieved for a given size of unit compared to some other types.

In general, solids contact systems are well suited to softening applications, in which the floc formed separates easily from the water and settles relatively quickly. These systems are less suited to processes such as alum coagulation, which produce a lighter, less settlable floc.

The most important single parameter in the operation of a gravity settler is the hydraulic loading rate, often called the ‘rise rate’. The rise rate is equal to the flow rate per unit area of clarifier surface, often expressed as cubic metres per hour (of flow) per square metre (of clarifier surface), or simply as metres per hour. This is equivalent to a vertical velocity in the clarifier, and gives some idea of which particles will settle to the bottom and be removed, and which will be carried over with the water leaving the unit.

The acceptable rise rates for a clarifier depends on many factors, including the type of floc, its settling rate, the water temperature, and the configuration of the clarifier. Generally, rise rates of between 1 and 2 m/hr are regarded as “typical” for separation of alum-type floc and about double these rates for softening applications.

As indicated in **Table 2.1**, the rise rates at design flows for Plants 1 and 2 are towards the upper end of the 2 to 4 m/h range, which is commonly used for softening applications; the rise rate for Plant 3 is in the mid-range.

2.2.3.2 Combined Clarification and Softening

Coagulation for turbidity and organics removal with aluminum sulphate, the chemical most commonly used for this purpose, is most efficient at relatively low pH values—typically in the range of about 6 to 7. Softening requires a much higher pH values, usually between 10 and 12. Because of these different operating conditions, many plants separate the two processes—turbidity and organics removal is carried out first in one process unit, then softening in a separate, second unit. By separating the two processes, each can be optimized to give the best quality treated water and minimum chemical consumption.

Because of the high capital cost of the equipment involved in these processes, it is tempting to combine them and carry out both simultaneously in the same process unit. This has been done in thousands of units all over the world, and there is no doubt that it can be made to work reasonably well—as has been done at the Brandon WTP. However, it must be realized that this type of system is a compromise, used to reduce capital costs.

After lime softening, water passes through recarbonation chambers to stabilize the softened water and remove residual calcium carbonate precipitated after pH adjustment. This process helps eliminate any solids precipitation post-filtration.

2.2.4 Filters

The primary dimensions and main operating parameters for the filters at the Brandon plant are shown in **Table 2.2**. All 16 filters are normally used, regardless of which clarifiers are in service, and the nominal flow rate is 27.2 ML/d. The filters are all of the rapid-gravity type, with pre-treated water draining through the filter media by way of gravity. Filtered water is collected by an underdrain system within each filter, which is then sent to the reservoir for disinfection and distribution.

Particle removal in the filters is governed by a process known as *depth filtration*, wherein suspended particles that travel though the filter bed adhere to the surface of the granular media or attach to previously retained particles. After a period of time, the accumulation of particulate matter in the filter bed increases the head loss from the filters and eventually leads to increased turbidity. To maintain treatment performance, treated water is regularly backwashed upwards through the filter bed, removing captured particulate matter, which is then directed to waste. Each filter is equipped with a turbidity meter to monitor performance.

The hydraulic loading rate (HLR) of a filter is a design criteria that dictates the volume of water treated with a given surface area of filter media, measured as m/h. The design HLRs of typical rapid-rate granular media filters fall between 5-30 m/h; the filters in the WTP operate near the lower end of this range.

Table 2.2: Filter Parameters

Description	Plant 1	Plant 2	Plant 3
Nominal rated flow, ML/d	13.6	13.6	27.2
Nominal rated flow, m^3/h	568	568	1135
Number of filters	4	4	8
Dimensions of each filter, m	8.33 x 4.06	4.27 x 6.40	4.27 x 6.40
Area of each filter, m^2	33.82	27.33	27.33
Total filter area, m^2	135.3	109.3	218.6
Hydraulic loading rate, m/h	4.2	5.2	5.2

2.2.5 Reservoir Storage and High Lift Pumps

Treated water leaving the filters enters one of three clearwells located under either Plant 1, 2 or 3. Water then travels through a baffled, circular reservoir before heading to the High Lift Pump wetwell for fluoridation and chlorination. The water is then either pumped directly to the distribution system, or to the transfer pump system for conveyance to the 9th Street Reservoir. All treated water passes through one of two UV disinfection systems as it leaves the WTP.

From as-built data, the reservoirs at the WTP were calculated to have a combined capacity of approximately 5.0 ML, assuming total usable water depth of 3.0 m. However, drawdown tests performed by the City staff determined the combined reservoir capacity to be 3.3 ML and the usable depth to be 2.1 m. The 9th Street Reservoir provides an additional 18.2 ML storage, for a total storage capacity of 21.5 ML. Other reservoirs across the City, such as the Brandon Water Tower, have been decommissioned.

The 2011 average water demand for both industrial and residential sources is approximately 21.7 ML/d, which is above the total available reservoir capacity; an expansion of total reservoir capacity may be required as part of future upgrades. Current and future water demands are discussed further in Section 3.

The City relies on two vertical turbine pumps (referred to as 'High Lift Pumps') at the WTP to convey water to the distribution system and/or the 9th Street Reservoir. A summary of the High Lift Pump capacities is presented in **Table 2.3**. A transfer pump system located within the WTP also allows direct conveyance of treated water to the 9th Street Reservoir. The transfer pump system consists of two pumps, each with a capacity of 158 L/s.

Table 2.3: Summary of High Lift Pump Capacities

Pump #	Type	Pump Capacity, each (L/s)
11, 12	Vertical Turbine	315

Figure 2.3: High Lift Pump #2

2.2.6 Disinfection

2.2.6.1 Chlorination

Water is chlorinated by injecting chlorine gas at the High Lift Pumps wetwell. This provides treated water with a disinfectant residual within the distribution system. Chlorine gas is fed from 9 one-tonne tanks located in a storage room in Plant 1. A chlorine gas detector is nearby to warn personnel of chlorine leaks, although no chlorine scrubbing units are available to remove excess chlorine gas in the event of a gas leak. Two chlorine feeders provide 225 kg/day, a third one provides 180 kg/day and a fourth providing 100 kg/day capacity.

Figure 2.4: 1-Tonne Chlorine Storage Tanks

2.2.6.2 UV Disinfection

Plant 1 has one inline UV reactor to disinfect treated water heading to the 9th Street Reservoir. The lack of redundancy at this location may present a problem if the reactor is taken offline for any reason. Plant 2 has two UV reactors to disinfect water heading directly to the distribution system. Some degree of redundancy is available at this location. This system is shared by Plant 3.

Both UV reactors in Plant 2 are Sentinel UV reactors manufactured by the Calgon Carbon Corporation, as shown in **Figure 2.5**. Each reactor has eight 4.5 kW mercury lamps, each oriented at right angles to the incoming water flow.

Figure 2.5: UV Disinfection Reactor

Although the UV disinfection system is working within the mandated guidelines, there has been some new research that suggests that the presently accepted UV dosages for *Cryptosporidium* inactivation from medium pressure reactors may be too low. Recent studies have indicated that indictor organisms use to evaluate UV reactor performance, such as the MS2 phage, can be inactivated much more easily by UV disinfection than previous studies have shown. While the UV disinfection system is presently operating at currently accepted performance standards, these standards may become more stringent in the near future.

2.2.7 Distribution System

A majority of the City distribution system is composed of PVC piping (>60%) and ductile iron. Other forms of piping include polyethylene, cast iron, and asbestos cement. As piping is replaced in the distribution system, PVC pipe installed, reducing the potential for metallic corrosion throughout the distribution system.

In order to maintain water pressure and meet water demands throughout the City, the distribution system is supplemented by four booster stations. A summary of the booster stations and their respective pumping capacities is presented in **Table 2.4**.

Table 2.4: Summary of Booster Station Pump Capacities (AECOM, 2008)

Location	Number of Pumps	Pump Capacity, each (L/s)	Station Capacity (ML/d)
9th Street Reservoir	4	158	41
1st Street Booster Station	3	55	14.25
16th Street Booster Station	3	55	14.25
13th Street Booster Station	3	82.5	31.4
	1	116	
34th Street Booster Station	3	82.5	31.4
	1	116	

Note:The 9th street reservoir has 4 pumps, 3 duty + 1 standby. Capacity is 3x158 l/s = 41 ML/d.

2.2.8 Process Wastes

Process wastes from a conventional WTP such as the one at Brandon consist mainly of clarifier blowdown and backwash waste water. The volume of these wastes as a percentage of the raw water flow will vary depending on the water characteristics and the types of processes used; 5 to 10% of the total flow is generally considered a reasonable range for most plants.

Table 2.5 is based on current water data provided from the City, and represent annual averages from 2007 through to 2012.

Table 2.5: Water and Process Waste Volumes for 2007 - 2012

Description	Megalitres Per Year	% of Raw Water
Raw water volume	7,892	100
Treated water volume	7,391	94
Filter backwash wastes	222	3
General in-plant use	187	2

The volume of backwash wastes, as a percentage of raw water volume, is low by normal standards and, assuming the figures are correct, probably cannot be reduced significantly.

The value of 2% for “general in-plant use” is made up of clarifier blowdown, belt filter press usage and general plant processes; based on current flow data provided by the City. The total process waste of 5% is within the typical acceptable range.

The City began to separately track the flow usage for the belt filter press and backwash from the ‘general in plant’ use in 2006. A breakdown of the process flows is not available prior to 2006. This would have stemmed from the installation of the new dewatering equipment at the WTP.

The raw sludge pump station is comprised of a sump and two submersible slurry pumps (one duty, one standby) rated at 40 L/s each. The raw sludge pumps discharge into a gravity thickener. The thickener is sized to store up to 16 hours of sludge at peak conditions of 3,200 m^3/d (48,000 kg as dry solids). From the thickener, thickened sludge (10-15 percent solids) is conveyed to belt filter presses via progressive cavity pumps; each with a capacity of 10 L/s. There are two 2 m belt filter presses designed to process a maximum of 5,200 kg dry solids per hour each. The overall sizing was set for assumed future plant flows of 54 ML/d (summer) and 27 ML/d (winter). It is assumed that some expansion may be needed in the future.

2.2.9 Chemical Systems

Overall, the WTP chemical systems are not very operator friendly. These systems are spread throughout the three Plants, requiring unnecessary chemical handling. Recent upgrades to these chemical feed systems included level controls; however, most of these systems are over 30-years old and are difficult to maintain even though they have proven to be very reliable.

Each treatment train has its own dedicated chemical handling and feed systems, and multiple chemical storage locations across the WTP. While this setup allows for simultaneous chemical deliveries, it requires complex chemical handling and conveyance procedures to meet process needs.

There is no dedicated chemical storage area with proper environmental controls, safety equipment, and containment. Chemicals are stored in drums and totes throughout the plant. A chemical spill could be inconvenient at best and catastrophic at worst. "Portable" eyewashes appear to be generously distributed throughout the facility in areas where the containers are stored. This addresses some of the immediate hazards to personnel, but not the environment (i.e., no spill containment).

2.2.9.1 Potassium Permanganate

Potassium permanganate ($KMnO_4$) is dosed at the raw water intake to maximize the oxidation of organics. The $KMnO_4$ chemical feed system is located near the raw water intake in a separate shed and is within the 1:300 year flood boundary. Due to its current location and limited storage space, the $KMnO_4$ is stored in pails at the WTP and has to be transported to the shed daily. Plugging of the chemical feeder occurs as the $KMnO_4$ powder “clumps” due to high humidity. Challenges occurred during the 2011 flooding when the operators could not access the feed system due to the high water levels.

The $KMnO_4$ feed equipment is in good condition and reliably provides chemical to the intake when required. However, the system does lack more common ancillaries such as dust control, calibration columns and standby equipment. $KMnO_4$ storage is approximately 757 L.

2.2.9.2 Powdered Activated Carbon

The plant has multiple Powdered Activated Carbon (PAC) feeding units located in Plant 1 and Plant 3. PAC is fed to the raw water intake in Plant 1 at the low lift pumps and can also be added to the recarbonation chambers if necessary for additional taste and odour control.

A large amount of manual labour is required to offload bags and load the carbon feeding systems. Hundreds of 25 kg bags require offloading into storage, along with daily loading of the carbon hoppers. Total PAC storage at the WTP is indeterminate, though it is likely several tonnes of product can be stored within the WTP at any given time, as shown in **Figure 2.6**. The average chemical consumption and dosages of pre-treatment chemicals are shown in **Table 2.6**.

Figure 2.6: PAC Storage

Table 2.6: Average Daily Consumption and Dosages of Pre-treatment Chemicals

Year	Consumption (kg)		Dose (mg/L)	
	PAC	$KMnO_4$	PAC	$KMnO_4$
2007	66.6	11.1	2.9	0.5
2008	27.2	8.7	1.1	0.4
2009	67.1	12.4	2.8	0.5
2010	53.9	14.7	2.2	0.6
2011	24.1	0.0	1.0	0.0
2012	14.2	0.0	0.6	0.0

2.2.9.3 Aluminum Sulphate and Ferric Sulphate

Alum is dosed into the feed lines before each solids contact unit to start the coagulation process. The alum feed system consists of two bulk storage tanks located in Plant 3 with metering pumps to feed the three plants. Previously, the bulk storage of alum was provided by a wood-lined tank, which has since been decommissioned.

Ferric sulphate is added directly into the to the solid contact units to aid in coagulation. Typically, the ferric sulphate solution is added in the summer months.

2.2.9.4 Lime and Soda Ash

Bulk quantities of lime and soda ash are stored in silos located in Plant 2 (shown in **Figure 2.7**), with a total storage capacity of 220 Mt for each chemical. The lime slaking process currently in use is the only one suitable for the varying quality of the product received. A lime slurry system is more effective for the treatment process, but needs a consistently high quality product which is not presently available. The average chemical consumption and dosages of the main coagulation and softening chemicals are shown in **Table 2.7**.

While the lime and soda ash silos are being filled, replenishing the feed systems throughout the WTP is not possible. A load takes hours to discharge, meaning that on delivery days, the in-plant feed systems may not be used if they run out of chemical.

Figure 2.7: Lime/Soda Ash Silos

Table 2.7: Average Daily Consumption and Dosages of Main Coagulation/Softening Chemicals

Year	Consumption (kg)				Dose (mg/L)			
	Alum	Ferric Sulphate	Lime	Soda Ash	Alum	Ferric Sulphate	Lime	Soda Ash
2007	1,999.9	138.6	4,636.0	1,189.3	89.5	6.2	207.0	54.9
2008	1,991.0	105.0	4,972.3	1,182.9	87.3	4.6	218.4	53.5
2009	2,318.0	114.3	5,170.8	1,061.1	100.9	5.1	223.9	47.7
2010	2,407.7	63.2	5,835.6	1,858.7	104.9	2.8	253.6	83.3
2011	2,498.4	35.6	7,424.3	1,637.6	108.4	1.5	318.9	72.8
2012	1,996.7	45.5	7,246.3	1,670.0	88.5	1.9	317.4	75.3

2.2.9.5 Coagulation Polymers, Coagulation Aids

Polymer is added to the solids contact units to aid in the coagulation process. The polymer solution is batched and then is transferred to a nearby day tank, from which the chemical feed pumps draw solution. Polymer is fed from an array of pumps in the Plant 3 lower level and is fed year-round. Coagulant aids are also added to the solids contact units on a seasonal basis to improve treatment performance.

Figure 2.8: Polymer Room Equipment

2.2.9.6 Filtration Aids

Filter aids such as SternPAC are dosed after the solids contact units to improve the performance of the downstream rapid-gravity filters. Such filtration aids are added on a seasonal basis and can be provided in standard 200 L (55 gal) drums, as shown in **Figure 2.9**. The average chemical consumption and dosages of polymer and other coagulation/filtration additives are shown in **Table 2.8**.

Figure 2.9: Sternpac Barrel

Table 2.8: Average Daily Consumption and Dosages of Polymer and Additives

Year	Consumption (kg)				Dose (mg/L)			
	Polymer	Coagulant Aids	Filter Aids	CatFloc	Polymer	Coagulant Aids	Filter Aids	CatFloc
2007	3.4	4.3	6.8	1.8	0.2	0.2	0.3	0.1
2008	3.4	2.3	6.9	1.3	0.2	0.1	0.3	0.1
2009	3.6	5.6	13.0	3.7	0.2	0.3	0.6	0.2
2010	3.3	4.7	22.9	5.8	0.1	0.2	1.0	0.3
2011	5.0	1.3	3.9	1.1	0.2	0.1	0.2	0.1
2012	2.8	3.8	2.6	0.5	0.1	0.2	0.1	0.0

2.2.9.7 Carbon Dioxide

Re-carbonation using carbon dioxide is practiced downstream of the softening treatment process and upstream of the filters. Bulk storage of carbon dioxide is kept outside of the WTP, to the south of Plant 3, as shown in **Figure 2.10**. Carbon dioxide is fed from the bulk storage tank into carbon dioxide feeders, which lead to submerged diffusers in the three recarbonation basins; one basin is located in Plant 2 to treat water from Plant 1 and Plant 2; two basins are located in Plant 3 to treat water from this plant alone.

Figure 2.10: Carbon Dioxide Storage Tank

2.2.9.8 Fluoride

Treated water is fluoridated after filtration in order to reduce the incidence of tooth decay of end users. Fluoridation of is conducted through the use of sodium silicoflouride powder, which is dosed upstream of the High Lift Pump wetwell. The feed system consists of a bag loader and solution tank which is used to create a saturated fluoride solution for dosing into the wetwell. Total storage for sodium silicoflouride is approximately 2500 kg. (dry 25kg bags x 100 bags storage)

The average chemical consumption and dosages of post-softening chemicals are shown in **Table 2.9**.

Table 2.9: Average Daily Consumption and Dosages of Post-Softening Chemicals

Year	Consumption (kg)			Dose (mg/L)		
	CO_2	Chlorine	Fluoride	CO_2	Chlorine	Fluoride
2007	708.0	110.1	27.5	32.0	5.0	1.3
2008	647.3	107.2	32.0	28.8	4.8	1.4
2009	714.5	123.5	30.1	31.4	5.6	1.4
2010	776.9	136.3	23.1	34.5	6.1	1.1
2011	851.5	139.7	27.8	37.4	6.5	1.3
2012	909.7	149.0	21.3	40.4	6.9	1.0

2.2.9.9 Sludge Dewatering Polymers

The sludge dewatering systems uses a cationic and an anionic polymer for dewatering. The chemical feed system consists of two dry polymer makeup systems and two liquid polymer makeup systems. The dry polymer feed system consists of two dry polymer feeders that mix polymer with water into a feed tank before use. The liquid polymer feed system consists of a two bulk tanks containing neat polymer, which also mixes polymer with water into a feed tank before use.

Blended polymer is stored in two feed tanks; one for the anionic and cationic polymer. The blended polymer is then transferred from the storage feed tanks to the process using four progressive cavity metering pumps. Anionic polymer is fed to the belt press feed line downstream of the thickened sludge pumps; cationic polymer is fed to a mixing tank on the belt filter press feed line.

The sludge dewatering facility is operated five days a week. Approximately use of cationic and anionic polymers are 5 tonnes/year and 11 tonnes/year, respectively.

2.3 Code and Condition Assessment

Most of the equipment at the Brandon WTP is between 30 and 60 years old. The fact that almost all of equipment remains fully functional—and in fact is used on a regular basis—is a tribute to the conscientious operational and maintenance procedures that have been carried out over the years and which continue today.

At some point, it becomes no longer desirable or realistic to continue to maintain and operate old equipment. Changing treated water quality standards, technological developments, and economic considerations all play a part in determining when that point is reached. The primary objective of conducting the code and condition assessment is to assess what existing infrastructure could be retained as part of future upgrades and equipment should be considered for decommissioning.

There are a number of methods available to determine the condition of infrastructure assets. The approach used in this work follows the UK Office of Water Services (OFWAT) rating system for non-linear assets (surface assets such as treatment facilities, sludge treatment facilities and buildings), which rates the condition of assets according to a five-point grading scheme, as shown in **Table 2.10**.

Table 2.10: OFWAT Condition Grades for Wastewater/Water Plant and Equipment

Condition Grades	Description
Condition Grade 1	Sound modern structure, operable and well-maintained.
Condition Grade 2	As 1, but showing some minor signs of deterioration. Routine refurbishment and maintenance required.
Condition Grade 3	Functionally sound, but appearance significantly affected by deterioration, structure is marginal in its capacity to prevent leakage, mechanical and electrical plant and components function adequately but with some reduced efficiency and minor failures.
Condition Grade 4	Deterioration has a significant effect on performance of asset due to leakage or other structural problems. Mechanical and electrical plant and components function but require significant maintenance to remain operational.
Condition Grade 5	Serious structural problems having a detrimental effect on the performance of the asset. Will require major overhaul/replacement of the asset in the short term.

This standard can be effectively utilized on a range of facilities and can be applied consistently to future iterations of the OFWAT model.

Since asset condition only makes up a portion of the reinvestment decision, it is also important that asset risk be taken into account. For example, some assets can be allowed to fail without serious ramifications, while other asset failures may result in catastrophic damage, and even jeopardize public health and safety. To ensure that risk is factored into the asset replacement decision, a risk rating for mechanical, structural and electrical assets were applied, as shown in **Table 2.11.**

Table 2.11: Risk Rating Criteria for Asset Management Planning Purposes

Risk Grade	Risk Level	Category	Definition
1	No Risk	Environmental	No risk
		Public Safety	No risk
		Workers Safety	No risk
		Equipment	No risk
		Process	Plant running below design capacity and 100% redundancy available
2	Minimal Risk	Environmental	Minor site only
		Public Safety	No risk
		Workers Safety	No risk
		Equipment	Minor repairs, no new parts necessary
		Process	100% redundancy available
3	Low Risk	Environmental	Minor, local area
		Public Safety	No risk
		Workers Safety	No risk
		Equipment	Repairs and new parts necessary
		Process	Backup available, between 99% and 25% redundancy available
4	High Risk	Environmental	Major, large area affected
		Public Safety	Possible risk
		Workers Safety	Minor injury
		Equipment	Necessary to replace equipment
		Process	Reduced capacity or <25% redundancy available
5	Extreme Risk	Environmental	Environmental disaster
		Public Safety	High risk of injury
		Workers Safety	Major injury or death
		Equipment	Entire process to be replaced
		Process	Equipment currently running over design capacity with no redundancy

The assessment is grouped by technical discipline as follows:

- Architectural;
- Structural;
- HVAC Mechanical;
- Electrical and Instrumentation; and
- Process Mechanical.

The Architectural assessment was a building code evaluation, while the Process Mechanical, Structural, HVAC Mechanical, Electrical, and Instrumentation sections evaluated the related equipment in each process area.

2.3.1 Overall Risk Assessment

On September 17, 2012, an AECOM team made up of members representing each technical discipline conducted the general code and condition assessment at the City of Brandon WTP. The assessment was performed on major equipment, buildings, tank and utilities, including mechanical and HVAC systems, instrumentation and electrical subsystems. A summary of the findings are provided below for each of the Plant areas. Complete details of the code and condition assessment including associated costs for each Plant area can be found in **Appendix A**.

Plant 1 would require significant upgrades to meet the National Building Code of Canada (NBCC) life safety and mechanical codes. For an un-insulated building of this age and construction type it is expected that significant challenges will be encountered. From a structural perspective, the Plant area can be characterized as in 'fair' condition. Ongoing repairs and maintenance can be expected on the building as well as the mechanical system. With regard to process, issues related to UV disinfection redundancy (with only one UV reactor in place in Plant 1) and the use of gas chlorination are significant items of concern. A significant electrical finding was the main incoming power feeder cable which enters Plant 1 is a single point of failure with no redundancy in place.

Plant 2 also requires upgrades to meet the NBCC life safety and mechanical codes. Additional exits, a fire sprinkler system, and work to the main staircase are recommended. From a structural perspective, the area is in fair to good condition. Cost associated with constructing a new chemical storage and handling facility for the lime and soda ash make up the majority of the process component and the total costs.

Structurally, Plant 3 is in good condition, including the condition of the concrete tanks. An analysis of the existing roof is recommended to determine if the structure meets the current building code. Major process items that should be addressed include filter piping, found to have localized corrosion, and chemical storage.

2.3.2 Process Risk Assessment

For the most part, the process equipment appeared in good shape and could potentially be used for another 5 to 10 years. Inadequacies within the system were found to be mostly safety related.

- **Dust:** The lime and soda ash silo room is thick with dust.
- **Chemical storage:** Dedicated area(s) with proper containment are required, along with other safety items such as ventilation and adequate decontamination devices (eyewash, showers).
- **Chemical handling:** Totes delivered in 25 kg bags need to be moved to the areas where they are immediately needed. There are three separate preparation and feed systems throughout the building, further complicating chemical handling requirements.
- **Redundancy of UV in Plant 1:** No bypass available or redundant unit.
- **Adequacy of UV Disinfection:** Present research may be re-examining the generally accepted dose rates and indicator organisms used for potable water disinfection using medium pressure reactors. If either of these parameters are changed at a regulatory level, the effectiveness of present systems may need to be re-evaluated.
- **Chlorination:** While the process components appear to be in good condition, other elements have been found noncompliant with present codes. Even if these are addressed, a gas chlorination system in a populated area presents major risk to residents and staff, and it should be replaced a safer chlorination alternative, such as the use of liquid sodium hypochlorite or on-site hypochlorite generation.

Table 2.12 summarizes the process risks that were identified during the assessment for each of the plant areas as well as the associated risks.

Table 2.12: Process Risk Assessment

Area	Condition	Risk	Category	Description
UV Disinfection 1		5	Process (no redundancy)	New UV reactor, new piping
UV Disinfection 2		2	Process	No major repairs appear to be needed
UV Disinfection 3	N/A			
Pipes	1 - 3	2-3	Equipment (localised corrosion; no visible leaks but structural effects unknown)	Assume replacement of about 20-25% of the piping
Chlorination	2 - 3	5	Worker safety, public safety, environmental	Replace with alternate system
		4	Equipment (hoist may be damaged)	Repair hoist
Silos		5	Worker safety (extreme dust levels)	New ventilation/dust collection
		4-5	Process (on-site systems can't be replenished while silos are being filled)	
Lime & Soda Ash	1-2	4	Worker Safety (excessive manual materials handling)	New centralized chemical storage and handling
Pumps	1	1-2	Process	No major repairs appear to be needed
SC Tank 1	1	1	Equipment (recently replaced)	No major repairs appear to be needed
SC Tank 2	2-3	3	Equipment (localised corrosion and some reported perforations and leaks)	Localized repairs
SC Tank 3	1	1	Equipment (in-service, visible components appeared OK)	No major repairs appear to be needed
Filters Plant 1	1	1	Equipment (in-service, visible components appeared OK)	No major repairs appear to be needed
Filters Plant 2	1	1	Equipment (in-service, visible components appeared adequate. Exception: pipes and valves have a high level of corrosion. Repairs on piping indicate wall thickness minimal, limiting the ability to repair pipes through welding.	Piping and valves should be replaced.
Filters Plant 3	1	1	Equipment (in-service, visible components appeared OK).Note: Water Treatment staff discovered when the filters are out of service; a significant amount of sand had intruded into the plenums in 3 of the filter cells. Concrete erosion around the strainers is evident.	Water treatment staff has performed some recent repairs and they are monitoring the situation for potential reoccurrences.
Raw Water Well	2	4	Environmental (open grating can overflow at high river levels)	
		1-2	Equipment	No major repairs appear to be needed

Area	Condition	Risk	Category	Description
Polymer			Present system is 'temporary'	Cost included as part of new centralized storage and handling
Alum			Not centralized	Cost included as part of new centralized storage and handling
Thickener	2	2	Equipment	No major repairs appear to be needed
Dewatering	2	2	Equipment	
Chemical Storage	N/A	4	Worker safety (No or limited permanent showers/eyewashes)	Cost included as part of new centralized storage and handling
	N/A	4	Environmental (no dedicated area with spill containment)	Cost included as part of new centralized storage and handling

N/A=Not available

Table 2.13 provides a summary outlining the risk grade and expected cost to bring the existing facility to code and meet the noted safety concerns for each plant area. Some costs would be incurred in plant areas through further inspections or excavations. These are shown as “Other” in the Risk Grade column for each plant area. As the upgrades required in the areas for the Risk Grade level 1, 2 and 3 were ‘nominal’ relative to the summation of the Higher Risk grades 4 and 5, it was agreed during the workshop held on May 21, 2013 that they also be included in the short-term plan.

Table 2.13: Risk Assessment Totals by Plant Area and Risk Grade

Risk Grade	Plant 1	Plant 2	Plant 3	Lime Sludge Dewatering	Total
1	$ 0	$ 103,000	$ 0	$ 0	**$ 103,000**
2	$ 175,000	$ 13,000	$ 10,000	$ 0	**$ 198,000**
3	$ 857,000	$ 400,000	$ 242,000	$ 17,000	**$ 1,516,000**
4	$ 4,663,000	$ 2,892,000	$ 72,000	$ 1,000	**$ 7,628,000**
5	$2,123,000	$ 852,000	$ 788,000	$ 10,000	**$ 3,773,000**
Other	$ 0	$ 22,000	$ 10,000	$ 10,000	**$ 42,000**
Total	**$ 7,818,000**	**$ 4,282,000**	**$ 1,122,000**	**$38,000**	**$ 13,260,000**

2.4 Benchmarking Data Review

In December 2012, AECOM completed a Technical Memorandum (TM) on the Water Utility Performance Measurement for the City of Brandon’s Water Utility Master Plan. This memorandum outlines a comprehensive utility performance management program consisting of a range of carefully selected Key Performance Indicators (KPIs) that can be used not only to monitor the achievements of the City’s core utility goals over time but also to enable a process of benchmarking them amongst other water utilities for the purpose of identifying and implementing Best Practices. The complete TM can be found in **Appendix B**.

The implementation of a Best Practice-based KPI program can be considered an investment in that the City will benefit from in the coming years as the Master Plan becomes fully implemented. According to the *CSA Plus 4010 Technical Guide* (Canadian Standards Association, 2009):

"Water utility managers can use a Best Practice-based KPI program for a number of purposes:

- *Identify strengths and weaknesses within the utility;*
- *Improve water quality and availability;*
- *Investigate the need for changes or corrective action to improve procedures and productivity;*
- *Monitor the effect of change;*
- *Measure resource use;*
- *Provide key information to support proactive decision making, and*
- *Facilitate benchmarking – both internally and externally.*

In this way, utility managers can continuously improve their systems and services."

2.4.1 Water Utility Performance Measurement Framework

Water utilities can conduct performance measurement at many levels within their organization. Individual performance measures can be directed to measure the attainment of management processes, service standards, work practices, program/project delivery approaches, technical standards, process performance, or cost targets. A framework to organize and arrange performance indicators is required to begin the process of agreeing on a standard and consistent suite of utility management related performance indicators. These aspects can generally be categorised into three levels for the evaluation and application of performance measurement and benchmarking:

- the management level;
- the intermediate level; and
- the functional level.

Like most Canadian water utilities, Brandon's water utility is owned by the municipality. The owners are represented by Brandon City Council on behalf of the residents of the City. In order to be successful, the utility manager must have a clear understanding of what the "owner" wants to accomplish and how the infrastructure service can contribute to that owner's success. While providing clean and safe drinking water is the core goal of the utility, there are a range of conditions that the utility is responsible for while meeting this goal. For example, water rates must be reasonable, the service must be reliable, and that the services must be provided in an environmentally responsible manner.

As a first step, the utility managers should confirm their organization's goals, and check them for alignment with those of the owner. In turn, each division of the infrastructure organization should set its own goals to align with the higher-level direction. This is not a one-time effort. Rather, the process should incorporate regular checks to ensure that activities can be, and are seen to be clearly addressing the owner's needs and priorities.

Managers should establish their goals through comprehensive discussions with key stakeholders such as politicians, regulatory agencies, industry, interest groups and the general public. At first, this process could reveal significantly different points-of-view. However, through consultation and involvement, stakeholders can generally reach consensus, providing a strong focus for the management process.

Once set, these goals should be relevant in the medium to long term and provide the basis for decision-making. However, as individuals change at the political or management level, the emphasis on particular goals may also change. As a result, infrastructure managers should stay attuned to the changing environment in terms of political and public opinion. This will help managers fine-tune their approach and priorities and stay aligned with the conditions of the day.

2.4.2 Water Utility Goals

Over the past decade, generic water utility goals have become well documented through a range of Best Practice guidance. The two Canadian standards are closely related:

The *CSA Plus 4010 Technical Guide* (Canadian Standards Association, 2009) sets the main goals as the following:

- Protecting public health;
- Meeting user needs and expectations;
- Providing service under normal and emergency situations;
- Sustaining the water utility;
- Promoting the sustainable development of the community; and
- Protecting the environment.

A variation of the goals stated within the *CSA Technical Guid*e forms the foundation of the National Water and Wastewater Benchmarking Initiative, where the goals are stated as:

- Provide reliable water services;
- Provide sufficient capacity to enable planned community growth;
- Meet service requirements in an economically efficient manner;
- Protect public health and safety;
- Provide a safe and productive workplace;
- Have satisfied and informed customers; and
- Protect the environment and minimize environmental impacts.

Even though these goals may seem self-evident to utility managers, it is vital that the entire organization including key stakeholders within senior City management have an opportunity to review and confirm goals as relevant and important. Each goal will require resources to attain. If the goal is not seen as important, resources can be deployed elsewhere in the utility.

2.4.3 Elements of the Utility Management Model

Following the affirmation of a statement of vision that describes what the organization is setting out to achieve, the Utility Performance Management model typically includes:

- **Goals:** Confirmed goals are documented as the highest level of organization ends. This is what the utility is mandated to achieve.

- **Key Performance Measures:** KPIs measure the progress of individual goal attainment. Performance measures describe “when you've reached your goal". If the goal has been reached, further investment in this goal may not be necessary. If certain goals always fall short, this provides guidance for future resource allocation.
- **Strategies:** In order to improve the attainment of an individual goal, strategies must be identified and implemented. A strategy is an action or approach that can be taken in order to achieve the associated goal. Once the strategy is implemented, the effectiveness of the strategy must be measurable by the respective performance measure. Of course, achievement of the parent goal and improved operations is the desired end result. Improvement strategies can be changed to prevent or correct problems or deficiencies, to emulate best practices, or to implement innovation.
- **On-Going Measurement (Benchmarking):** Finally, ongoing benchmarking should be utilized to continually provide current and accurate feedback regarding the outcome of strategies. Successful strategies will have the effect of improving performance, while unsuccessful strategies may not have the desired effects. With timely feedback, managers can insure that the correct selection of strategies is in place to ensure continuous improvement is occurring from year to year.

2.4.4 Recommendations

The Utility Performance Measurement TM (**Appendix B**) provides background information as a primer for a Best Practice-based water utility performance management system that includes utility goal confirmation, KPI selection and ultimately, continuous improvement through benchmarking. It is recognized that it will take some time to establish an effective performance management program so this effort should be seen as an investment. Since the City of Brandon is beginning to advance its Water Master Plan, it is recommended that the City begin efforts in implementing a performance management system that will help measure the results of the Master Planning effort in the coming years. The information that is consolidated from a utility management model can be used to guide the introduction of new capital investments in clear association with goal needs. In addition to assisting utility management and staff, this information can also help communicate the utility strategies to City stakeholders and water utility customers. Experience has demonstrated that if customers fully understand the level of service implications on new investments in their water utilities, they are more inclined to support the investment with higher water rates.

Should Brandon want to commence a performance measure program in association with the Water Master Plan, the following is recommended at starting efforts:

1. **Begin internal discussion and communication relating to appropriate water utility goals:** The goals form the foundation of performance measurement effort. It is highly likely that the City of Brandon’s water utility goals will be very similar to those of other Canadian water utilities, but it is important to review and confirm goals before taking the next steps.
2. **Begin advancing a range of Management Level performance indicators to support goal measurement:** Most important performance indicators have been identified in this TM but the full range may not be required to support the implementation of the Master Water Plan. It is recommended that Brandon start simply and advance to higher levels of detail as needed over time.
3. **Begin identifying current and potential data sources for populating the individual performance indicators**: This process could take a number of annual iterations before it is complete. Data accuracy is an important factor, as staff need to have confidence in the level of service indicator results in order to respond proactively. Our experience has shown the current data source may include some corporate data bases, but it is highly likely that some key data is stored in a range of spreadsheets that does not form part of the formal data management system within the City. It is also likely that key data is still being managed at the personal level within the collective knowledge of senior operations and maintenance staff. Unless this data can be documented, utilities are at risk of losing this important information as senior staff retire.

3. Decision Making Process

As the roadmap for the Master Plan is developed, decisions will need to be made which impact the overall direction of the Water Utility. A systematic, step-wise method for making decisions is necessary to focus and clarify decision-making.

The primary objective of this section is to present a Triple Bottom Line (TBL) Decision-Making Framework that will be used throughout the Master Plan to guide decision-making. Decisions regarding water source selection, WTP siting and chlorination method were evaluated using this process. Refer to **Appendix C** for the TBL Decision Making Framework TM.

3.1 Triple Bottom Line

The TBL model is a common and valuable instrument for assessing sustainability issues as it integrates the three classic pillars of sustainability - economic viability, environmental protection and social responsibility. In its broadest sense, TBL modeling embraces the set of interests, issues and processes that human activity should address in order to create economic, social and environmental value while at the same time minimizing undesirable consequences. The term triple bottom line was first coined by John Elkington in 1999 in his publication "*Cannibals with Forks: The Triple Bottom Line of 21st Century Business*".

At the local government level, the TBL model is widely used in the planning stages of environmental and water/wastewater programs and projects. Several Canadian municipalities have used this approach, including Regina, Saskatoon, Calgary, Vancouver and Toronto.

Although the TBL model is commonly used in local government to assist in decision-making, there is no *de facto* industry standard for applying the model. Melbourne Water has published a set of guidelines for applying a TBL framework for assessing project options. Guidelines have also been presented by the Cooperative Research Center for Catchment Hydrology for Urban Stormwater Management Measures to Improve Waterway Health (Taylor, 2005).

Notwithstanding the lack of a generally accepted industry standard, the TBL frameworks used at the local government level have several common features, including the use of multi-criteria analysis (MCA) and the method of weighted summation for scoring and ranking options.

3.1.1 Benefits of TBL

TBL assessment methodologies using MCA can be used to determine which option, among a set of options, best meets a project's objectives, where these objectives incorporate economic, environmental and social elements. In some cases, these objectives can be clearly aligned with widely accepted objectives and principles for sustainable development, so that the assessment system can be used as a broad indicator of the relative progress of the various options towards the goal of sustainable development.

Potential benefits of using a TBL approach to evaluate options are as follows (Taylor, 2005):

- The framework can help to ensure an organization's visions, values and actions/projects are consistent with each other.
- The process can help to improve stakeholder relations through open communication channels and participation techniques, as well as greater transparency and accountability.
- The process can help improve communication pathways within organizations by involving various functional groups or disciplines.

- The process can be designed to utilize and share the knowledge and views of technical experts as well as non-technical stakeholders, including the general public.
- The use of a TBL assessment process involving MCA can assist with making more systematic, informed, holistic, participatory, transparent, multidisciplinary, defendable, socially acceptable, ecologically sustainable and cost-effective decisions.
- TBL assessment process can encourage innovation as new ideas are put forward in finding sustainable solutions.
- A TBL framework can allow ‘good governance’ by public organizations. Through their mandates in economic and social development, various agencies of the United Nations broadly recognize the characteristics of ‘good governance’ as participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follow the rule of law.

3.1.2 Limitations of TBL

The weaknesses that have been identified of the TBL assessment process are as follows:

- The TBL selection process may become complex if many assessment criteria and/or stakeholders are involved.
- There is no guarantee of a ‘sustainable’ outcome.

As the many benefits of the TBL assessment process outweigh these limitations, the TBL model is continually being used in industry for decision-making.

3.2 Proposed Decision Making Framework

3.2.1 Proposed Approach

The proposed approach for the Master Plan is to follow the methodology as described in the Melbourne Water guidelines with the Multi-Criteria Analysis enhanced evaluation technique (Melbourne Water, 2007).

The proposed approach is presented in **Figure 3.1**. The steps of the process are outlined in sub-sections 3.2.2 to 3.2.4 that follow.

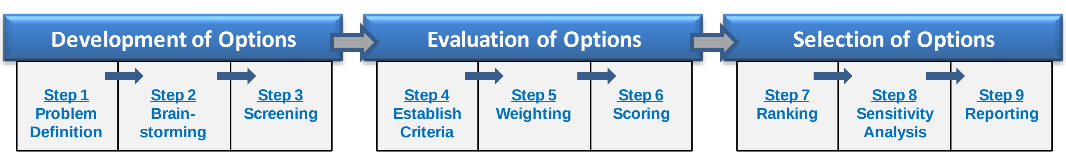


Figure 3.1: Proposed Decision Making Process

3.2.2 Development of Options (Steps 1 to 3)

3.2.2.1 Step 1 - Problem Definition

The first step will be to identify the objectives and issues.

At the project kickoff meeting held on September 7, 2012 with the City, some ideas of a successful project outcome were discussed. These items included the following:

- Concerns about DBPs.

- The desire to eliminate the hazards associated with using gaseous chlorine.
- The need to have a guaranteed water supply.
- The need to minimize risk of water supply contamination.
- Issues such as chemical storage and environmental protection.
- Concerns related to aging plant components/infrastructure and the impact on operation.
- Proactive approaches to standards and limits. Consideration should be given to future requirements (i.e., plant expandability and upgrade for future regulations).
- Consideration related to the impact of flooding and operations, such as those experienced during the 2011 flood.

3.2.2.2 Step 2 – Brainstorming

This step is the development of a long-list of potential alternative concepts/options that address the project objectives.

3.2.2.3 Step 3 – Screening

Screening will eliminate those options that will not be applicable, practical or feasible for Brandon. The long-list will be screened to remove those alternatives considered not feasible, based on a set of specific “must meet” criteria which defines the project requirements and constraints. If any single criterion is not met for an option, then that particular option will not be included in the list of options to be considered.

3.2.3 Evaluation of Options (Steps 4 to 6)

3.2.3.1 Step 4 - Evaluation Criteria

A full range of evaluation criteria and their indicators were established that reflect the full range of criteria within the TBL categories.

An example listing of potential treatment process criteria is presented in **Table 3.1**. The criteria were developed with the involvement of the City of Brandon staff. A similar approach will be used to develop the TBL criteria for the raw water source and the plant siting options.

Table 3.1: Example TBL Criteria for Shortlisting

TBL Criteria	
Economic	• Minimize capital cost • Minimize O&M cost • Minimize cost for future expansion to meet more stringent regulatory requirements • Minimize dependence on commodities that are subject to market variability • Minimize loss of revenue from user fees • Maximize opportunities for grant funding
Social	• Minimizes risks associated with water supply • Consistent with City's vision and policies • Protect public and operations staff health (minimize risk from air/other exposure during processing, handling, transportation and management) • Maximize quality of community life by minimizing traffic, community impacts during construction; minimize negative public opinion and perception of risk. • Minimize loss of land for new facilities, compatible with existing land use, impact on property values
Environmental	• Meets performance objectives for treated water (turbidity, DBPs, hardness etc.). • Ability to meet a higher treatment standard. • Minimizes risks associated with gaseous chlorine • Minimize risk associated with water supply contamination • Ease of future expansion • Minimize risks associated with flooding

3.2.3.2 Step 5 - Weighting

Each TBL category, as well as each criterion, will be assigned a value weight that reflects the importance of that particular criterion relative to others and a net weight will be calculated. Determination of the net weight is illustrated in **Figure 3.2**.

Category	Weighting	Criteria	Weighting	Net Weight
Financial	F%	F-01	F1%	F% x F1%
		F-02	F2%	F% x F2%
		F-03	F3%	F% x F3%
		Σ	100%	
Environmental	E%	E-01	E1%	E% xE1%
		E-02	E2%	E% x E2%
		E-03	E3%	E% x E3%
		Σ	100%	
Social	S%	S-01	S1%	S% x S1%
		S-02	S2%	S% x S2%
		S-03	S3%	S% x S3%
		Σ	100%	
Σ	100%			

Figure 3.2: Determining Net Weighting

3.2.3.3 Step 6 - Scoring

Scores will be assigned to each alternative based on the technical, impact and cost information developed for each as well as the degree of risk and/or mitigation required. This information provides a technically sound basis for assigning a score for each criterion, specific to each alternative, on a comparative basis.

Scores will range from +4 to -4 and will assigned based on guidelines of Melbourne Water (2007) as presented below:

- +4 Very much better
- +3 Much better
- +2 Moderately better
- +1 Little better
- No change (same as existing WTP)
- -1 Little worse
- -2 Moderately worse
- -3 Much worse
- -4 Very much worse

The criteria and weighting will be used to develop a weighted score for each alternative design concept where the weighted score is calculated as follows:

Weighted Score = Score x Net Weighting

The score provides a quantitative comparison of one alternative to another. The total score is the sum of criteria categories.

Criteria Catergory	No.	Criteria Description	Net Weighting	Weighted Score Option # 1	Option # 2	Option # 3
Financial	F-01	Capital Cost				
	F-02	O&M Cost				
	F-03	NPV of Life Cycle Cost				
	F-04	Minimize Dependency on Commodities that are Subject to Market Variability				
	F-05	Maximize Opportunities for External Funding				
Environmental	E-01	Footprint				
	E-02	Ability to Meet Future Drinking Water Requirements				
	E-03	Technology Demonstrated at Similar Scale				
	E-04	Maximize Beneficial Reuse				
	E-05	Maximize Substainable End Use				
Social	S-01	Traffic				
	S-02	Protect Public and Operations Staff Health				
	S-03	Maximize Quality of Community Life (Noise/Traffic Dust)				
	S-04	Disruption During Construction				
	S-05	Public & Stakeholder Acceptability				
	S-06	Consistent with City's Vision and Policies				
		TOTAL				

Figure 3.3: Example Model Input for Evaluation Step

3.2.4 Selection of Option (Steps 7 to 9)

3.2.4.1 Step 7 - Ranking

The options will be ranked based on the total TBL score and assessed whether the results seem reasonable, based on past experience with similar projects.

3.2.4.2 Step 8 - Sensitivity Analysis

A sensitivity analysis will be carried out to determine the robustness of the evaluation methodology. The following scenarios will be evaluated to assess the sensitivity of the scoring to various scenarios, such as:

- Using equal weightings on all criteria.
- Using a full range of weightings expressed by stakeholders.
- An emphasis on a specific category.

3.2.4.3 Step 9 - Reporting

The decision-making process will be documented and the results of the process will be presented to the City.

3.3 Input Required from the City

The proposed Decision Making Framework requires the following input from the City at each step:

Step 1 - Problem Definition	Confirming objectives
Step 2 - Brainstorming	Reviewing and confirming long-list of alternatives
Step 3 - Screening	Confirming that the screening criteria and their application to the long-list is satisfactory
Step 4 - Evaluation Criteria	Identifying the criteria within each of the broad TBL categories that should be used in the analysis.
Step 5 - Weighting	Establish the weightings to be used in the MCA
Step 6 - Scoring	Reviewing the indicators and scoring system
Steps 7, 8, 9	Reviewing the ranking, sensitivity analysis and reporting

3.4 Summary

A series of decision making workshops were held between the City of Brandon and AECOM. The evaluation of the water supply source was held on April 23, 2013. The evaluation of the proposed WTP site and treatment selection was held on May 21, 2013. The results of these workshops are detailed in Section 6 to Section 9.

4. Planning Criteria

4.1 Population Growth

The City of Brandon is the second largest city in Manitoba with a population of approximately 46,000 people. The area surrounding the City of Brandon is mostly comprised of farms and rural towns and villages. Population is commonly used in conjunction with other parameters, like industrial use, as a basis for predicting water demand to be treated in the future. The City of Brandon has indicated that water planning, like wastewater planning, should be based on Statistics Canada published census reports instead of Brandon Regional Health Authority data.

Statistics Canada Census information dating back to 1941 is listed in **Table 4.1**. Historical population growth has varied from periods of significant growth (i.e., 1951-1975 average growth 2.3%) to periods of relatively little growth (i.e., 1975-2001 average growth 0.45%). Over the last 20 years the City has grown an annual average growth rate of 0.89%. One significant economic driver over the last 10 years has been the construction of the Maple Leaf Foods processing facility, which initially operated on a single shift from 1999 to 2007, and then increased production to the current double shift.

The City of Brandon continues to be an attractive location for new businesses; however the growth of future commercial and industrial development is difficult to anticipate. The assumptions used in generating population projections and the resulting water demand will have a great impact on planning of the long term requirements for the City's utility infrastructure.

The City of Brandon currently uses a model that predicts growth to continue at 0.9%, a rate similar to that seen over the past 20 years. This is also the value that AECOM used for wastewater planning in the Phase III Wastewater Treatment Plant Upgrade Project. Furthermore, the City has indicated that it is important to keep growth projections and design life between utilities consistent to avoid confusion and to be flexible in the planning approach in the event economic conditions change. For the purpose of this Master Plan an average growth rate of 0.9% will be used, which will provide a comfortable basis on which to base long term planning of Brandon's water treatment infrastructure. To maintain consistency between utilities, a design year of 2035 (23 years) has been selected as the planning horizon. This results in a population of 57,111 in the year 2035. This growth is illustrated in **Figure 4.1** and tabulated in **Table 4.1**

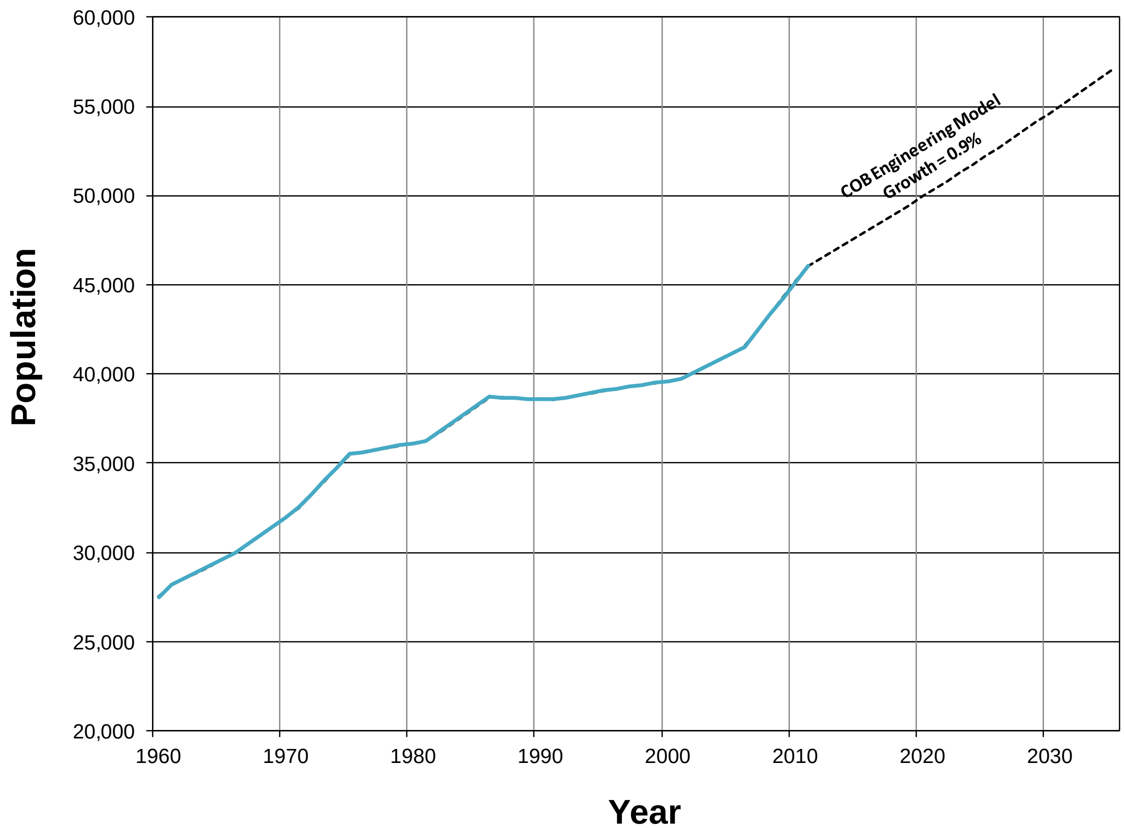


Figure 4.1: Historic Population and Predicted Growth

Table 4.1: Statistics Canada Census Populations and Project Future Population

Year	Population	Annual Percent Growth
1941	17,383	0.18
1951	20,598	1.85
1956	24,796	4.08
1960	28,166	2.72
1966	29,981	1.29
1971	32,500	1.68
1975	35,500	2.31
1981	36,242	0.35
1986	38,708	1.36
1991	38,567	-0.07
1996	39,175	0.32
2001	39,716	0.28
2006	41,511	0.9
2011	46,061	2.19
2022	**50,832**	**0.9 projected**
2035	**57,111**	**0.9 projected**

4.2 Water Demand Projections

A review of the raw water system and the treated water consumption records was performed and is detailed in **Appendix D**. This review also includes an analysis of the City's current water conservation plan and the impact that industrial users have on overall consumption. As part of the work, the City's unaccounted for water loss (12% -15%) was estimated and used to predict future water supply requirements.

Industry is one of the largest and fastest growing sources of water consumption in the community of Brandon. Maple Leaf Foods accounts for more than 93% of the City's industrial water consumption each year, on average, and their consumption has steadily increased since 2001. Other large industrial water consumers include Koch Fertilizer and Pfizer Canada, which account for another 6% of the industrial demand, on average. Because these contributions are small relative to Maple Leaf, only the effects of Maple Leaf's consumption will be discussed.

Maple Leaf's water consumption has been increasing steadily since 2001, with the change from single shift to the current double shift production, as shown in **Table 4.2**. In 2011, 22.0% of the total annual water consumption in Brandon could be attributed to Maple Leaf's operations. These trends indicate that if Maple Leaf were to ever shut down production, there would be major implications to the water system.

Table 4.2: Industrial Water Consumption

Year	Total Water Annual Water Consumption (m^3)	Maple Leaf Foods (m^3)	Total Industrial Consumption (m^3)	Total Industrial Consumption as % of Total Consumption
2001	7,407,966	1,076,551	N/A	N/A
2002	7,328,586	1,161,552	N/A	N/A
2003	8,023,443	1,318,555	N/A	N/A
2004	7,564,047	1,205,541	1,286,428	17.0 %
2005	7,472,638	1,333,172	1,417,799	19.0 %
2006	7,967,166	1,225,029	1,304,796	16.4 %
2007	8,001,118	1,365,577	1,493,598	18.7 %
2008	8,158,470	1,572,456	1,683,173	20.6 %
2009	8,068,168	1,604,453	1,703,537	21.1 %
2010	8,028,436	1,721,084	1,837,166	22.9 %
2011	7,925,070	1,740,495	1,864,270	23.5 %

N/A=Not available

Table 4.3 outlines the per capita consumption rates based on population data and historical consumption rates provided from the City. The City of Brandon Water Conservation Plan indicates that the City plans to target a 10% reduction in per capita consumption every 10 years over a 30-year period based on the total current water use. For the Master Plan design criteria, AECOM recommends a more conservative approach of not applying the 10% reduction in per capita every 10 years and maintain the 2011 per capita. If applicable, the per capita demand would potentially decrease to 289 L/c/day in 2035.

Table 4.3: Estimated Per Capita Consumptions

Year	Population	Per Capita Consumption, Treated (L/day)
2001	39,716	435
2006	41,511	445
2011	46,061	368

4.3 Water Demand Design Criteria

Table 4.4 outlines AECOM's recommendations for future water system design parameters based on the population and flow data provided, as well as the anticipated trends in future City growth and water use.

Table 4.4: Population and Flow Design Values

Parameter	Unit	2011	2022	2035
Population		46,061	50,832	57,111
Per Capital Water Consumption	L/c/day	368	368	368
Residential Water Consumption – Average Day	m^3/day	16,941	18,699	21,009
Maple Leaf Water Consumption – Average Day	m^3/day	4,769	4,769	4,769
Total Average Water Consumption – Average Day	**m^3/day**	**21,710**	**23,468**	**25,777**
Total Water Consumption – Maximum Day	**m^3/day**	**36,907**	**39,896**	**43,821**
Total Water Consumption – Peak Instantaneous Day	**m^3/day**	**73,814**	**79,791**	**87,642**

Assumptions were made in developing the above table in collaboration with the City. The population growth the City predicts to see annually was agreed to be 0.9% with no reduction in per capita use. In addition, it was assumed that the Maple Leaf consumption will continue at the current rate. The system loading conditions were based on historical peaking factors; it was assumed that these factors will continue to apply in the future.

There is a potential for reducing the capacity requirements of the WTP in the future through industrial reuse of water treated at the City of Brandon's Water Reclamation Facility (WRF). The WRF will accept wastewater from various sources across the City for discharge into the Assiniboine River. As the treated effluent from the WRF is expected to be of high quality, there is a possibility of also using the effluent for industrial purposes, such as for process water, boiler water or cooling water. Consumers of reclaimed water may include Canexus Chemicals Canada, Koch Fertilizers Canada and Maple Leaf Foods. AECOM completed a draft overview of water reuse opportunities in 2012, although further evaluation of water reuse opportunities is required before any change to the projected water consumption can be made.

The nominal capacities of the softening and filtration systems in the WTP are 27.2 ML/day, which would meet 2035 average water demands. Water requirements during maximum day demands would need to be met using reservoir storage capacity, of which the current capacity is approximately 21.5 ML. While reservoir expansions may be required in the future, the main focus for the WTP in the short-term is the adequacy of existing treatment systems to achieve current and future water quality requirements.

5. Regulatory Review and Treatment Performance

Drinking water quality in Manitoba is regulated at the provincial level through the *Drinking Water Safety Act* and its associated regulations, which are in turn affected by federal and international policy. Manitoba drinking water quality standards are periodically updated to address health risks caused by contaminants in the water supply.

The performance of existing water treatment processes is in part determined by the source water quality. By evaluating the water quality of current and potential water sources, the selection of future treatment upgrades may be better informed. An evaluation of short- and long-term treatment upgrades is covered in Section 8 and 9, respectively.

5.1 Existing Regulations

Public water suppliers must abide by the criteria given in the provincial *Drinking Water Quality Standards Regulation*, which makes the water quality criteria set out in the *Guidelines for Canadian Drinking Water Quality* (GCDWQ) as legally enforceable standards. These criteria are separated into the following three categories:

- Maximum Acceptable Concentrations (MAC), which are limits to which a contaminant may be present in a water supply before posing a significant risk to human consumption;
- Aesthetic Objectives (AO), which are concentration limits on contaminants that do not pose an immediate threat to public health, yet influence the public's perception of their water supply; and
- Operation Guidance (OG) targets, which are applied when specific water treatment processes are used which may affect overall water quality, such as the use of aluminum-based coagulants.

Province-specific water quality criteria are also included in the *Drinking Water Quality Standards Regulation*, which are identical to those stated in the GCDWQ with the exception of the criteria based on bromodichloromethane contamination, which is not directly covered in the GCDWQ. A summary of relevant water quality parameters is shown in **Table 5.1**.

Table 5.1: Summary of Existing Water Quality Guidelines

Parameter	GCDWQ (mg/L)		Parameter	GCDWQ (mg/L)	
	MAC	AO/OG		MAC	AO/OG
Aluminum		[0.1/0.2][1]	Manganese		≤0.05
Antimony	0.006		Mercury	0.001	
Arsenic	0.010		Nitrate and Nitrite (as N)	10	
Barium	1		Nitrite-N		1.0
Benzene	0.005		pH		6.5-8.5
Boron	5		Selenium	0.01	
Cadmium	0.005		Sodium		≤200
Chloride		≤250	Sulphate		≤500
Chromium	0.05		Toluene		≤0.024
Colour		≤15	Total Dissolved Solids		≤500
Copper		≤1.0	Total Haloacetic Acids	0.08 (ALARA[2])	
Cyanide	0.2		Trihalomethanes	0.1	
Ethyl-Benzene		≤ 0.024	Turbidity	0.1/0.3/1.0[3]	
Fluoride	1.5		Uranium	0.02	
Hardness (as $CaCO_3$)		≤200 or ≤500	Vinyl Chloride	0.002	
Iron		≤0.3	Xylenes		≤ 0.3
Lead	0.010		Zinc		≤5.0

[1]For plants using aluminum-based coagulants, ≤ 0.1 mg/L; for conventional treatment plants, ≤ 0.2 mg/L.

[2]ALARA: As Low As Reasonably Possible

[3]Turbidity guidelines are dependant on the water source and form of water treatment in use. For groundwater not classified as GUDI, such standards are typically not applied.

The provincial regulations make a distinction in water quality criteria for surface water, groundwater and groundwater under the direct influence of surface water (GUDI), specifically with regards to disinfection requirements. A summary of existing disinfection requirements for public water systems is shown in **Table 5.2**. These microbial standards do not apply in the case of groundwaters or high quality source waters.

Table 5.2: Summary of Microbial Standards for Surface Water and GUDI

Parameter	Treatment Standard
Cryptosporidium	3-log removal (99.9%)
Giardia lamblia	3-log removal (99.9%)
Viruses	4-log removal (99.99%)

5.2 Future Regulatory Trends and Long Term Goals

A review of current water quality criteria in relevant worldwide jurisdictions and for which there is no equivalent in the federal GCDWQ was conducted in order to assess potential changes to drinking water quality criteria used in Manitoba. Of the comparable worldwide regulations, boron, cyanide, *n*-nitrosodimethylamine (NDMA), nitrite, dichloromethane and vinyl chloride appear to be potential candidates for stricter regulations in Manitoba water supplies. The criteria on dichloromethane are of particular concern given the current WTP's difficulty with addressing trihalomethane (THM) formation, described in Section 5.5. Another compound of particular interest is acrylamide, which presents a risk to human health and is present as a by-product of some coagulation processes during water treatment. Currently, water quality criteria for vinyl chloride and for waterborne bacterial pathogens are being reviewed by the Federal-Territorial-Provincial Committee of Drinking Water (CDW).

Research in other jurisdictions regarding the presence of pharmaceuticals, endocrine-disrupting compounds and perchlorate may also be the subject of research in Canadian water supplies in the future. The presence of pesticides in Manitoba source water may be the target of future regulations, given their presence in surface waters and the absence of any recommended treatment criteria.

5.3 Parameters of Concern

Health Canada, which manages the Federal-Territorial-Provincial CDW, periodically reviews water quality guidelines and management principles in consultation with other international organizations such as the United States Environmental Protection Agency (USEPA) and the World Health Organization (WHO). Health Canada is also recognized as a WHO/Pan American Health Organization Collaborating Centre for Water Quality, and shares data with the WHO and USEPA regarding water quality research.

The CDW also conducts public consultations in Canada for determining the health effects of various contaminants in drinking water and is currently reviewing health-based measures regarding vinyl chloride and waterborne bacterial pathogens. Comparisons of water quality criteria and pending research from the following organizations were used to forecast future water quality regulations:

- The WHO;
- The European Commission (EC);
- The United Kingdom's Drinking Water Inspectorate (UK DWI);
- The USEPA; and
- The pertinent regulatory agencies of Alberta (AB), Saskatchewan (SK) and Ontario (ON).

A comparison of all water quality criteria investigated can be found in **Appendix E**. Water quality criteria that are more stringent than those set in place by the current GCDWQ and Manitoban regulation can be found in **Table 5.3**.

Table 5.3: Water Quality Criteria More Stringent than Manitoban Regulations, mg/L

Parameter	GCDWQ	MB	WHO	EC	UK DWI	USEPA	ON
Inorganic Parameters							
Antimony	0.006	-	0.02	**0.0050**	**0.0050**	0.006	0.006
Barium	1	-	**0.7**	-	-	2	1
Boron	5	-	**0.5**	**1.0**	**1.0**	-	5
Cadmium	0.005	-	**0.003**	0.0050	0.0050	0.005	0.005
Cyanide	0.2	-	**0.07**	**0.050**	**0.050**	0.2	0.2
Iron	0.3	-	0.3	**0.200**	**0.200**	0.3	-
Nitrite	3.2	-	**0.2**	**0.50**	**0.10**	3	3
Nitrilotriacetic acid	0.4	-	**0.2**	-	-	-	0.4
Sulphate	500	-	**250**	**250**	**250**	**250**	-
Uranium	0.02	-	**0.015**	-	-	0.03	0.02
Organic Parameters							
Benzene	0.005	-	0.01	**0.0010**	**0.0010**	0.005	0.005
Dichloroethane, 1,2-	0.005	-	0.03	**0.0030**	**0.0030**	0.005	0.005
Dichloroethene, 1,1-	0.014	**-**	**-**	-	-	**0.007**	0.014
Dichloromethane	0.05	**-**	**0.02**	-	-	**0.005**	**0.05**
Microcystin-LR	0.0015	**-**	**0.001**	-	-	-	0.0015
Tetrachloroethene	0.03	-	0.04	**0.010**[1]	**0.010**[1]	**0.005**	0.03
Thrichlrorethene	0.005	-	0.02			0.005	0.005
Vinyl chloride	0.002	**-**	**0.0003**	**0.00050**	**0.00050**	0.002	0.002
Disinfectant By-Product Parameters							
Chlorate	1	**-**	**0.7**	-	-	-	-
Chlorite	1	**-**	**0.7**	-	-	1	-
NDMA	0.00004	-	0.1	-	-	-	**0.000009**
Total haloacetic acids	0.08	-	**Varies**	-	-	**0.060**	-
Trihalomethanes	0.1	**-**	**Varies**	0.100	0.100	**0.080**	0.1

All values in mg/L unless stated otherwise. Values in bold are more stringent than GCDWQ limits.

[1]*Based on the sum of the concentrations of tetrachloroethene and trichloroethene.*

The compounds in **Table 5.3** may be subject to increased regulation in the future due to more stringent requirements found in other jurisdictions. Contaminants of note are those limits that vary by more than 50% of the total concentration, including boron, cyanide, NDMA, nitrite, sulphate, dichloromethane and vinyl chloride. Currently, water quality criteria for vinyl chloride and for waterborne bacterial pathogens are being reviewed by the Federal-Territorial-Provincial CDW. The water quality criterion for NDMA is currently under review by the UK DWI.

Several water quality criteria were addressed in other jurisdictions for which there is no equivalent in the GCDWQ. A compound of particular interest is acrylamide, which presents a risk to human health and is present as a by-product of some coagulation processes during water treatment. Overall, a greater number of compounds present in the environment are being regulated worldwide as health concerns grow over previously unregulated compounds. This is leading to the categorization of contaminants based on their chemical characteristics to aid in treatment evaluations. Based on the assessment of the Brandon distribution system water quality data from 2007-2012, THMs appear to be one the parameters of greater concern. The USEPA currently has the strictest guidelines for THMs, with both the USEPA and the WHO defining additional limits on specific THMs.

Research in other jurisdictions regarding the presence of pharmaceuticals, endocrine-disrupting compounds and perchlorate may also be the subject of research in Canadian water supplies in the future. The presence of pesticides in Manitoba source water may also be the target of future regulations, given their possible presence in the water supply and the absence of any recommended treatment criteria. A full review of regulatory requirements in Manitoba and other jurisdictions can be found in **Appendix E**.

5.4 Raw Water Quality

The effectiveness of current WTP in meeting water quality objectives is in part determined by the raw water quality. Developing new raw water sources may enhance treated water quality and offer greater reliability on overall supply.

5.4.1 Existing Water Sources

The raw water quality coming into the WTP from the Assiniboine River, the Canada Games Well and the Turtle Crossing was compared to the current GCDWQ. The results from this assessment can be found in **Table 5.4**. Values in bold indicate parameters which exceed the GCDWQ. Both the Canada Games Well and Turtle Crossing draw water from the ARVA, one of many aquifers surrounding the City of Brandon.

Table 5.4: Main Raw Water Source Characteristics (2006 – 2012)

Parameter	Unit	Assiniboine River			Canada Games Park Well			Turtle Crossing Park Well			GCDWQ
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	
Inorganic Parameters											
Aluminum	mg/L	**0.13**	**14.7**	**1.87**	< 0.0050	**0.12**	0.05	< 0.005	**0.20**	0.08	O.G. ≤ 0.1
Antimony	mg/L	< 0.00020	0.003	0.001	< 0.00020	0.001	0.001	< 0.001	0.002	0.001	0.006
Arsenic	mg/L	0.0031	**0.0206**	0.0060	**0.0245**	**0.0338**	**0.0280**	**0.0228**	**0.0279**	**0.0251**	0.01
Barium	mg/L	0.0414	0.192	0.074	0.021	0.025	0.023	0.022	0.027	0.024	1
Boron	mg/L	0.08	0.23	0.14	0.09	0.41	0.32	0.11	0.39	0.16	5
Cadmium	mg/L	< 0.00020	0.0011	0.0002	< 0.00001	0.0005	0.0002	< 0.0002			0.005
Chromium	mg/L	< 0.0010	0.019	0.004	< 0.0010	0.006	0.006	< 0.0010			0.05
Copper	mg/L	< 0.001	0.015	0.005	< 0.001	0.016	0.004	< 0.001	0.003	0.002	A.O 1.0
Cyanide	mg/L	–	–	–	< 0.0020			< 0.0020	0.000	0.000	0.2
Fluoride	mg/L	< 0.50	0.4	0.24	< 0.10	0.40	0.25	< 0.50	0.40	0.28	1.5
Iron	mg/L	0.17	**13.4**	**1.90**	**1.72**	**3.24**	**2.17**	**1.77**	**3.39**	**2.72**	A.O. ≤ 0.3
Lead	mg/L	< 0.00050	0.0074	0.0016	< 0.000090	0.0018	0.0009	< 0.0005	0.0006	0.0006	0.01
Manganese	mg/L	0.0308	**0.602**	**0.160**	**0.131**	**0.219**	**0.155**	**0.122**	**0.162**	**0.141**	A.O ≤ 0.05
Nitrate+Nitrite	mg/L as N	< 0.001	0.51	0.289	< 0.005	0.040	0.020	< 0.005	0.061	0.026	10
Selenium	mg/L	< 0.0010	0.004	0.002	< 0.0010	0.007	0.003	< 0.0010	0.003	0.002	0.01
Sodium	mg/L	33.7	123	72.2	70.6	**230.0**	168.0	61.0	178.0	79.1	A.O. ≤ 200
Sulphate	mg/L	147	360	255	43	233	203	163	198	176	A.O. ≤ 500
Uranium	mg/L	0.00144	0.0076	0.0040	0.0003	0.0018	0.0006	0.0004	0.0023	0.0019	0.02
Zinc	mg/L	< 0.0050	**6**	0.4798	< 0.005	0.0400	0.0198	< 0.01	0.0400	0.0162	A.O. ≤ 5.0
Microbiological Parameters											
Cryptosporidium	oocysts/L	0	2	–	–	–	–	–	–	–	–
Giardia lamblia	cysts/L	0	102	–	–	–	–	–	–	–	–
Other Treatment-Related, Aesthetic Parameters											
Alkalinity[1]	mg/L as $CaCO_3$	95	580	274	–	–	–	–	–	–	–
Colour	TCU	0	**174**	**24**	< 5.0	**25**	9	5	10	7	15
Hardness	mg/L as $CaCO_3$	134	**568**	**383**	**286**	**463**	**355**	**299**	**488**	**427**	A.O. ≤ 200
pH		6.91	**8.73**	8.29	7.65	**8.51**	7.91	7.52	8.47	7.79	6.5 – 8.5
TDS	mg/L	184	**748**	**493**	9	**910**	**796**	**650**	**710**	**684**	500
TOC	mg/L	8	61	16	2	25	9	1	18	7	–
Turbidity	NTU	**3.7**	**405**	**41.4**	< 5.0	**25**	**9**	**5**	**10**	**7**	0.1

Values in bold indicate parameters which exceed the GCDWQ.

[1]*Alkalinity of raw water entering the WTP, the majority of which was derived from the Assiniboine River.*

The raw water entering the WTP was found to occasionally have high pH levels as well as high levels of aluminum, arsenic, iron, manganese, colour, hardness, total dissolved solids (TDS) and turbidity. Water taken from the Assiniboine River, in particular, has a high level of TOC compared to the well water. The capacity for the WTP to address these parameters is discussed later in this section.

5.4.2 Potential Water Sources

Various aquifers around the City of Brandon may act as possible water sources in the future and are briefly evaluated here. It should be noted that much of the available data is limited, and continued testing may be required to make accurate conclusions on water quality. Suitability of these water sources is further explored in Section 6.

In 2011, KGS Consulting evaluated an alternate well site located east of the existing City wells. One of the aims of this study was to determine the well water quality of the ARVA at this location, as well as potentially develop the Brandon Channel Aquifer (BCA). Testing consisted of 5 tests holes, with water samples taken at various depths to evaluate each aquifer. Water quality data collected from the estimated location of each aquifer is summarized in **Table 5.5**.

Table 5.5: KGS Test Wells (2011)

Parameter	Unit	ARVA			BCA			GCDWQ
		Min	Max	Avg	Min	Max	Avg	
Inorganic Parameters								
Aluminum	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	0.002	0.002	O.G. ≤ 0.1
Antimony	mg/L	0.00032	0.00131	0.00079	0.00033	0.00103	0.00064	0.006
Arsenic	mg/L	**0.00434**	**0.0343**	**0.019**	0.00681	**0.0297**	**0.01526**	0.010
Barium	mg/L	0.0251	0.0694	0.0367	0.0099	0.0523	0.0304	1
Boron	mg/L	0.07	0.656	0.25	0.085	0.483	0.335	5
Cadmium	mg/L	0.000014	0.000041	0.000026	0.000013	0.00005	0.00003	0.005
Chromium	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.05
Copper	mg/L	0.00049	0.0049	0.0014	0.00052	0.00167	0.00093	A.O. ≤ 1.0
Fluoride	mg/L	0.122	0.259	0.172	0.11	0.44	0.25	1.5
Iron	mg/L	0.1	0.28	0.2	0.47	1.71	1.09	A.O. ≤ 0.3
Lead	mg/L	<0.000090	0.000126	0.000126	<0.000090	<0.000090	<0.000090	0.01
Manganese	mg/L	**0.0526**	**0.621**	**0.206**	0.0482	**0.495**	**0.210**	A.O. ≤ 0.05
Nitrate+Nitrite	mg/L as N	<0.050	0.423	0.216	0.055	0.072	0.0635	10
Selenium	mg/L	<0.0010	0.0012	0.0012	<0.0010	0.0012	0.0012	0.01
Sodium	mg/L	38.3	**234**	94	54.5	**425**	**227**	A.O. ≤ 200
Sulphate	mg/L	183	**642**	301	232	**762**	445	A.O. ≤ 500
Sulphide	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	A.O. ≤0.05
Uranium	mg/L	0.00098	0.00586	0.00375	0.00076	0.00384	0.00194	0.02
Zinc	mg/L	0.0035	0.0097	0.0057	0.0039	0.0098	0.0062	A.O. ≤ 5.0
Other Physical, Aesthetic Parameters								
Hardness	mg/L as CaCO3	**317**	**580**	**449**	**239**	**707**	**530**	A.O. ≤ 200
pH		8.26	8.41	8.35	8.27	8.42	8.32	6.5-8.5
TDS	mg/L	**572**	**1290**	**772**	**906**	**1320**	**1182**	A.O. ≤500
DOC	mg/L	2.8	7.9	4.8	5.2	11.1	7.2	

Values in bold indicate parameters which exceed the GCDWQ.

From the data above, water from both aquifers appears to be high in arsenic, manganese, sodium, sulphate, hardness and TDS, similar to the existing well water sources. These water quality results are preliminary; aggregate water quality from these aquifers may be significantly different from these results.

The Assiniboine Delta Aquifer (ADA) located east of the City likely presents that largest source of groundwater for the area. Water quality from the nearest sub-basin of the aquifer was taken from the Shilo area, as shown in **Table 5.6**. Four different wells are used for the evaluation of area, with one water sample taken from each well over the course of seven years.

Table 5.6: ADA Wells (Shilo Farms Data, 2001-2007)

Parameter	Unit	Well Code				GCDWQ
		MH 026	MH 066	MH 067	MH 068	
Inorganic Parameters						
Aluminum	mg/L	0.001	0.019		0.001	O.G. <0.1
Antimony	mg/L	0.0008			0.0003	0.006
Arsenic	mg/L	0.0011			**0.014**	0.01
Barium	mg/L	0.116	0.253		0.14	1.0
Boron	mg/L	0.01	0.02		0.02	5
Cadmium	mg/L	0.00004			0.00004	0.005
Chromium	mg/L	0.0002	0.002		0.0002	0.05
Copper	mg/L	0.0004	0.002		0.0002	A.O. ≤1.0
Fluoride	mg/L	0.05	0.15	0.05	0.1	1.5
Iron	mg/L	0.25	0.19	**0.68**	**0.83**	A.O. ≤0.3
Lead	mg/L	0.0002			0.0002	0.010
Manganese	mg/L	**0.197**	0.007	**0.273**	**0.421**	A.O. ≤0.05
Nitrate+Nitrite	mg/L	3.4	**30.6**	0.01	0.01	10
Selenium	mg/L	0.0033			0.0002	0.01
Sodium	mg/L	1.3	2.01	2.01	3.8	A.O. ≤200
Sulphate	mg/L	91.8	80.4	41	80.4	A.O. ≤500
Uranium	mg/L	**0.8**			**1.3**	0.02
Zinc	mg/L	0.007	0.008		0.001	A.O. ≤5.0
Other Treatment-Related, Aesthetic Parameters						
Alkalinity	mg/L as $CaCO_3$	170	180	194	229	
Hardness	mg/L as $CaCO_3$	**307**	**394**	**217**	**326**	A.O. ≤200
pH		7.56	7.42	7.15	7.38	6.5-8.5
TDS	mg/L	381	**628**	323	410	A.O. ≤500
Turbidity	NTU	**394**	**0.58**	**9.9**		0.1

Values in bold indicate parameters which exceed the GCDWQ.

From these data, the groundwater at this location appears to high in arsenic, iron, manganese, nitrate and hardness. Of particular interest is the presence of high nitrate levels, which may be caused by the presence of fertilizers and organic matter near groundwater sources. As this data has only been taken from one area of the aquifer, a wider range water quality testing may reveal more accurate results.

In the future, the City may wish to supplement its water supply by acquiring existing water rights in the surrounding area, such as those owned by the Koch Fertilizer Company (Koch) and the Canexus Corporation (Canexus). The wells of both Koch and Canexus are believed to draw their water from the BCA. Available water quality data from the Koch Fertilizer Company well field is summarized in **Table 5.7**.

Table 5.7: Koch Wells (Simplot Data, 1996)

Parameter	Unit	Well 3			Well 4			Well 5			GCDWQ
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	
Inorganic Parameters											
Chloride	mg/L	60	61	60	56	**500**	243	**509**	**530**	**517**	A.O. ≤250
Fluoride	mg/L	0.21	0.24	0.23	0.22	0.32	0.28	0.33	0.38	0.35	1.5
Iron	mg/L	**0.38**	**1.96**	**1.54**	**0.34**	**0.43**	**0.40**	**0.34**	**0.75**	**0.63**	A.O. ≤0.3
Manganese	mg/L	**0.157**	**0.196**	**0.181**	**0.147**	**0.158**	**0.154**	**0.101**	**0.132**	**0.122**	A.O. ≤0.05
Nitrate+Nitrite	mg/L as N	<0.01	0.01	0.01	<0.01	0.01	0.01	<0.01	0.24	0.23	10
Sodium	mg/L	124	138	132	139	**359**	**253**	**374**	**403**	**386**	A.O. ≤200
Sulphate	mg/L	323	388	353	135	352	255	133	145	141	A.O. ≤500
Other Treatment-Related, Aesthetic Parameters											
Alkalinity	mg/L as $CaCO_3$	318	321	320	269	320	301	266	271	269	
Hardness	mg/L as $CaCO_3$	**437**	**451**	**444**	**238**	**452**	**319**	**259**	**268**	**264**	A.O. ≤200
pH		7.42	7.69	7.56	7.66	7.72	7.68	7.68	7.85	7.79	6.5-8.5
TDS	mg/L	**840**	**870**	**855**	**830**	**1200**	**997**	**1100**	**1300**	**1225**	A.O. ≤500
Turbidity	NTU	**11**	**19**	**15**	**1.1**	**18**	**7**	**2.2**	**7.3**	**5.0**	0.1

Values in bold indicate parameters which exceed the GCDWQ.

The Koch wells appear to be high in iron, manganese and hardness, which is typical for some groundwater sources. The water also appears to exceed the GCDWQ in terms of sodium, TDS and turbidity. If obtaining water supplies from existing wells are to be further investigated, efforts to acquire more recent data may be necessary.

5.5 Treatment Performance

To determine if the WTP was adequately addressing raw water quality issues, the water quality of the treated water leaving the plant was evaluated against the GCDWQ, as seen in **Table 5.8**.

Table 5.8: City of Brandon's Treated Water Characteristics (2006 – 2012)

Parameter	Unit	Treated Water			GCDWQ
		Minimum	Maximum	Average	
Inorganic Parameters					
Aluminum	mg/L	0.011	**0.14**	0.053	O.G. ≤ 0.1
Antimony	mg/L	<0.00020	0.002	0.0008	0.006
Arsenic	mg/L	<0.0005	0.00782	0.0016	0.01
Barium	mg/L	0.003	0.0568	0.0163	1
Boron	mg/L	0.01	0.189	0.091	5
Cadmium	mg/L	<0.000010	0.00002	0.00002	0.005
Chromium	mg/L	<0.0010	0.002	0.0012	0.05
Copper	mg/L	<0.0010	0.031	0.0034	A.O ≤1.0
Fluoride	mg/L	0.15	1.2	0.82	1.5
Iron	mg/L	<0.100	0.09	0.07	A.O. ≤ 0.3
Lead	mg/L	<0.000090	0.00012	0.00012	0.01
Manganese	mg/L	<0.0003	0.0026	0.0010	A.O ≤ 0.05
Nitrate+Nitrite	mg/L as N	0.02	0.957	0.364	10
Selenium	mg/L	<0.0010	0.004	0.002	0.01
Sodium	mg/L	40	152	98.9	A.O. ≤ 200
Sulphate	mg/L	166	389	267	A.O. ≤ 500
Uranium	mg/L	<0.00010	0.0027	0.0003	0.02
Zinc	mg/L	<0.0050	0.1	0.0375	A.O. ≤ 5.0
Microbiological Parameters					
Cryptosporidium	oocysts/L	0	0	0	
Giardia lamblia	cysts/L	0	0	0	
Other Treatment-Related, Aesthetic Parameters					
Alkalinity	mg/L as $CaCO_3$	25	156	68	–
Colour	TCU	0	7	0.2	15
Hardness	mg/L as $CaCO_3$	76	**244**	159	A.O. ≤ 200
pH		6.36	8.09	7.74	6.5 – 8.5
TDS	mg/L	44	**634**	388	500
TOC	mg/L	2	11.6	6.8	
Turbidity	NTU	0	**0.407**	0.069	0.1

Values in bold indicate parameters which exceed the GCDWQ. Averages do not include non-detectable results.

From the treated water analysis, the WTP was found to occasionally exceed the past GCDWQ limits for aluminum, TDS, turbidity and pH. The production of trihalomethanes (THMs) in particular was found to be a point of concern, with further analysis showing noncompliance to the levels for bromodichloromethane, as seen in **Table 5.9**.

Table 5.9: City of Brandon Disinfectant By-Product Results (2006 – 2012)

Parameter	Treated Water (mg/L)			GCDWQ	MB
	Min	Max	Average		
Total haloacetic acids	0.014	**0.138**	0.052	0.080 ALARA[1]	
Bromoacetic acid	< 0.0005	0.0012	0.0010		
Bromochloroacetic acid	0.0036	0.0124	0.0070		
Dibromoacetic acid	< 0.0005	0.005	0.0023		
Dichloroacetic acid	0.005	0.0684	0.0269		
Monochloroacetic acid	< 0.001	0.0314	0.0069		
Trichloroacetic acid	0.003	0.0494	0.0184		
Trihalomethanes	0.024	**0.163**	0.065	0.1	0.1
Bromodichloromethane	0.0034	**0.091**	**0.0173**		0.016
Bromoform	<0.0001	0.0021	0.0007		
Chloroform	0.014	0.123	0.045		
Dibromochloromethane	0.0003	0.0213	0.0055		

[1]ALARA: As Low As Reasonably Possible

THM production is closely related to the total organic carbon (TOC) content of the treated water. THM levels increase as the contact time between chlorine-based disinfectants and organic matter increases in the distribution system.

Any upgrade to the City of Brandon's WTP must address these water quality concerns. Water quality criteria tend to become stricter over time, possibly creating greater issues with compliance in the future. Reviewing current treatment performance will aid in determining the efficacy of current treatment processes and may help target likely solutions for future upgrades.

5.5.1 Alkalinity

Alkalinity provides an indication of the buffering capacity of water. Low alkalinity is associated with corrosion in distribution systems. The raw water alkalinity appears to be slightly lower during the spring sampling period than in the winter, as shown in **Figure 5.1**

Water sampling showed that lime softening significantly lowers the alkalinity from 95-580 mg/L as $CaCO_3$ down to 25-156 mg/L as $CaCO_3$. The soda ash used in the softening step of the treatment process likely maintains alkalinity after softening, while also improving hardness reduction.

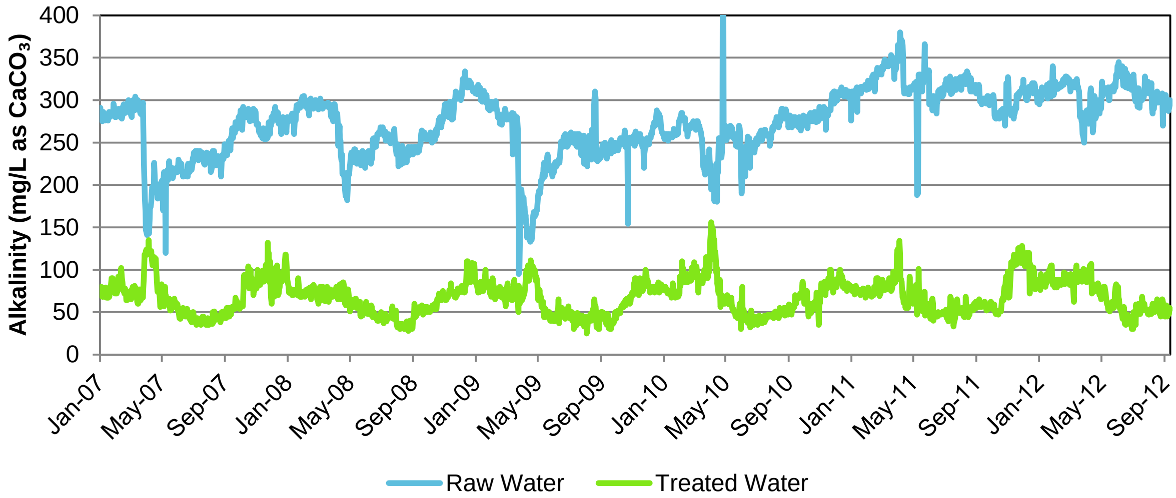


Figure 5.1: Raw and Treated Water Alkalinity (2007-2012)

5.5.2 Total Organic Carbon

The TOC of the raw and treated water is tested on a regular basis at the WTP to determine how effective treatment is in removing organics, subsequently reducing DBP formation. Water sampling has shown that an average of TOC level of 16 mg/L is received by the Assiniboine River, which is reduced to an average of 6.8 mg/L after treatment, as shown in **Figure 5.2**

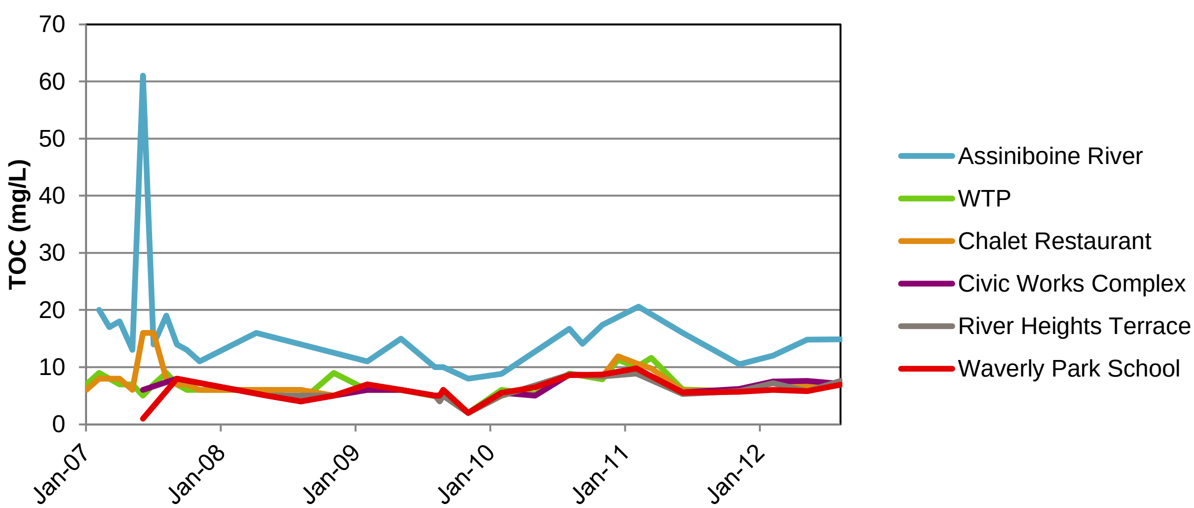


Figure 5.2: Total Organic Carbon in the Distribution System (2007-2012)

While there are no regulatory requirements for TOC removal, general guidelines may be adopted from the United States Environmental Protection Agency's (USEPA) *Stage 1 Disinfectants and Disinfection Byproducts Rule* for conventional water treatment plants. According to the *Disinfectants and Disinfection Byproducts Rule,* plants with an influent TOC >8.0 mg/L and an alkalinity >120 mg/L as $CaCO_3$ should be able to meet an overall TOC reduction 30.0% or more, as see in **Table 5.10**.

Table 5.10: Required TOC Removal by Enhanced Coagulation for Conventional Treatment Plants (United States Environmental Protection Agency, 1999)

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 to 60	>60 to 120	>120
>2.0 – 4.0	35.0%	25.0%	15.0%
>4.0 – 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

It appears that the City is achieving an average TOC removal rate of 53%, as shown in **Figure 5.3.** Despite this TOC reduction, DBPs still appear to be a problem in the distribution system. As the *Disinfectants and Disinfection Byproducts Rule* is simply a guideline, future upgrades should focus on reducing TOC even further to limit DBP formation.

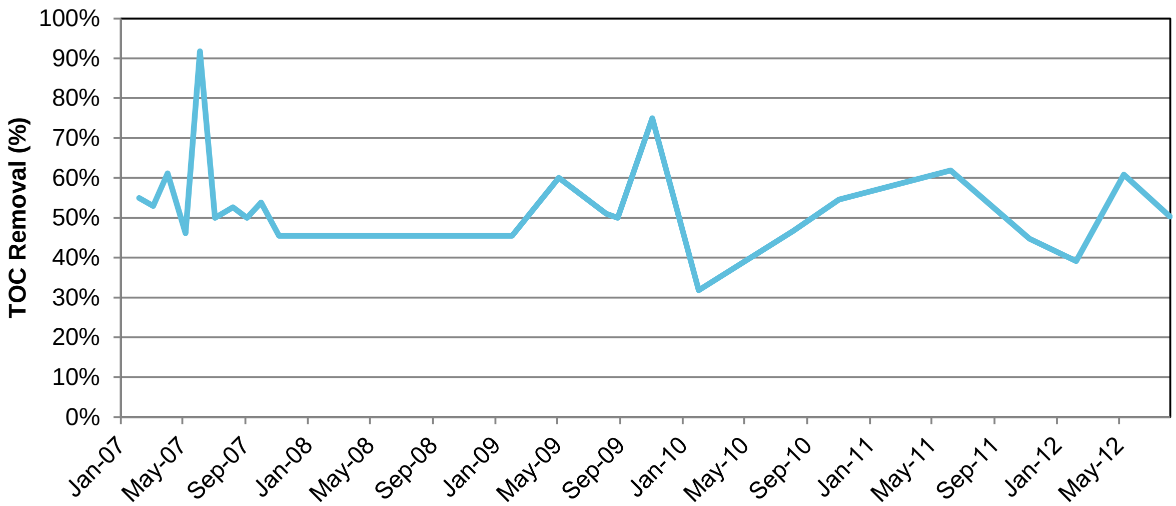


Figure 5.3: TOC Removal Performance (2007-2012)

5.5.3 Hardness

The data provided by the City shows a regular seasonal variation in hardness, as shown in **Figure 5.4**. Between March and April, hardness decreases significantly with the spring thaw. Hardness of around 200 mg/L as $CaCO_3$ is common towards the end of this period. From May to December, hardness steadily increases to winter levels. The WTP typically reduces hardness to an average 159 mg/L as $CaCO_3$ after softening. The GCDWQ states that hardness levels “greater than 200 mg/L are considered poor but can be tolerated.” Thus, the plant is achieving moderate success reducing the hardness, but there may be room for improvement as the total hardness does exceed 200 mg/L as $CaCO_3$ on occasion. Limiting hardness will help reduce the calcification of boiler system piping and prevent scale buildup on pipe walls.

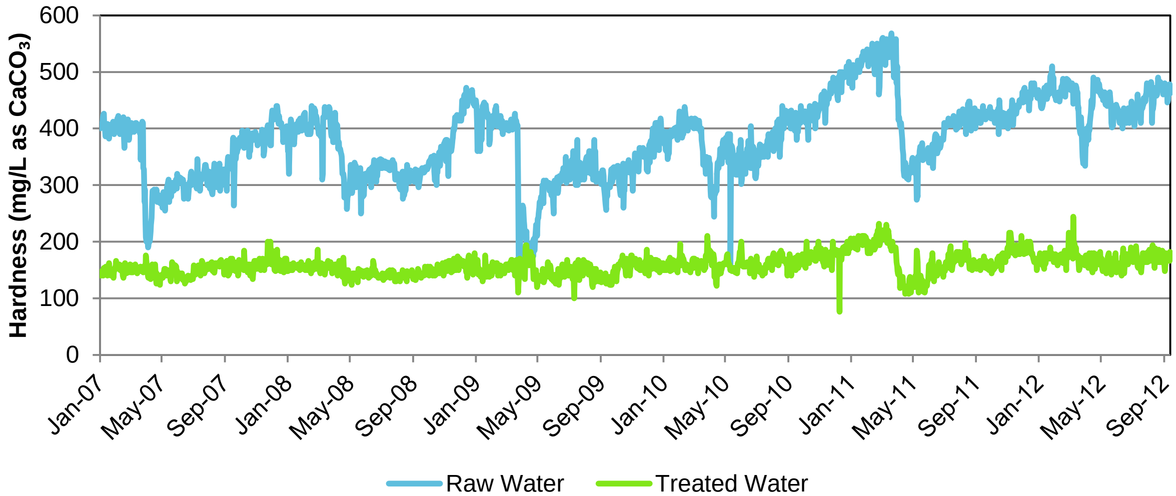


Figure 5.4: Raw and Treated Water Hardness (2007-2012)

5.5.4 Turbidity

Suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms cause turbidity in water. Turbidity measurements relate to the optical property of water that causes light to be scattered and absorbed rather than transmitted in straight lines through the samples. Control of turbidity in public drinking water supplies is important for both health and aesthetic reasons. Excessive turbidity detracts from the appearance of treated water and has often been associated with unacceptable tastes and odours. Turbidity can serve as the source of nutrients for waterborne bacteria, viruses and protozoa, which can be embedded in or adhere to particles in the raw water. Turbidity can also interfere with disinfection processes and the maintenance of a chlorine residual.

Like hardness, turbidity also varies seasonally, with spikes seen most frequently in April during spring runoff, as shown in **Figure 5.5**. The effluent turbidity follows roughly the same trend as the raw water turbidity, but at a fraction of the concentration. **Figure 5.6** illustrates the influent and effluent turbidity recorded at the WTP from 2007-2012. The average treated water turbidity level 0.069 NTU, which is below the Manitoba *Drinking Water Quality Standards Regulation* guideline of 0.3 NTU for chemically assisted filtration. Given the very high level of the raw water turbidity (ranging from 3.7 NTU to 405 NTU), this level of reduction is quite good. A treated water turbidity target of 0.1 NTU is recommended by the GCDWQ, where achievable. By aiming to achieve this lower turbidity target, other processes such as UV disinfection will become more effective. Currently, the WTP achieves this limit most of the time.

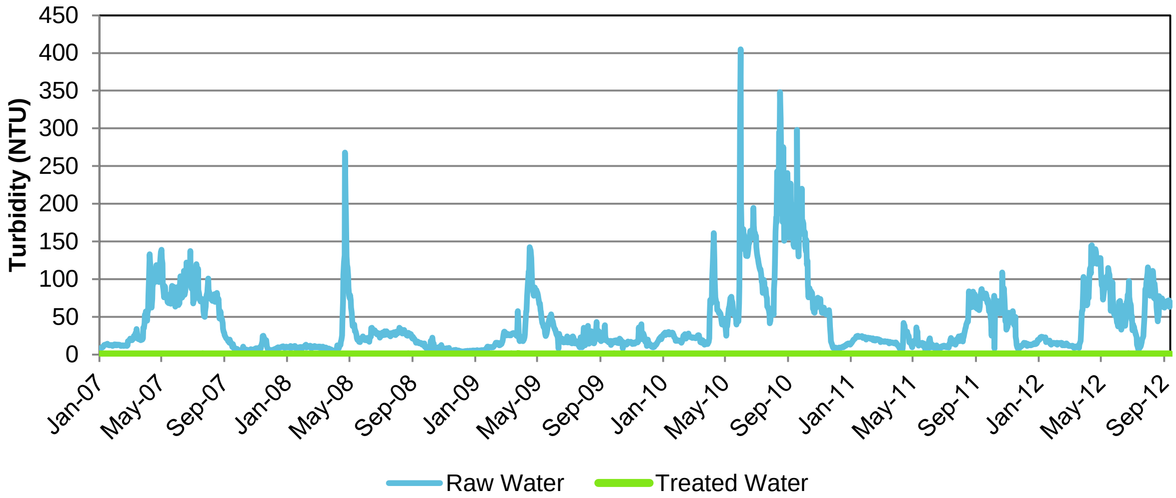


Figure 5.5: Raw and Treated Water Turbidity (2007-2012)

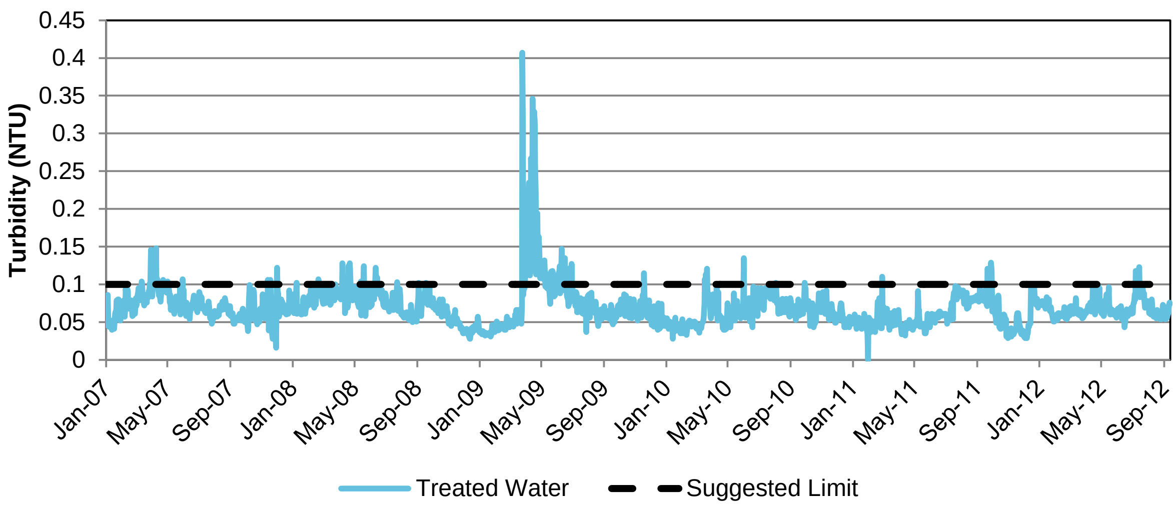


Figure 5.6: Treated Water Turbidity (2007-2012)

5.5.5 Disinfection By-products

DBPs form when chemical disinfectants added to drinking water react with DBP precursors, such as naturally occurring organic matter (NOM). In general, DBP levels are highest in treated water from sources with high organic matter content such as rivers and lakes and lowest when the source water is groundwater. Within a single water supply, DBP levels can vary depending on water quality (e.g. ammonia, bromide, pH, temperature and TOC) and on treatment conditions (e.g. disinfectant dose, contact time and point removal of NOM).

Both THMs and Haloacetic Acids (HAAs) are a group of compounds that are formed in drinking water primarily as DPBs after chlorination. THMs normally refer to four compounds: chloroform, bromodichloromethane, chlorodibromomethane and bromoform. 'Total THMs' (TTHM) refer to the sum of these four compounds. HAAs normally refer to monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid . 'Total HAAs' typically refers to the sum of these five compounds. Currently, DBPs are sampled from four points in the distribution system, as shown in **Figure 5.7**.

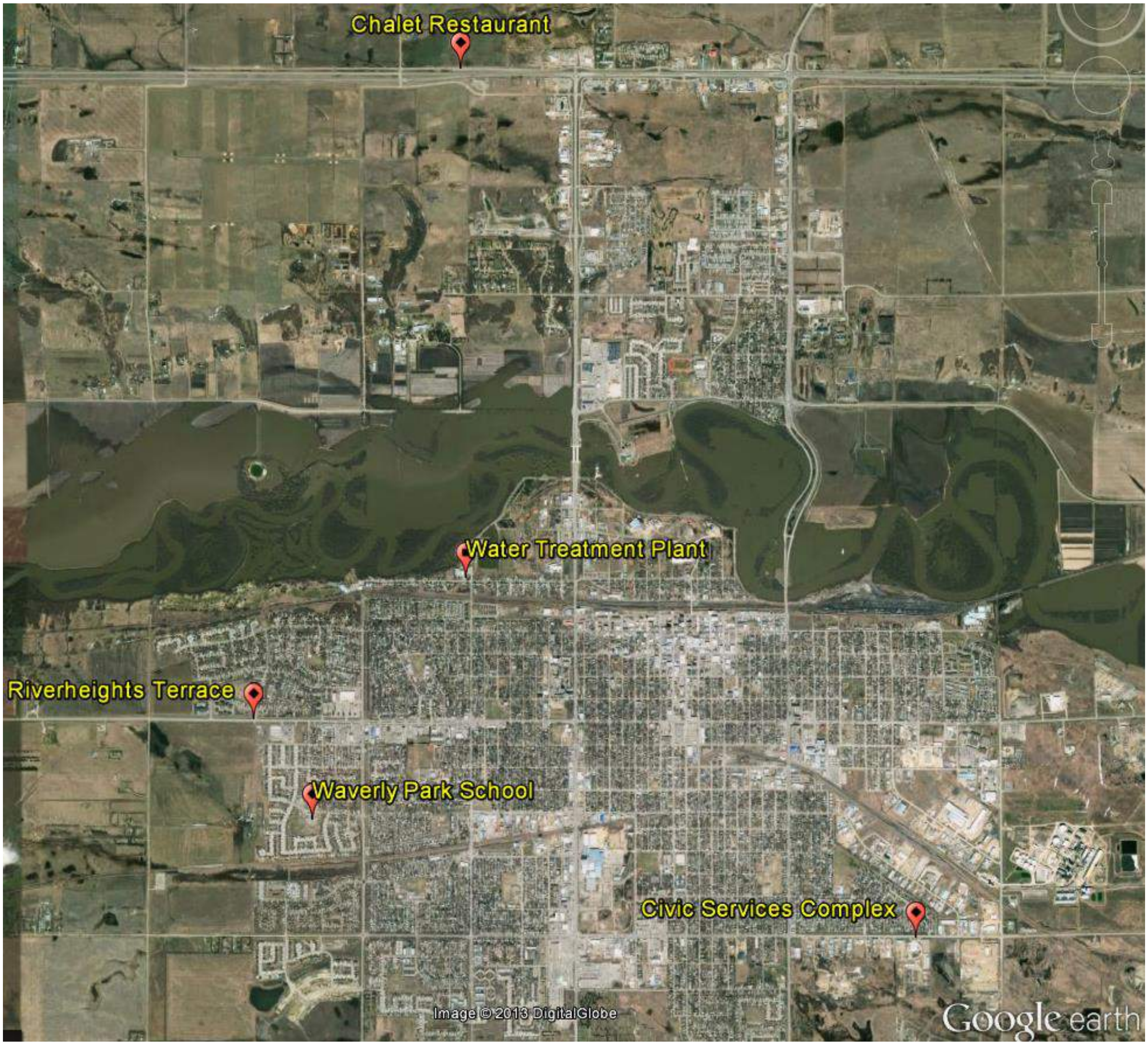


Figure 5.7: Distribution System Sampling Points

Distribution water quality monitoring from 2007-2012 shows that both THMs and HAA are often above GCDWQ limits. Approximately 80% of the THM samples and 60% of the HAA samples were above their respective MACs across all samples, as shown in **Figure 5.8** and **Figure 5.9**.

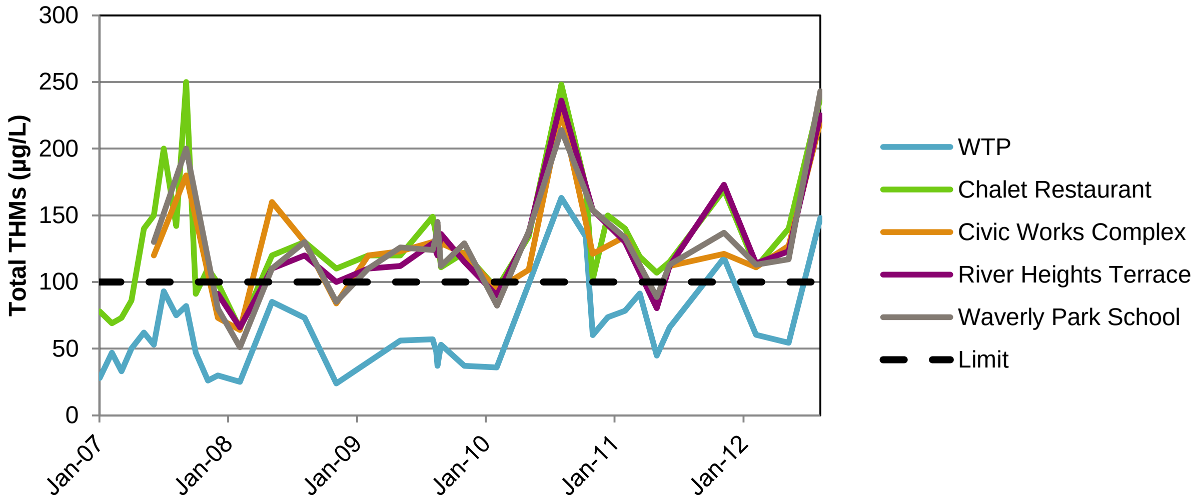


Figure 5.8: Total Trihalomethanes in the Distribution System (2007-2012)

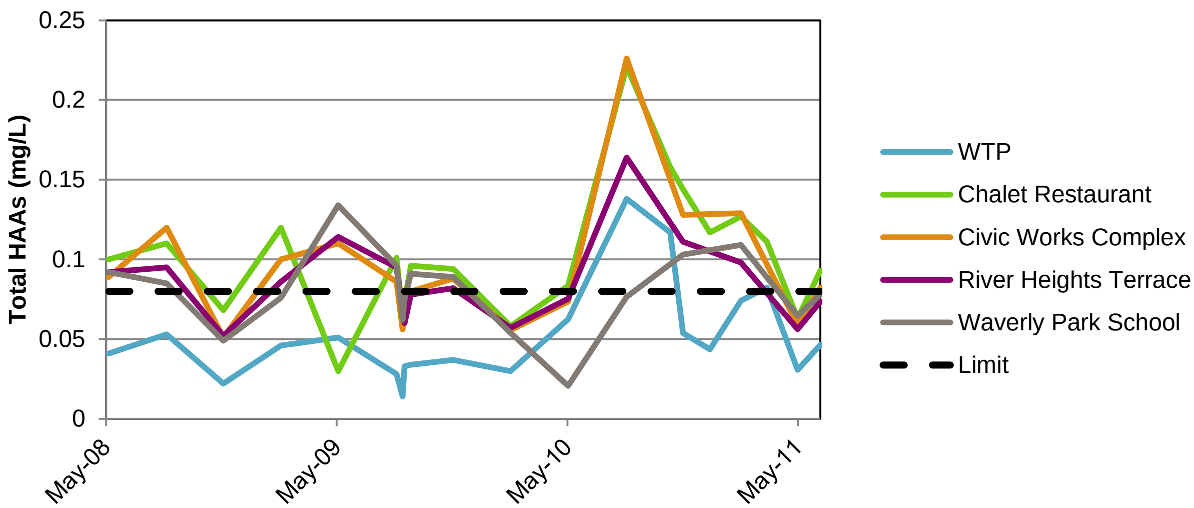


Figure 5.9: Total Haloacetic Acids in the Distribution System (2008-2012)

The production of DBPs appears to be a consistent issue with the current water treatment system. DBP reduction can be achieved by several methods which include reducing influent TOC, using alternative treatment technologies, or disinfection compounds.

5.5.6 Metals

Testing for other metals can provide important data that can be used to achieve a higher level of understanding of water quality in the distribution system and provide an indication of where corrosion is an issue. The data received for this project appears to only include metals analysis for one location in the distribution system; the Civic Services Complex. The *Guidance on Controlling Corrosion in Drinking Water Distribution System* published by Health Canada recommends water quality sampling at least weekly at the entry point to the distribution system, as well as monthly within the distribution system for utilities that employ corrosion inhibitors, pH adjustment and alkalinity adjustment. Future data received by the City for such analysis can aid in determining whether such corrosion control measures should be included in future WTP upgrades.

6. Water Source Options

The existing raw water supply has generally provided sufficient water to meet the plant and distribution system demands. Historically, primary issues have been related to elevated organics, varying water quality, high turbidity and high hardness. In 2008, the 3rd Street dam which sets the water level at the intake had a partial failure. A new dam was recently installed in the fall of 2012.

In 2011, historic flooding highlighted the vulnerability of the existing plant site to floodwaters. The plant was at risk from both direct water inflow and the inability to discharge plant wastes. Several concerns regarding the raw water intake structure have also been raised. Being a surface water source, there is the risk of upstream contamination and/or discharge of pollutants that could challenge the plant's ability to treat to potable water standards.

As part of this Master Plan, the City has requested that all sources of surface and groundwater be investigated to determine the feasibility of providing a long term reliable source of good quality water to Brandon. A detailed assessment of the groundwater options are provided in **Appendix F**, with a summary provided below.

6.1 Surface Water Source Options

6.1.1 Assiniboine River

The City of Brandon currently has a Water Rights Licence that allows for a peak withdrawal of up to 1.17 m^3/s from the Assiniboine River. The licensed annual withdrawal is 14,802 cubic decameters per year which is equivalent to a continuous withdrawal of 0.47 m^3/s. The 2035 average flow requirements are estimated to be 0.30 m^3/s and that peak requirements are 0.51 m^3/s. Both of these values are below the licensed maximum withdrawal rates.

The recorded flows at the Water Survey of Canada's Assiniboine River station near Brandon (05MH013) were used to conduct a frequency analysis of low flows. The low flow analysis was conducted after the construction of the Shellmouth Dam and as such includes the effect of operations of this structure. The analysis indicated that the required maximum daily water demand estimated will not be met in one out of approximately 500 years; the average daily water demand will not be available in one out of approximately 900 years. Both of these frequencies may underestimate the threat to Brandon's water supply as they both assume usage of 100% of the water in the river during periods of very low flow.

Anecdotally it is has been reported that water quality issues affect treatment requirements when the river flows are merely "low". The lowest flow recorded since 1974 is 1.93 m^3/s or nearly 4 times the average daily demand. In other words, if this flow rate causes problems with the water supply, the issues with the Assiniboine River as a water source will occur much more frequently than indicated by an analysis of flow rates alone.

6.1.2 Shellmouth Reservoir

At the present time there are studies being undertaken on the feasibility of increasing the storage in the Shellmouth Reservoir by the installation of gates on the spillway. This would increase the full supply level by approximately 1.5 meters and could allow for a larger minimum release than has been used historically. This project has a number of issues from an environmental standpoint and there seems to be limited chances of successful implementation. In addition there are no guarantees that the operations would be altered to ensure that minimum flows would be increased for domestic withdrawals.

6.1.3 Clear Lake

Clear Lake has been suggested as a water source due to a perception of an abundant supply of high quality water. Clear Lake is approximately 100 km north of the City of Brandon inside Riding Mountain National Park. This option has a number of challenges not the least being the construction of a canal or aqueduct over such a long distance.

Although flow data is limited, it indicates that natural outflows approach zero in the winter and as such withdrawals would draw down the lake levels. This and the Federal jurisdiction would make securing approvals difficult. For this reason this surface water option will not be considered further.

6.1.4 Rivers Reservoir

The Rivers reservoir is located approximately 40 km from the City of Brandon and would require a long and expensive pipeline to get the water to the city. More importantly, it has insufficient capacity to meet Brandon's requirements. The reservoir only stores 30,200 cubic decameters of water, or approximately double Brandon's annual licensed withdrawal. In a drought year, the reservoir would need to be drawn down to less than half of the full supply level just to meet Brandon's licenced withdrawal. This would be unacceptable from both recreational and environmental standpoints. For this reason this surface water option will not be considered further.

6.2 Groundwater Source Options

Groundwater is available both in close proximity to the City of Brandon and at a distance from the City which could potentially be used to address the City's water quality issues by either supplementing the existing supply or switching to a groundwater source supply. To date, the City has established two emergency supply wells within the Assiniboine River Valley and has recently been undertaking studies to potentially utilize groundwater (partially or wholly) to address the water quality issues. As part of this Master Plan, AECOM retained W.L. Gibbons & Associates Inc. to undertake a detailed assessment of the groundwater aquifers within the Brandon region.

Previous studies have demonstrated that there are technical and financial advantages to the use of groundwater. However, developing a sustainable groundwater source is technically challenging and has considerable risk associated with it, primarily related to the sustainability of the sources and potential effects on existing groundwater users. A series of staged, long-term studies will be required to obtain the necessary information to address the issues associated with developing a groundwater source.

The City's two existing groundwater supply wells located at the Canada Games Park and the Turtle Crossing Park withdraw water from the ARVA. These wells were originally installed in 1997 as an emergency back up to the river water supply. Due to limited recovery rates the City only draws up to a maximum 1900 Cubic Decameters per year. They blend as much as 60% groundwater during spring, when runoff starts and the river water is very turbid and cold. Operations gradually slow down the wells as soon as the river turbidity begins to lower in order to save the volume of available water in the aquifer. In general, when blending occurs it is less than 25% groundwater.,

The ARVA aquifer is located beneath the river valley and is hydraulically connected to the river. In addition, the ARVA is connected to the Brandon Channel Aquifer (BCA) on the east side of the City from which both Koch and Canexus (and potentially Maple Leaf in the future) withdraw water. Studies to date have demonstrated that the hydrogeology of this aquifer system is very complex and as such, it is not possible to accurately calculate the sustainability of any withdrawal and how this may affect both the aquifer water levels and the existing users. An example of this complexity includes an observed significant variability in the recharge rate to the ARVA with initial results indicating that even short-term withdrawals were not sustainable on a year to year basis, and other results which indicated that recharge rates can be very high when surface water conditions are optimum and the short-term withdrawals become sustainable. The implications of this are that there is a significant risk associated with developing a reliance on groundwater from the current two wells, as the withdrawals may not be sustainable over the long-term. Experience with similar situations has shown that the only reasonable method of addressing this risk is through the incremental development of the groundwater supply, coupled with long-term monitoring which is then used to establish the long-term safe withdrawal rates.

Another factor to be considered in the potential development of the ARVA and BCA aquifer system is that both Koch and Canexus have relied on groundwater withdrawals to sustain their operations since the 1960's. Should the City's development of groundwater adversely affect these operations, there is a potential economic consequence to the City from the curtailing or shutdown of these operations. The risks of this occurring and the potential consequences to the City have to be considered in any groundwater development plans. It is noted that Canexus is currently working to expand its groundwater withdrawal rate, and that Maple Leaf Foods is investigating developing a groundwater supply for its operations. These potential increases to the groundwater withdrawal rate from the BCA increase the potential that the sustainable limit of the aquifer system will be reached, and increase the risks associated with the City's potential development of groundwater from this aquifer system.

Other potential sources of groundwater may be available at a distance from the City of Brandon and could potentially be used to supplement the City's water supply. The most significant of these is the Assiniboine Delta Aquifer (ADA) located a short distance east of the city. The ADA is a major aquifer system that has been the subject of long term studies and monitoring. As such, its recharge mechanisms are well understood and the effects of any withdrawals are predictable. At present, there is an allocation limit in place that precludes the issuance of any new licenses for water withdrawals. However, provincial policy allows for new users to acquire the licenses from existing users which would be one means for the City of Brandon to access water from this aquifer. There is also the potential that the allocation limits could be raised as new studies have indicated that higher than current withdrawal rates may be sustainable. Wastewater reuse and/or groundwater recharge may also play a key role in assessing the viability of long term groundwater supplies for the City.

As mentioned at the end of Section 3, there is a possibility of providing industries in Brandon with an alternative water supply through the WRF. By providing Koch with an alternate water supply, it may be possible to purchase their groundwater rights. Combined pumping from both the existing wells and the Koch site vicinity could provide the year 2035 average day demand for the City, although this would need to be confirmed with long-term testing. Regulatory and ministerial approval would also be required.

6.2.1 Bedrock Aquifers

6.2.1.1 Odanah Shale Aquifer

The Odanah Shales are present both to the north and south of the City of Brandon. The well yields in this aquifer are generally low and suitable primarily for domestic wells. It is very unlikely that a groundwater supply system of a capacity suitable for the City of Brandon's water supply requirements could be developed.

6.2.1.2 Boissevain and Turtle Mountain Formation Aquifers

These aquifers are found in the Turtle Mountain Uplands. The yields of wells established within these formations are generally low and would not be suitable for use as part of the City of Brandon water supply.

6.2.2 Sand and Gravel Aquifers

Numerous sand and gravel aquifers exist in the area, most are small and will not sustain the supply required by Brandon. The major sand and gravel aquifers are as follows:

6.2.2.1 Assiniboine Delta Aquifer

The ADA is the single largest source of groundwater in the City of Brandon area. The deposits extend over an area of 3,800 km^2 from just east of the Brandon city limits to near MacGregor, MB. The hydrogeology of the ADA is well understood and water could become available if the allocation limits were raised. If access to water can be achieved, the risk of not being able to obtain water is low. The capital cost or pipelines and infrastructure, as well as potential costs to compensate existing users will be significant. It is unlikely that the City would be able to get access to the full year 2035 average day demand (289 L/s) and therefore, would likely still need to pump existing wells.

6.2.2.2 Oak Lake Aquifer

The Oak Lake Aquifer is located west of Souris, MB. Similar to the ADA, recharge is by direct infiltration of precipitation. The allocation for this aquifer is 9,250 cubic decametres. Some potential does exist to develop high capacity wells in the portion of the aquifer located approximately 115 km from the City. However, the development of these wells would result in extensive drawdown effects, and the associated third-party and environmental effects. Based on these negative effects and the length of the pipeline needed to deliver the water, the potential to obtain water from the Oak Lake Aquifer is considered very low.

6.2.2.3 Spiritwood Aquifer

The Spiritwood Aquifer (Margaret-Killarney-Cartwright Aquifer Complex) is located a distance 60 to 100 km southeast of the City of Brandon. Past work in the area has found wells showing a potential of producing 76 L/s. Development of the aquifer is mainly the result of low demands for water in the area. Due to this low demand only limited amount of work has been conducted to investigate this system and determine its potential capacity. Pursuing this potential source will require a substantive exploration program to define the limits and characteristics.

6.2.2.4 Assiniboine River Valley Aquifer

The ARVA from which the City of Brandon currently withdraws water is one of a series of aquifers contained within the river valley upstream of the City. For example, water supply systems are currently being operated at Virden and the RM of Wallace. In general, the potential for these deposits to be developed as water supplies have never been investigated to any significant degree. Evaluating the potential to use these aquifers as a water supply would require hole-drilling and installation of pumping wells and tests.

6.2.2.5 Buried Valley Aquifers

The Buried Valley Aquifers consist of sand and gravel deposits in valleys erode into the bedrock surface and then subsequently covered by glacial till and other sediments. Less exploration for these aquifers have been done in Manitoba due primarily to the abundance of shallow sand and gravel and bedrock aquifers. It is very difficult to predetermine the sustainable yield of these aquifers, often taking years. In some cases, where initial estimates of recharge rates have been too high, it has been necessary to reduce pumping rates or cease completely. Given the high risks associated with these types of deposits, using these aquifers as a water source should be approached with a high level of caution.

6.3 Selection of Water Source

In Section 3, the approach to decision making was described. As part of this process a Water Supply Decision Making Workshop was held on April 23, 2013 at the Victoria Inn in Brandon with the following attendees; Ted Snure, Ian Christiansen, Patrick Pulak, Brad McIntosh, Alexia Stangherlin, Louisa Garbo, Scott Hildebrand, Gerald Cathcart, Ryan Nickel, Dean Hammond, and Brian Kayes of the City of Brandon; Keith Sears, Ray Bilevicius, and Owen Van Walleghem of AECOM; and Steve Wiecek of W.L. Gibbons. Individual TBL criteria was discussed and reviewed, with the following being selected by the workshop attendees.

6.3.1 Economic

The economic influence in the decision making process is to minimize costs for the project, including both capital costs and operating and maintenance (O&M) costs. For this reason, the overall index weight of 40% was applied to this TBL index category. When looking at the O&M costs for this evaluation as well as the siting option evaluation discussed later, a 20 year net present value was applied at a 4% discount rate.

Other economic criteria used in the evaluation were to also minimize any costs that may be incurred for future expansions or to meet more stringent regulatory requirements; this was weighted low by the City. Higher weights were applied to the possibility of dependence on commodities that may be subject to market viability as the goal of the City is to reduce these risks. There may be the opportunity for the City to obtain external funding for the capital costs through grant money; this potential would be maximized to reduce the overall capital cost for the City.

In summary, the criteria for the economic TBL category are as follows:

- Minimize capital cost.
- Minimize O&M cost.
- Minimize cost for future expansion and to meet more stringent regulatory requirements.
- Minimize dependence on commodities that are subject to market variability.
- Maximize opportunities for grant funding.

6.3.2 Environmental

For the Environmental TBL Index category, the capacity of the potential water supply source and the risk potential of the source supply becoming contaminated were criteria of high concern for the City. The water source will also dictate the level of treatment required. Scenarios will be evaluated based on 100% surface water, 100% groundwater and varying degrees of blending options to minimize the treatment level required.

In summary, the criteria for the Environmental TBL category are as follows:

- Ability to meet higher treatment standards without additional costs.
- Minimize risk associated with obtaining the necessary water quantity.
- Minimize risk associated contamination of the water supply.
- Minimize risk associated with flooding.
- Maximize sustainable outcomes.

6.3.3 Social

The selection of the raw water supply must be consistent with the City's *Environmental Strategic Plan* (2007). However, more importantly to the City, it must not bring risk or harm to the public or the operations staff. This may be from emission exposure, or chemical transportation/handling.

In summary, the criteria for the Social TBL Category are as follows:

- Consistency with the City's vision and policies.
- Minimize risk to the public from air/other exposure during processing/transportation.
- Minimize risk to staff safety.
- Minimize current and future community impacts during normal plant operation.
- Minimize the risk of negative public opinion.
- Maximize opportunities for partnerships to support regional growth.
- Minimize community impacts during construction.

- Avoid reduction of property values as a result of an expanded plant.
- Minimize risk associated with regulatory licensing.

6.4 TBL Weighting

Weights were applied to each of the category performance siting option criteria based on the level of importance to the City, as already described, in terms of each individual criterion relative to the overall criteria in the evaluation.

The capital cost of sourcing raw water from either groundwater wells, surface water or a combination of the two in a blend ratio is rated as a high level of importance for the City. The goal in evaluating each raw water source option was to minimize the overall capital costs. For this reason the capital costs had a high importance index of +4 applied with an overall weighting of 17.8% of the total Economic Index Category of 40%. Other criterion with high importance weighting was the available capacity of the raw water supply as it is essential to developing a sustainable raw water source. This is reflected in the Environmental Index category where a weight of 13.3% of the total 30% is carried. The Social TBL Index rated a high relative level of importance on staff and public safety, with a total of 10.4% overall total weighting. **Table 6.1** represents a summary of each of the TBL Index weights for each category applied in evaluation and scoring the water source options.

Table 6.1: Summary of TBL Index Weights for Water Source Options

TBL Index	Overall Index Weight (%)
Economic	40
Environmental	30
Social	30
Total TBL	**100**

6.5 Proposed Water Source Evaluation

The evaluation of a proposed raw water source, being completely groundwater, surface water or a combination thereof; and based on the information preceding this evaluation summary, five potential raw water source options were selected. As noted in Section 2.2, the current raw water line in not twinned, potentially being a source of failure for the water supply. The proposed pipeline routings on the plan shows single pipelines as well as twinning routes. Refer to **Figure 6.1** for a general overall layout of the proposed raw water source options. **Appendix G** contains the detailed TBL evaluation and scoring sheets for each of the raw water source options. The water source options were evaluated and scored at the workshop with the details summarized below.

6.5.1 Option 1 – Assiniboine River and Emergency Wells.

As Option 1, the existing raw water source of the Assiniboine River and the Emergency Wells as the base case scenario, receives a score as 0.0 in the sense that all would remain as is. This is maximizing the use of the existing infrastructure as the surface water intake structure and supply and distribution piping is already in place.

Water quality from the Assiniboine River generally tends to be high in colour, hardness, dissolved solids and turbidity. TOC levels range from 8-16 mg/L throughout the year, which is believed to cause a majority of the issues related to DBP formation in the distribution system.

6.5.2 Option 2 – Groundwater from Aquifers BCA + ARVA

Option 2 is using exclusively groundwater from around the Koch area being aquifers BCA and ARVA, described in the above section. This raw water source option scored the 'best' relative to the other options evaluated with the TBL method.

Water from these aquifers tends to be low in organics, low turbidity and moderate hardness relative to the Assiniboine River. In the Economic category, the TBL score was a 40.0. The City scored high on the criterion of chemicals required for treatment, with a groundwater source requiring less dependency on them. This would minimize chemical handling, power requirements, and delivery. Capital costs would be required for the supply piping of approximately 3.3 km of pipeline required, whether it is a single line or twinned for redundancy.

In the Environmental TBL evaluation, the wells, being outside of the 1:300 year flood boundary was given full scoring points. In addition, sustainability of the well and the risk of contamination were low; these were also awarded with the +4 scoring. The performance criterion that scored the lowest was in the Social category for regional and socio-economic growth. This source option resulted in less opportunity for regional growth. **Table 6.2** summarizes the findings of the TBL score for each category.

Table 6.2: Groundwater from Aquifers BCA + ARVA TBL Scoring Summary

TBL Index	TBL Scoring
Economic	40.0
Environmental	33.3
Social	2.6
Total	**75.9**

6.5.3 Option 3 – Groundwater from Aquifer ADA

Looking at other groundwater options in the near Brandon area, the ADA aquifer from the Shilo area is referred to as the Option 3 raw water source option. Although this option is also a groundwater option, its distance does not score it as favourable from a capital cost perspective requiring approximately 21 km of piping. However it does score high in the O&M and sustainability criteria for ease of maintenance and low chemical requirement. Water from this aquifer appears to have relatively low turbidity, and moderate hardness when compared to the Assiniboine River. It is expected that the organics content from this well is also relatively low, although this has yet to be confirmed.

There is concern on the water supply sustainability with the Shilo source capacity, which would be a risk for the City to commit to develop such a length of pipe with uncertainty of its long term capacity. However the site is not inside the 1:300 year flood boundary and is a good source in terms of water quality, rating it a positive score, although still resulting in an overall score of -13.3 for the Environmental category. Through the evaluation, the City scored negatively to the criteria of developing outside of the region as well as from the public. **Table 6.3** shows the TBL scoring summary for this option.

Table 6.3: Groundwater from Aquifer ADA TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-13.3
Environmental	-13.3
Social	-24.8
Total	**-51.4**

6.5.4 Option 4 – Blending of Assiniboine River and Aquifers BCA + ARVA

Option 4 references the raw water source for blending river water with groundwater from the Koch wells. For the purposes of the evaluation, it was assumed that a ratio blend of 50/50 split would be used. The only positive scoring was for the Economic TBL category at 4.4 points. This would be resulting from the scores being marginally positive with using the Koch wells for groundwater due to their location.

The blending of these water sources resulted in a score equivalent to the existing plant water source for potential of water supply contamination, risk of flood and sustainability. Further investigations are required to determine if the capacity of the existing Koch wells can meet supply in a 50/50 blend ratio, or more or less. **Table 6.4** shows the summary of the TBL scoring.

Table 6.4: Groundwater from Blending Assiniboine River and Aquifers BCA + ARVA TBL Scoring Summary

TBL Index	TBL Scoring
Economic	4.4
Environmental	-10.0
Social	-2.6
Total	**-8.2**

6.5.5 Option 5 – Blending of Assiniboine River and Aquifer ADA

Similar to Option 4 is Option 5, which is the blending of the Assiniboine River with the groundwater supply from Shilo. This Option is not as ‘negative’ as the 100% groundwater supply from Shilo as the use of the existing surface water supply provides improvements to the scoring. The pipeline is smaller (900 mm reduced to 600 mm) however the length is still significant at 21 km. The negative score associated with public perception and regional development still exists with the supply coming from Shilo. **Table 6.5** shows the summary of the TBL scoring.

Table 6.5: Groundwater from Blending Assiniboine River and Aquifer ADA TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-8.9
Environmental	-13.3
Social	-52.2
Total	**-74.4**

6.6 Selection of Water Source

The result of the raw water sourcing TBL evaluation was that the raw water source should be groundwater, based on the results of the TBL evaluation. The Koch wells scored the most positive at 75.9 with the existing plant being the base case at 0.0. Detailed TBL scoring for the five options is provided in **Table 6.6** with a summary as follows:

It was later discussed in a separate meeting held between the City and AECOM regarding the raw water supply, that there is some value of maintaining the surface water as a raw water source in consideration that the supply intake and related infrastructure is in place and can continue to provide service.

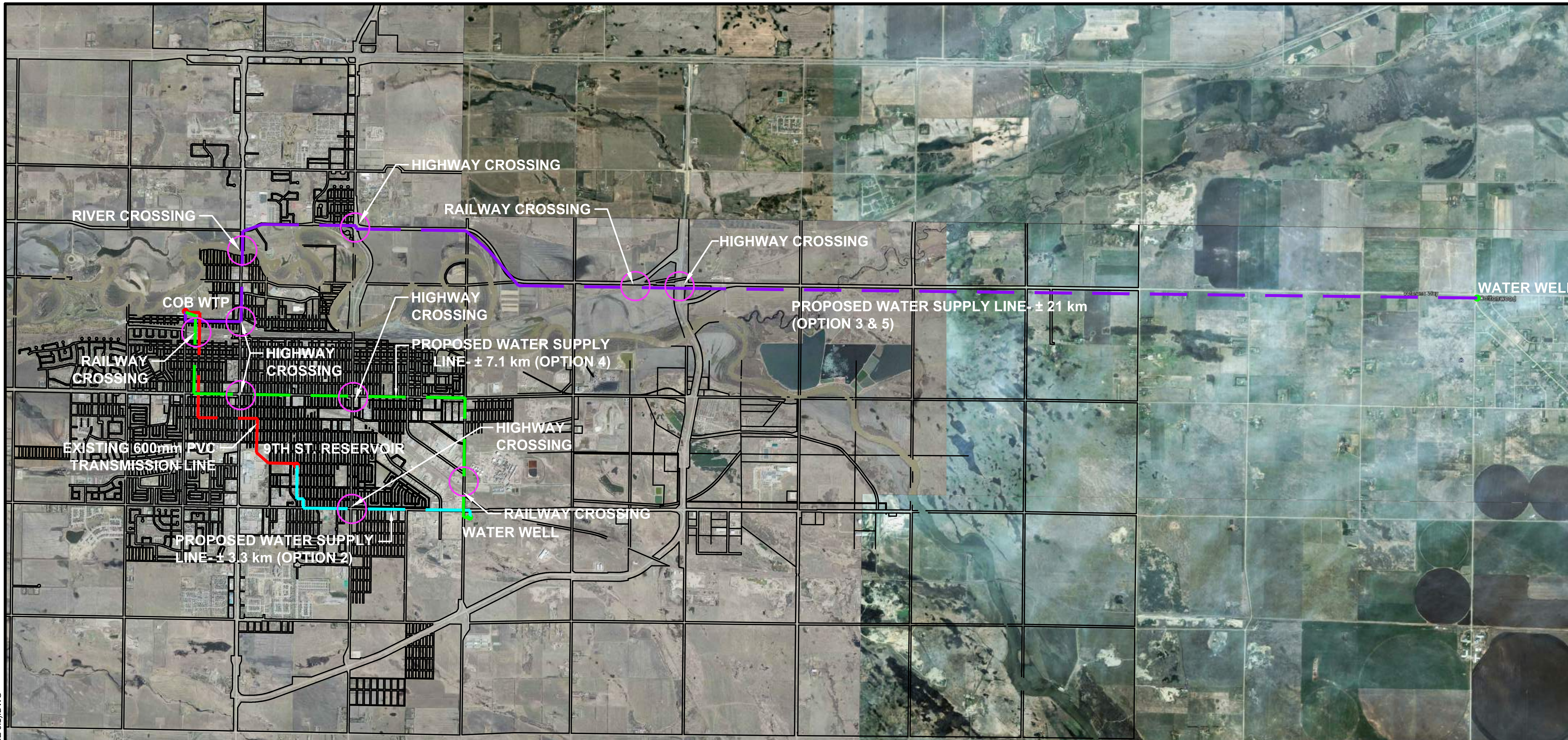
Table 6.6: Raw Water Source TBL Scoring Results

Rank	Water Source Option	Score
1	Option 2 – Groundwater from Aquifers BCA + ARVA	75.9
2	Option 1 (Base Case) – Assiniboine River and Emergency Wells	0.0
3	Option 4 – Blending of Assiniboine River and Aquifers BCA + ARVA	-8.2
4	Option 3 – Groundwater from Aquifer ADA	-51.4
5	Option 5 – Blending of Assiniboine River and Aquifer ADA	-74.4

The degree to which surface water is used will greatly affect the treatability of the water supply. Significant time, (approximately five years) is required to further investigate the development of the groundwater wells for capacity. It is anticipated that while this investigation occurs, the City could continue to use the existing surface water source of the Assiniboine River.

Figure 6.1

PROPOSED RAW WATER SOURCE OPTIONS



Option 2:
Scenario 1 - 100% MDD (510 L/s), Twinned Supply Line
Twinned pipe: 450 mm

Scenario 2 - 100% MDD (510 L/s), Single Supply Line
Single pipe: 600 mm

Option 2: Deliver 25% of MDD from 9th St. reservoir to WTP

Option 3:
Scenario 1 - 100% MDD (510 L/s), Twinned Supply Line
Twinned pipe: 600 mm

Scenario 2 - 100% MDD (510 L/s), Single Supply Line
Single pipe: 900 mm

Option 4:
Scenario 1 - 50% MDD (255 L/s), Twinned Supply Line
Twinned pipe: 300 mm

Scenario 2 - 50% MDD (255 L/s), Single Supply Line
Single pipe: 450 mm

Option 5:
Scenario 1 - 50% MDD (255 L/s), Twinned Supply Line
Twinned pipe: 450 mm

Scenario 2 - 50% MDD (255 L/s), Single Supply Line
Single pipe: 600 mm

LEGEND:

- ***EXISTING TRANSMISSION LINE*** (red)
- ***PROPOSED WATER SUPPLY LINE (OPTION 2)*** (cyan)
- ***PROPOSED WATER SUPPLY LINE (OPTION 3 & 5)*** (purple)
- ***PROPOSED WATER SUPPLY LINE (OPTION 4)*** (green)

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081 2013-05-16

Project Management Initials: _ Designer: _ Checked: _ Approved: _ ANSI B 279.4mm x 431.8mm

Last saved by: LAPOINTEP1(2013-12-17) Last Plotted: 2013-12-17
Filename: P:\60275081\000-CADD\03-SKETCHES\C60275081-FIG-20-C-0001 (FIGURE 6.1).DWG

7. Water Treatment Plant Siting Options

Five potential sites for the future WTP were selected using preselected criteria and weighting. Using the TBL methodology, the five locations were evaluated, scored and ranked. The following section discusses the siting options criteria, the weighting applied as well as the results for each potential location.

7.1 Site Selection Criteria

A pass/fail approach was initially applied to narrow down the five sites. All potential locations were required to be within the City of Brandon limits and above the approximate 1 in 300 year flood event elevation. In addition to these restrictions, the City had developed a “City Owned Land Development Plan” noting potential future development locations within the City limits in a ‘10 year’, ‘20 year’ and ‘Beyond’ forecasts. Areas also identified on the Plan were based on the degree of development (potentially, partially, developable, non-developable or reserved). These areas were excluded in the site selection. The City would also only consider for acceptance sites that were City-owned or privately-owned as potential candidates for new sites. Refer to **Figure 7.1** for a map of WTP location options and development zones.

As part of the selection evaluation, the existing WTP site was included as one of the five potential locations. The existing WTP consists of four distinct plant expansions (areas) with the earliest constructed in 1905 and the latest being the sludge dewatering building in 1997. The findings in the Code and Condition Report summarized significant upgrades required at the existing plant in order to maintain treatability and address safety concerns. In consideration of the upgrades required at the existing and the varying infrastructure costs at a new WTP Site, the existing WTP would be considered as the base case for a fair comparison between the new sites.

Siting option selection criteria were developed between the City and the AECOM during a workshop held on May 21, 2013. The TBL Index categorizes economic, environmental and social performance based on these siting option selection criteria, which are summarized below.

7.1.1 Economic

The selection of each site option was based on maximizing existing infrastructure to minimize capital and operating costs. The proximity of the new site to the existing surface water intake structure and groundwater supply wells, as well as access to the distribution system, was used as a guide. In addition, the new plant would need to be relatively accessible to the existing sewer system.

The approximate size of the new WTP building, with consideration for possible expansion, was also taken into account. The new land site area at a minimum had to accommodate the equivalent size of the existing WTP building.

7.1.2 Environmental

From an environmental perspective, access to the site must be with a major road for ease of large truck consumable deliveries and residual disposal. A major road would also increase the security of the site and access by emergency response vehicles. The disposal of the reject / backwash water to an alternate location than the sewer system would also need to be taken into account.

7.1.3 Social

The social impacts of the selection of the new sites would not be high as public consideration would have been taken into account during the initial selection. However, in the event that one of the sites was selected on private land, the land would have to be appropriated by the City. This would have to be resolved prior to any development. The overall Index weights summarized in **Table 7.1** reflect this as the Social TBL Index is only carrying 10% of the total index weight.

7.2 TBL Weighting

Weights were applied to each of the category performance siting option criteria based on the level of importance to the City in terms of each individual criterion relative to the overall criteria in the evaluation.

The capital cost of building the new WTP in a new location and the ability to reuse any of the existing assets rated as a high level of importance for the City. The goal for each site is to minimize the overall capital costs. For this reason the capital costs had a high importance index of +4 applied with an overall weighting of 40% of the total Economic Index Category of 60%. Other criterion with high importance weighting was the hydraulic impact to the overall distribution system and the disposal of the reject water. These are reflected in the Environmental Index category where both are weight as 10%. **Table 7.1** summarizes the weights applied for each TBL Index for evaluating each siting options.

Table 7.1: Summary of TBL Index Weights for Siting Option

TBL Index	Overall Index Weight (%)
Economic	60
Environmental	30
Social	10
Total TBL	**100**

7.3 Proposed Site Location Evaluation

7.3.1 Option 1 – Hydro Site

The proposed Option 1 site is referred to as the “Hydro” Site and was selected as a potential option for the new WTP due to its proximity to the Municipal Wastewater Treatment Plant (MWWTP) and major transportation routes. The proposed site is on the north side of Victoria Avenue East between Shape Foods Inc. and the Manitoba Hydro Service Centre, as shown in **Figure 7.2**. The site is outside of the 1:300 year flood boundary, however it is still in close proximity to the flood boundary. The MWWTP and the City of Brandon Landfill are both on Victoria Avenue East, therefore the additional heavy traffic required for operations was considered to have marginal additional impact as truck traffic routing is already common. From a public perspective the area is already prone to industrial activity.

This location is in closer proximity to the existing raw groundwater wells 1 and 2 than to the surface water intake. Approximately 6 km of forcemain would be required from the intake structure whereas approximately 2.2 km of piping would be required for the raw groundwater supply. A new 4.4 km forcemain would transfer the treated water to the 9th St. Reservoir. **Figure 7.2** shows the proposed supply and distribution piping arrangement for this site. The proposed piping routes for a raw line and the transmission line would each require crossing two highways and one railway; six crossings in total. The existing sewer main runs along Victoria Avenue East discharging into the MWWTP further down the road. A short gravity sewer connection (approximately 700 m) into the main wastewater sewer system for discharge of WTP-generated wastewater would be required.

A summary of the TBL scoring is outlined in **Table 7.2**. The capital cost of locating the WTP to the Hydro site proved to be high. The City would not be able to reuse any of the existing assets at the WTP, and cost of construction a new facility in a Greenfield site would be significant. There are added benefits to this location from an Environmental perspective, as the site is easily accessible and the method of disposal of the reject water is mostly in place with the utilization of the forcemain to discharge to the Lagoons. In the Social Index category, the City scored high in its land use suitability, as the Site already met the industrial zoning requirements. There was some discussion on the public perspective of having the WTP in such close proximity to the MWWTF. Additionally, the City does not currently own the property. These items were reflected negatively in the scoring.

Table 7.2: Hydro Site TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-120.0
Environmental	75.0
Social	-7.5
Total	**-52.5**

The budgetary cost for the supply and distribution piping for the proposed “Hydro” Site Option is estimated to be $18.3 million.

7.3.2 Option 2 – 1st and Rosser

The proposed site Option 2, known as “1st and Rosser” Site, was selected as a means to evaluate a potential location within the City Limits. The Site is bounded by railway tracks and the river to the north and residential areas to the south. The 1st street route runs north-to-south and would provide a direct route out of the City. However, this location is not an industrial zone, therefore the area would see an increase in truck traffic during deliveries. This may not be favourable to the public.

The site is approximately midway between the intake structure and the existing groundwater wells. Approximately 5.3 km of groundwater piping and 2.8 km of surface water piping would be required for this option. The treated water would be conveyed approximately 2.6 km to the 9th St. reservoir. A total of five crossings would be required for the proposed routings for both highway and railway traffic. **Figure 7.3** shows the proposed supply and distribution piping arrangement for this site. Approximately 100 m of gravity sewer line would be needed to tie into the main wastewater sewer. Although the Site is outside of the 1:300 year flood boundary, it is still in close proximity.

As with the Hydro Site, the new facility would prevent the reuse of any existing WTP assets. **Table 7.3** summarizes the results of the TBL evaluation. The Economic Index scored the same as the Hydro Site for the same reasons of the lack of reusable assets and the cost of a new plant. The Environmental Index was less favourable the Hydro Site but still very positive. The site scored low for access, as it is located in a residential area, and for disposal of WTP wastewater. It was seen as equal to the existing plant when it came to the site security and site access.

Table 7.3: 1st and Rosser TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-120
Environmental	22.5
Social	-5.0
Total	**-102.5**

The budgetary cost for the supply and distribution piping for the proposed “1st and Rosser” Site Option is estimated to be $16.5 million.

7.3.3 Option 3 – Aberdeen

Option 3 is referred to as the “Aberdeen” Site. The site is in a developed Industrial Park on the southern edge of Brandon. It is accessible by either 1st Street or Richmond however upgrades would be required on 17th Street East to accommodate truck traffic. From a public perspective, traffic would not be noticeable as the site is in an Industrial location and is located on the outskirts of the City. This location would require approximately 6.9 km of piping to the intake structure as well as from the groundwater wells at approximately 4.5 km. The transmission line to the Brandon

9th Street Reservoir would follow Richmond and require approximately 3.8 km based on the preliminary routing as shown in **Figure 7.4**.

Some land development would be required for the site and due to its distance from the existing WTP. Because of this, reuse of assets would be almost minimal, therefore this site scored low in the Economic Category.

The Environmental and Social categories both scored in the positive on the TBL scoring, showing 80.0 and 7.5 respectively, as shown in **Table 7.4**. The site is easily accessible for delivery, security and emergency response and is the furthest of the Options from the 1:300 year flood boundary.

Table 7.4: Aberdeen Site TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-160.0
Environmental	80.0
Social	7.5
Total	**-72.5**

The budgetary cost for the supply and distribution piping for the proposed “Aberdeen” Site Option is $21.3 million.

7.3.4 Option 4 – Jail

In selecting potential site options for the new WTP, areas were evaluated to the north of the Assiniboine River and the 1:300 year flood boundary. Option 4, known as the “Jail” Site is the area located between 1st Street North and the Jail, in the northeast corner of Veterans Way and 1st Street North. This Option proved to score the least of all the Options when evaluated by the City and AECOM. The raw water and distribution piping would have to cross the river resulting in approximately 11 km of total raw piping and 5.6 km of treated water piping. Highway and railway crossings would also be required. **Figure 7.5** shows the proposed piping routing.

The economic category scored -240.0, the lowest possible score. The evaluation of the site resulted in TBL scoring of -4 for the reuse of existing assets and capital costs. The cost of the piping was significantly higher than the other options based on the preliminary routing. The Jail Site is easily accessible from 1st Street North, scoring positive in security and site access. It would also be within the public view and may not prove to be a positive public image. Also, some property acquisition may be required for this site. For these reasons, the evaluation of the site resulted in a negative Social category.

Table 7.5: Jail Site TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-240.0
Environmental	10.0
Social	-12.5
Total	**-242.50**

The budgetary cost for the supply and distribution piping for the proposed “Jail” Site Option is approximately $28.7 million

7.3.5 Option 5 – Existing WTP

The existing WTP was used as the base case for the evaluation of the sites for a new WTP. New raw groundwater piping would be required in this option as the site currently has piping only to the intake structure from both the river and the emergency wells. The estimated length of the piping from these wells is approximately 8 km based on the proposed routing. Refer to **Figure 7.6** for the proposed route. The existing transmission piping would remain in service to the 9th St. Reservoir.

The budgetary cost for the groundwater supply piping for the existing WTP is approximately $13.7 million

7.4 Selection of Water Treatment Plant Site

In following the outlined decision making process and TBL methodology, the results showed that building a new WTP may not be economically viable. A summary of the costs for the supply and distribution piping for each Option is shown in **Table 7.6**. The existing WTP site was found to be the most cost effective Option from the others. This investment shown in **Table 7.6** must be made at the existing WTP in addition to costs required for a new WTP.

Table 7.6: Summary of Capital Costs for Supply and Distribution Piping

Rank	Description	Cost Estimate
1	Option 5 – Existing WTP	$ 13.7 M
2	Option 1 – Hydro Site	$ 18.3 M
3	Option 3 – Aberdeen	$ 21.3 M
4	Option 2 - 1st and Rosser	$ 16.5 M
5	Option 4 - Jail	$ 28.7 M

The TBL evaluation scores are summarized in **Table 7.7**. More detailed results for the evaluation for each Site Option can be found in **Appendix H**. The existing WTP site scored the 'best' relative the other sites evaluated. It was set as the base case; however through the evaluation it was found that a new plant in a new location would require a significant increase in capital costs.

Table 7.7: WTP Siting TBL Scoring Results

Rank	Site Selection Option	Score
1	Option 5 (Base Case) – Expand on the Existing WTP Site	0.0
2	Option 1 – New WTP on Manitoba Hydro Site	-52.5
3	Option 3 – New WTP on Aberdeen Site	-72.5
4	Option 2 – New WTP on 1st and Rosser Site	-102.5
5	Option 4 – New WTP on Jail Site	-242.5

The Hydro and the Aberdeen Sites (both located in the east) were comparable in the scoring results. To further evaluate whether to build a new WTP or to expand on the existing site, power consumption and operating costs were theoretically calculated for both Site Option scenarios.

- **Table 7.8** shows the results in the estimated O&M costs for both scenarios. The O&M costs were comparable, differing by $20,000 in favour of a new site.
- For the scenario of a new plant site, the average pump requirements and piping costs for the two new plant locations were used in the evaluation. The capital costs for the distribution and supply piping for a new site may be higher than what is presented in **Table 7.8**.

- The increase in the existing site O&M would be from the additional pumping to provide the groundwater to the existing site as well as the use of a new lift station for the wastewater generated during treatment.

Table 7.8: Cost Summary and Comparison for New WTP vs. Existing

WTP Site Options	Raw Water Supply		Distribution	Capital Costs	Operating and Maintenance	
	Well Water 287 L/s	Surface Water 96 L/s	Treated Water 300 L/s		Estimated Annual O&M	20 Year Net Present Worth (4% Discount)
Eastern Site: 1 – Hydro Site or 3 – Aberdeen Site	94 kw (126 hp)	25 kw (34 hp)	38 kw (52 hp)	$19,800,000	$ 80,000	$ 1,100,000
5 – Existing Site	144 kw (193 hp)	28 kw (37hp)	67 kw (90hp)	$13,700,000	$ 100,000	$ 1,400,000

The routing to the each of the new plant locations is proposed, noting that the both sites are Greenfield and that investigations would need to be conducted to evaluate existing underground piping. Another aspect not fully investigated for this evaluation is the supply of ample site power at each site. Although this was reflected in the TBL scoring, the costs of providing new power were not carried in the capital.

In summary, it was found that there is value in the existing WTP site. The existing site proved favourable during the capital cost evaluation for the new supply and wastewater piping; the distribution piping would remain intact. Also, in the TBL evaluation scoring, the existing site continued to prove more favourable then constructing a new WTP on at a new location.

AECOM

City of BRANDON

Figure 7.1

PROPOSED WATER TREATMENT PLANT LOCATIONS

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081

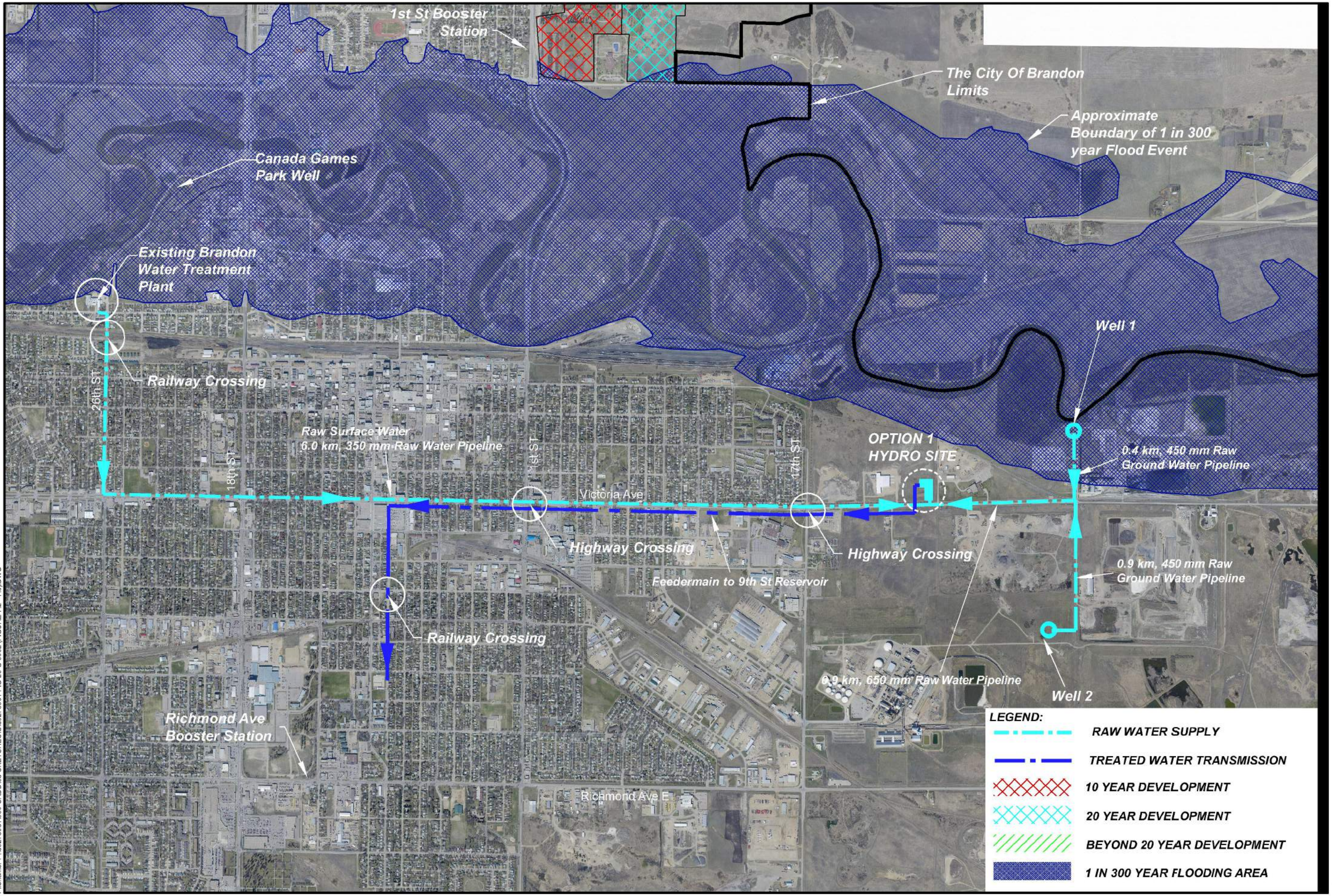
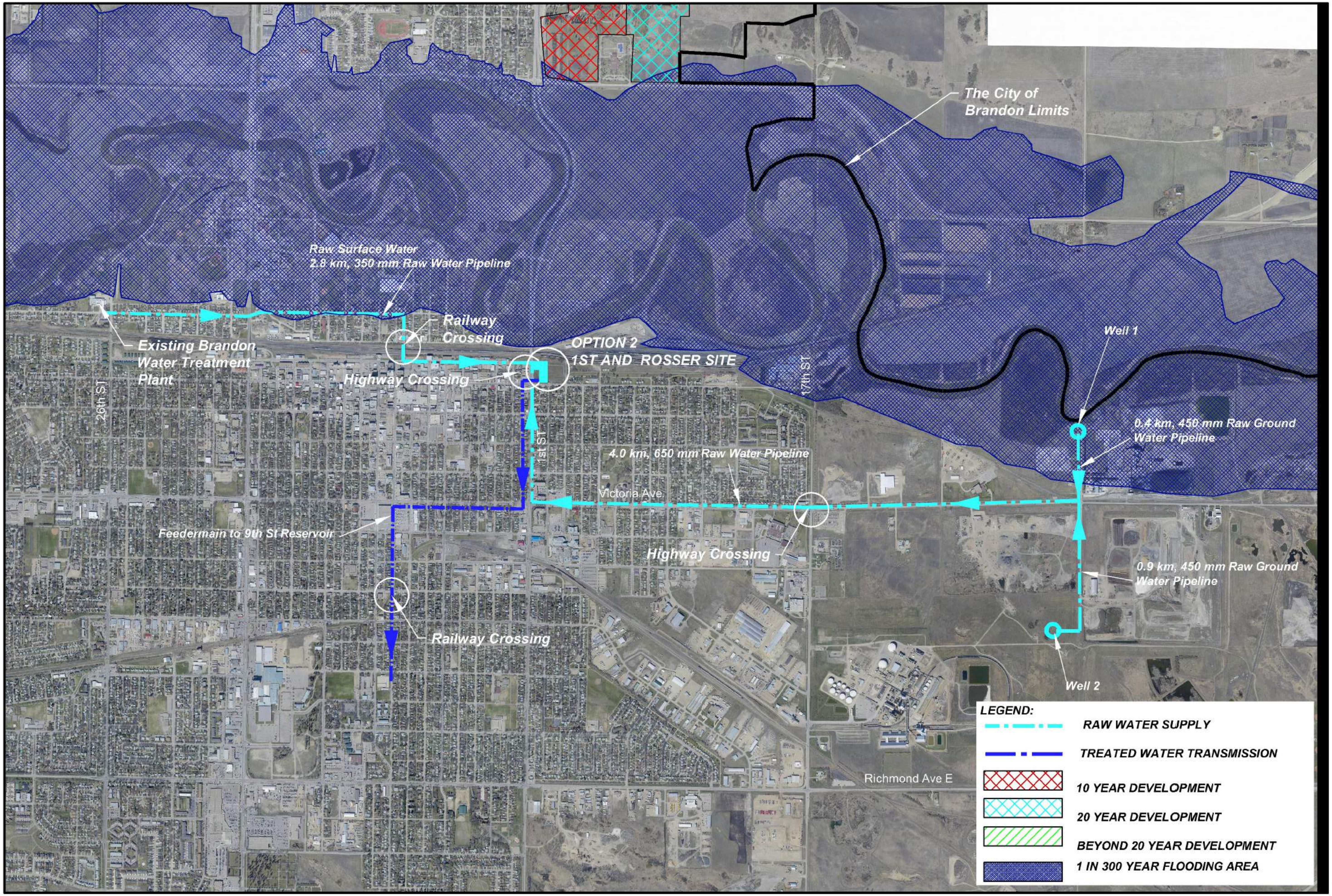


Figure 7.2

WATER TREATMENT PLANT
OPTION 1 - HYDRO SITE

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081 2013-05-16



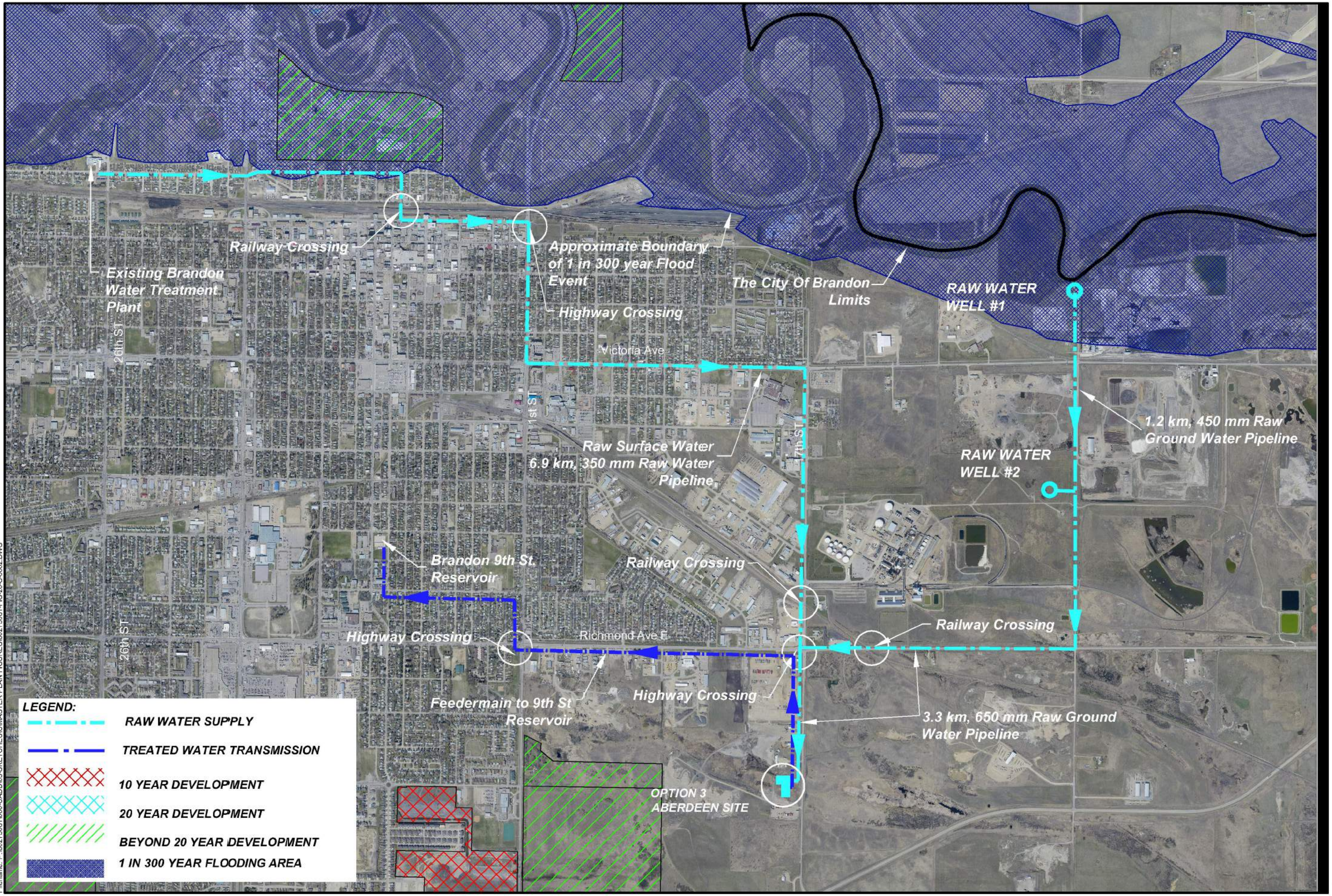
AECOM

City of BRANDON

Figure 7.3

WATER TREATMENT PLANT
OPTION 2 - 1ST & ROSSER SITE

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081



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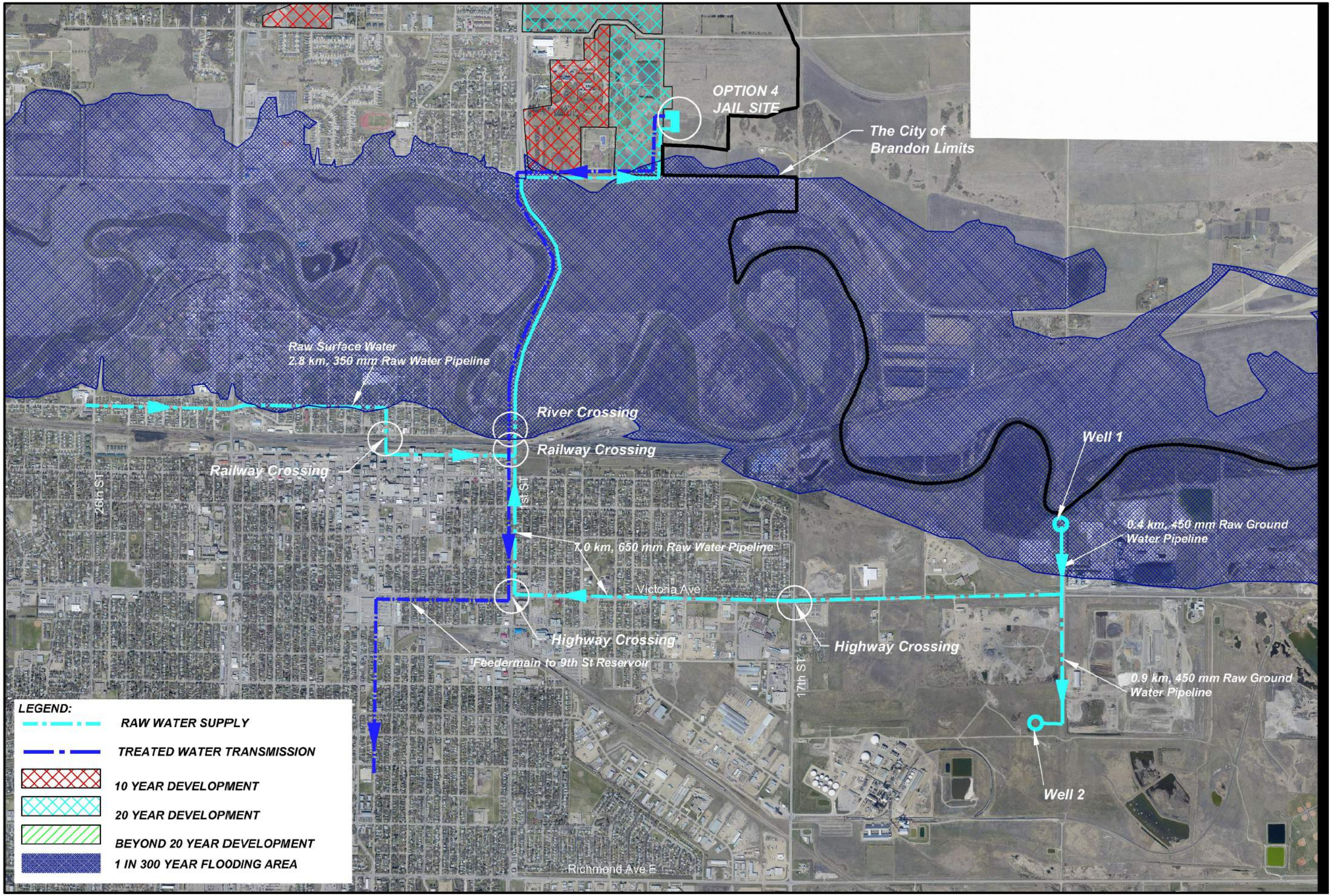
Filename: P:\60275081\000-CADD\03-SKETCHES\MASTER PLAN FIGURES\60275081-FIG-20-C-0002.DWG

WATER TREATMENT PLANT
OPTION 3 - ABERDEEN SITE

Figure 7.4

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081



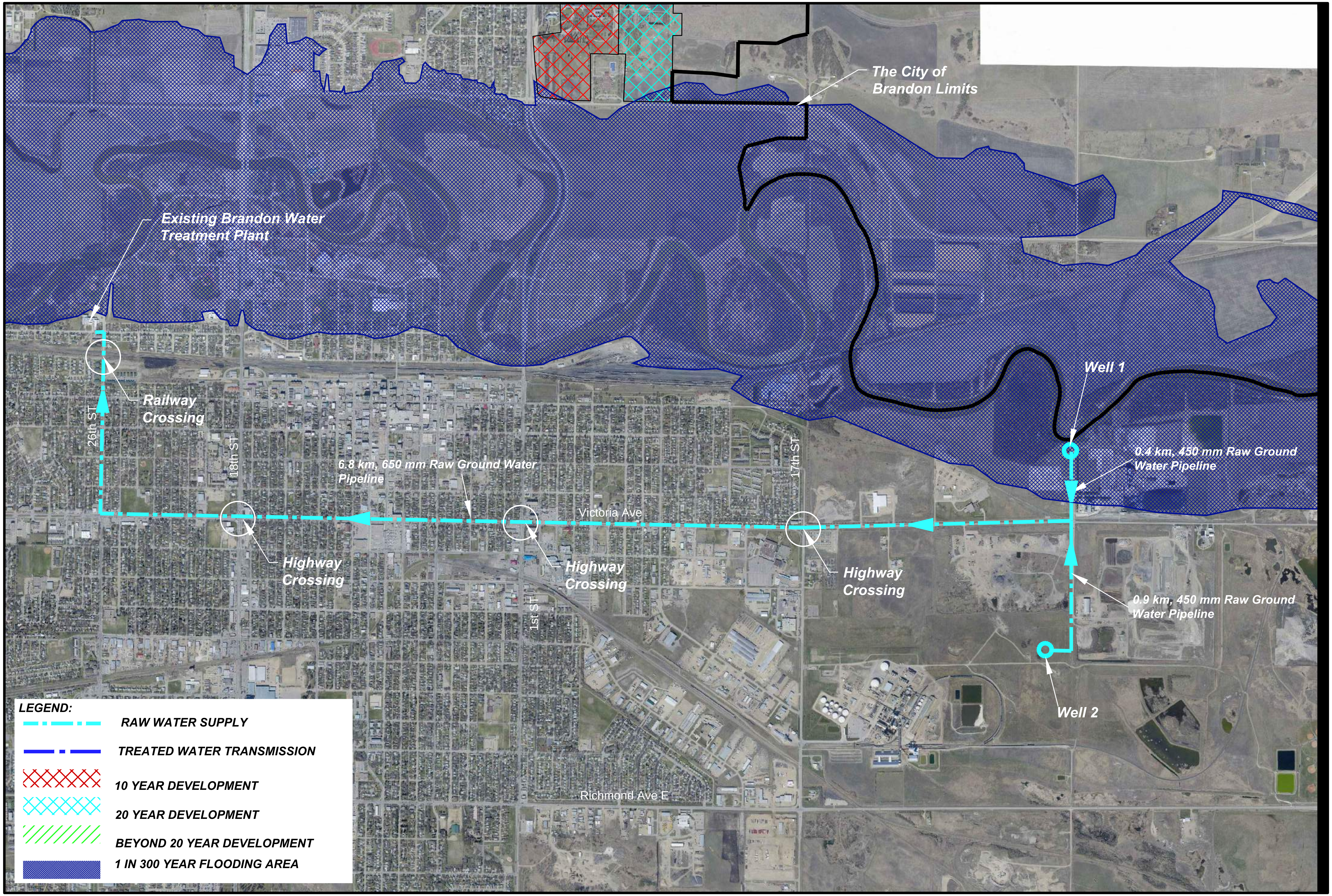
AECOM

City of BRANDON

Figure 7.5

WATER TREATMENT PLANT
OPTION 4 - JAIL SITE

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081



AECOM

City of BRANDON

Figure 7.6

WATER TREATMENT PLANT
OPTION 5 - EXISTING SITE

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081

8. Plant Expansion and Upgrade Options

8.1 General

As described in Section 6, the selected long term water supply option is to convert to 100% groundwater supply assuming it is proven to be available to fully satisfy the City's long term needs. However, until hydro-geotechnical investigations are completed over the next 5 years or so, the viability of the 100% groundwater supply will not be known. There is a high likelihood that some surface water will remain as part of the City's overall water supply. In the short term, the existing surface water supply supplemented by the existing emergency groundwater wells will remain as the source of water for the City. The water quality of this existing water supply is well documented and treatment options can be advanced. The water quality of the long term water supply is unknown and will entirely depend on the final blend, if any, of the Assiniboine River and the existing and new groundwater wells. It is because of this uncertain future raw water quality that the Master Plan must focus on the short term needs. This is done with full recognition that in the near term (<5 years), the major plant expansions decisions will be made. This timeframe works well with the other key design criteria – water demand.

Section 4 presented likely population growth scenarios along with expected future water demands. Over the next 5 years however, several key decisions will be made that may significantly affect actual City water demands. The first such decision is on Maple Leaf Foods plans for its water supply. Should Maple Leaf Foods successfully convert some or all of its supply to its own wells, the City's demands will be greatly reduced. The second such decision is related to possible wastewater reuse options, whereby some industrial facilities may utilize the City's highly treated wastewater effluent in exchange for groundwater rights. Any such programs that either directly reduces the City treated water demands or increases the percentage of groundwater used in the raw water supply will affect the overall water supply, treatment and distribution needs.

Section 7 of this Master Plan presented the plant siting options. As described, the existing site was selected as the sole location for the City's water treatment facilities irrespective of what the water supply (groundwater/surface water blend) might look like. The recommended continued use of this existing site and infrastructure mandates certain upgrades to address the concerns documented in Section 2.

The following sections describe in detail what the short term plant needs are but only generally describe what the long term upgrades might look like. The key decision point in the City's road map to its water supply is in Year 5 once the above noted considerations have fully evolved.

8.2 Short Term Upgrades

The recommended short term upgrades for the City of Brandon are focused on the existing WTP and are specifically related to existing regulatory and health and safety concerns. The upgrades can generally be grouped into the following categories:

- Disinfection by-product reduction program;
- High priority code and condition improvements, focused primarily on Plants 2 and 3; and
- Chemical handling and safety.

8.2.1 Disinfection By-product Reduction Program

There are many treatment options available to manage DBPs. In the case of Brandon, the primary contaminants of concern are THMs, which at present are regulated to a maximum total concentration of 0.100 mg/L under the GCDWQ. DBPs are formed when disinfectant chemicals, such as chlorine, react with NOM and/or bromide left in the water after filtration to create new compounds which are deemed to be detrimental to human health. The range of treatment options to address DBP formation includes:

- Precursor removal through processes such as enhanced coagulation, membrane filtration, ozonation and Granular Activated Carbon (GAC) filtration;
- Use of alternative disinfectants such as chlorine dioxide and chloramines;
- Physical removal of formed DBPs through air stripping or GAC; and
- Distribution system management to reduce water age.

This wide array of options has an associated wide range of capital and operating costs. The City plans to introduce a new process to address DBP removal, which may include membrane filtration or a process train such as ozonation followed by biological filtration. A detailed assessment of the preferred technologies will be undertaken at the conceptual design stage.

8.2.2 High Priority Code and Condition Improvements

As presented in Section 2, the existing WTP is old and much of the plant infrastructure and systems have long since exceeded their design life. There are several systems that have become obsolete and that spare parts can no longer be found for. In other cases, the reliability of the systems is in question. While the City operations and maintenance staff have done an excellent job keeping the plant running, the likelihood of significant failure increases with each passing day. The possible impacts of such failure could be significant and could affect the ability for the City to deliver water for potable consumption, industrial use and fire protection. The consensus of the team was that it would be imprudent to hope for 5 years or more of continuous operation without significant upgrades. It was also agreed that the oldest part of the facility (Plant 1) should be retired at some point so the focus of the upgrades should be on Plants 2 and 3. As discussed earlier, the required plant capacity could change significantly in the near term hence it would be premature to finalize plans now for ultimate plant expansion/retirement. For planning purposes, it was assumed that some expansion would be required (upwards of 50% of total capacity) with the balance coming from existing Plants 2 and 3.

Significant high- and medium risk upgrades include:

- Upgrading the structures of Plant 1 and Plant 2 to meet current NBCC life safety and mechanical codes;
- Adding redundant UV units within Plant 1;
- Replacing or gas chlorination system within Plant 1 with a safer disinfection alternative. Currently, no gas scrubbing unit is installed to protect staff and the surrounding population in the event of a gas leak;
- Adding redundancy to the incoming power feeder cables entering Plant 1;
- Adding additional exits and a fire sprinkler system to Plant 2;
- Constructing a new chemical storage facility for the lime and soda ash for Plant 2, particularly to address dust accumulation. The new facility should also address current issues with chemical containment and handling; and
- Improving chemical storage in Plant 3.

The recommended costs to upgrade the existing WTP to meet the NBCC are estimated to be in the range of $14,000,000. Complete details of the code and condition assessment including associated costs for each Plant area can be found in **Appendix A**.

8.2.3 Chemical Handling and Safety

The review of the existing water treatment facilities identified a number of concerns with the existing chemical storage and feed systems. The concerns include the following:

- Inability to deliver softening chemicals and transfer to day tanks simultaneously. The existing chemical delivery is cumbersome and time consuming;
- Decentralized storage of chemicals;
- Lack of adequate spill containment;
- Aging equipment, piping and instrumentation; and
- Use of gaseous chlorine in a residential area, without scrubbers and with aging equipment.

It is recommended that the new chlorination system be located within the new chemical storage facility, as this will allow construction to occur without disrupting existing chlorination practices. The new building will provide the opportunity to address the other issues listed above along. A stand-alone chemical storage and feed facility is proposed for the envisioned ultimate water treatment facility at the site. Siting of the new facility will be such that construction of a new Plant 4, if required, can be accommodated.

This new chemical storage facility could accommodate the storage and handling of following chemical feedstocks:

- **Coagulant(s), polymer and acid:** Coagulant storage should be kept in a single location, with a designated room to ensure adequate ventilation, dust control and spill containment. The polymer storage and feed systems would be located in another area, as they present different hazards.

  The current coagulation process is conducted in tandem with softening. If these processes are separated in the upgraded WTP (see Section 9) the use of acid (such as sulphuric acid or hydrochloric acid) could be considered to increase coagulation efficiency. Multiple acid tanks could be located in a designated room with adequate ventilation and spill containment.
- **Lime and soda ash:** Lime and soda ash could be provided by separate silos, located outside of the chemical storage facility.

Figure 8.1: Lime Silos

- **Potassium permanganate and PAC:** The use of PAC and $KMnO_4$ can be used for both pre- or post-coagulation processes. These materials both present significant dust hazards, while $KMnO_4$ tends to be corrosive. Both of these chemical could be located in designated rooms with the appropriate dust control equipment.
- **Sodium hypochlorite system:** As discussed in the next section, a review of alternative chlorination system suggests that on-site hypochlorite generation equipment be used. This system would require its own room with adequate ventilation to remove any hazardous accumulation of gases created during hypochlorite generation process.
- **Fluoride:** Fluoridation equipment and chemicals could be stored in a designated room with adequate ventilation and spill containment.
- **Sodium hydroxide (caustic):** Use of a caustic dosing system in the can allow for accurate pH control in the treated water leaving the WTP, which may be considered in the future. Sodium hydroxide feedstocks tend to be very corrosive. Sodium hydroxide dosing equipment and chemicals could be stored in a designated room with appropriate ventilation and spill containment.

A layout of the suggested chemical storage facility is shown in **Figure 9.8.** It is recommended at the chemical storage facility could be constructed in 2 phases; the first phase would include the complete chlorination system while the second phase would include the rest of the chemical systems listed above.

Chemical systems related to dewatering are not to be included in the new chemical building. In making the recommendation for the new chemical storage and feed facility, it was recognized that it would be required regardless of the final blend of surface and groundwater. As such, it was recommended to be advanced in the immediate term.

8.2.4 Alternative Chlorination Systems

Alternate chlorination systems were investigated in order to address the current safety issues posed by the existing gas chlorination system. These alternatives included the use of liquid sodium hypochlorite and the use of on-site hypochlorite generation. This review was considered along with other long-term disinfection options, such as UV disinfection. Layouts of the potential chlorination options are shown in **Figure 9.7**.

8.2.4.1 TBL Weighting

Weights were applied to each of the chlorination options based on the level of importance to the City in terms of each individual criterion relative to the overall criteria in the evaluation.

The risk from exposures during processing, handling and transportation was considered to be especially important for the chlorination options, given the potential widespread impact on public safety. These are reflected in the Social Index Category, which is weighted at 50%. Other criteria of high importance were the goal to minimize overall capital, operations and maintenance costs, reflected in the Economic Index Category, which is weighted at 20%. The ability for each technology to meet regulatory approval and water treatment standards was also considered, as reflected in the Technical Index Category, also weighted at 20%. **Table 8.1** summarizes the weights applied for each TBL Index for evaluating each chlorination option.

Table 8.1: Summary of TBL Index Weights for Chlorination Options

TBL Index	Overall Index Weight (%)
Economic	20
Technical	20
Operational	10
Social	50
Total TBL	**100**

8.2.4.2 Option 1 – Chlorine Gas with Air Scrubbing

Chlorine gas is commonly used for disinfection as it is relatively cheap, effective system. Unlike other forms of disinfection, chlorine gas does not degrade under regular storage conditions, provides a disinfectant residual and is relatively easy to operate and maintain. This form of disinfection is widespread amongst WTPs and is currently in use at the existing WTP facility. Chlorine is typically supplied as a pressurised gas and shipped in 70 kg to one-tonne containers for use in water treatment. Feed systems include a series of pressurized storage tanks, gas injectors/diffusers for chemical addition, chlorine gas detectors, weigh scales for mass flow measurement, associated valves and piping.

While chlorine gas disinfection does have a relatively safe track record, there are some substantial hazards associated with its accidental release, both during transport and handling. An unforeseen release of chlorine gas can present an immediate hazard to surrounding personnel as it is both a highly toxic and is more than twice as dense as air. Air scrubbing equipment is usually installed near the chlorine gas systems to mitigate the release of any gas leak. Both ‘wet’ and ‘dry’ air scrubbers can be used in these installations. Dry air scrubbers use dry sorptive media to filter contaminant particles in the air. Wet air scrubbers use a concentrated caustic solution to remove chlorine gas. Air scrubbing units typically require a dedicated standby generator in the event of a power failure. Chlorine gas storage containers are typically housed in separate, well-ventilated rooms for additional safety

Figure 8.2: Chlorine Gas Scrubber (Image from Powell Fabrication and Manufacturing Inc.)

Air scrubbing units are currently not installed at the existing WTP facility.

As the City already uses chlorine gas for disinfection, this disinfection option was considered to be the base case, as reflected in **Table 8.2**.

Table 8.2: Chlorine Gas TBL Scoring Summary

TBL Index	TBL Scoring
Economic	0.0
Technical	0.0
Operational	0.0
Social	0.0
Total	**0.0**

8.2.4.3 Option 2 – Bulk Sodium Hypochlorite Storage

Sodium hypochlorite (NaOCl) provides similar disinfection properties as chlorine gas and has widespread use in water treatment across North America. Sodium hypochlorite is typically supplied as a 5 to 20% solution by weight. Feed systems typically include bulk storage tanks, day tanks, transfer pumps, dosing pumps, chlorine gas detectors, injectors, associated valves and piping.

Unlike chlorine gas, sodium hypochlorite degrades during storage, with solutions of higher concentration degrading more quickly due to a self-catalyzed decomposition process. This tends to lead to myriad problems, such as off-gassing of decomposition products (oxygen and chlorate) and difficulty in maintaining an accurate chlorine dose. Typically, higher liquid doses are required to make up for the loss in hypochlorite activity over time.

Sodium hypochlorite degradation can be handled in a variety of ways, such as limiting on-site storage, dilution or on-site hypochlorite generation. Chemical storage is typical limited to 3 months to avoid the effects of long-term depredation of the sodium hypochlorite stock. By using 12-13% NaOCl solution, hypochlorite degradation is limited to a loss of 9% during 3-month storage at 20°C. Diluting sodium hypochlorite to half of its original concentration can typically decrease the rate of degradation bay a factor of 4 to 5. By purchasing hypochlorite solutions below 12% concentration, dilution can be avoided without large changes to the chemical feed rate.

Because of the limited concentration (<12%), a large volume of sodium hypochlorite solution must be used to achieve disinfection requirements comparable to that of chlorine gas. While not as immediately dangerous as chlorine gas, the 12% NaOCl solution is still corrosive, requiring protective equipment and spill containment to handle.

The bulk sodium hypochlorite option was considered to be a robust option in its ability to deal with abnormal operating conditions. The ease of operation was also considered to a general advantage to this system. The corrosive nature of the chemical feedstock, while better than chlorine gas, was still considered to be a concern. **Table 8.3** provides a summary of the TBL scoring for this option.

Table 8.3: Bulk Sodium Hypochlorite Storage TBL Scoring Summary

TBL Index	TBL Scoring
Economic	3.3
Technical	8.0
Operational	10.0
Social	83.3
Total	**104.7**

8.2.4.4 Option 3 – On-Site Hypochlorite Generation Equipment

Sodium hypochlorite can be generated on-site at the WTP using specialized equipment. During on-site hypochlorite generation, an electric current is passed through a saltwater solution to create a low-concentration sodium hypochlorite solution (approximately 0.8%). During this process, hydrogen gas is produced which must be vented to atmosphere to prevent a dangerous accumulation of flammable gas. Typical generation systems include a series of electrolytic cells, feed water filters, transfer pumps, chemical injectors, brine storage tanks, blowers (for hydrogen gas reduction), hydrogen gas detectors, as well as associated valves and piping. Large amounts of energy are required to drive the reaction forward, with approximately 4.4 kWh required per kilogram of sodium hypochlorite produced.

On-site sodium hypochlorite generation is mechanically complex compared to other disinfection systems. A large amount of instrumentation is required to maintain operation, with a significant increase in the amount of alarms required to notify personnel of equipment malfunction. Because of the low concentration of hypochlorite solution, large volumes of solution must be produced to achieve disinfection requirements.

By creating a low concentration of solution, the degradation of the hypochlorite solution becomes negligible. This reduces the production of dangerous off-gassing by decomposition products. As the main chemical feedstock for this process is salt, transportation of chemical is also inherently safe. The 0.8% hypochlorite solution is less hazardous to personnel that most typical solutions of liquid sodium hypochlorite, although spill containment and personal protection would still be required.

Figure 8.3: On-site Chlorine Generation (Image from Parkson Corp.)

The capital, operation and maintenance costs of the on-site hypochlorite generation system were the highest of the three chlorination options, which was reflected negatively during the TBL scoring process. Operation of the equipment is also the most difficult of the three options. However, the inert nature of the salt feedstock was considered to be a major advantage to this system, particularly as these shipments would travel through highly populated areas. **Table 8.4** provides a summary of the TBL scoring for this option.

Table 8.4: On-Site Hypochlorite Generation TBL Scoring Summary

TBL Index	TBL Scoring
Economic	-11.3
Technical	8.0
Operational	-2.0
Social	100
Total	**94.7**

8.2.4.5 Evaluation

The three chlorination options were evaluated as follows:

- Option 1 (Base Case) – Continue using chlorine gas, with the addition of a chlorine scrubber.
- Option 2 – Use bulk liquid sodium hypochlorite storage.
- Option 3 – Use on-site hypochlorite generation.

Detailed TBL scoring for the three chlorination options is provided in **Table 8.5** with a summary as follows:

Table 8.5: Water Source TBL Scoring Results

Rank	Water Source Option	Score
1	Option 2 – Use bulk liquid sodium hypochlorite storage	104.7
1	Option 3 – Use on-site hypochlorite generation	94.7
3	Option 1 (Base Case) – Continue using chlorine gas, with the addition of a chlorine scrubber	0

The difference between Options 2 and 3 were considered to be mainly qualitative. In the spring of 2015 City representatives toured several on-site hypochlorite generation facilities and talked to Operations staff. Based on the outcome of this tour the on-site hypochlorite generation was selected as the preferred technology. A summary of the TBL evaluation for the chlorine disinfection options is included in **Appendix I**. A cost estimate of the disinfection options is shown in **Table 8.6**

Table 8.6: Cost Estimate, Disinfection Options

Description	Gas Cylinders with Air Scrubber	On-Site Sodium Hypochlorite Generation	Bulk Sodium Hypochlorite Storage
Capital Costs			
Building	$747,000	$629,000	$634,000
Process Equipment	$473,500	$1,096,000	$179,000
Chemical Systems	$27,000	$50,000	$50,000
Instrumentation and Controls	$47,000	$110,000	$18,000
Electrical	$71,000	$110,000	$27,000
Mechanical	$71,000	$110,000	$27,000
Subtotal	$1,537,000	$2,105,000	$935,000
35% Contingency	$538,000	$737,000	$327,000
15% Engineering	$231,000	$316,000	$140,000
Total Capital Costs	**$2,306,000**	**$3,158,000**	**$1,402,000**
Operation and Maintenance Costs			
Annual Treatment Chemical Cost	$46,000	$27,000	$43,000
Annual Power Consumption	$7,000	$9,000	$9,000
Annual Operation and Maintenance Costs	$75,000	$100,000	$75,000
Estimated Annual Operating Cost	$128,000	$136,000	$127,000
20-Year Net Present Value (4% discount rate)	$1,740,000	$1,848,000	$1,726,000

9. Long Term Upgrade Evaluation

9.1 Water Supply

As noted earlier, the long term upgrades cannot be finalized until the raw water supply is confirmed. Raw water characteristics could vary significantly; especially turbidity and organics. Regular update of the Master Plan is required to reflect new information as it is received. However, some general guidance can be provided by considering several possible scenarios:

- Primarily a surface water supply with only marginal supplemental groundwater (the as-is scenario).
- A 50/50 blend of surface and groundwater. The intent is for the blend to obviate the need for DBP control measures. Softening of both sources may or may not be required depending of hardness targets.
- Primarily a groundwater supply with the ability to plan the use of surface water such that poorest surface water quality conditions can be avoided.

Within each scenario, various water demand options could be considered ranging from reducing water demands to increasing water demands. To simplify the evaluation at this stage, only the baseline predicted values as shown in Section 4 have been considered. A last, but critical, consideration is that of the ultimate life of the existing plant and infrastructure. While the short term upgrades as presented in this Master Plan will greatly improve reliability and address major deficiencies, the City will still be utilizing buildings and equipment that have greatly exceeded their design lives. Through discussions with the City, it was suggested that planning for an initial 50% plant expansion would be prudent. The new facility would be ready to come on-line within the next 10 years. At that point, decommissioning or retirement of some of the old plant (particularly Plant 1) could be considered. Plant 3 and the new Plant 4 would become the primary treatment systems. Plant 2 would be maintained and remain available as a backup for maintenance and/or emergencies. Depending on how water demands actually evolve over the long term, a further plant expansion might be deemed necessary but this is beyond the present planning horizon of this Master Plan.

9.1.1 Surface Water Supply

As noted above, this option reflects the as-is situation to a large extent. The existing emergency groundwater wells would continue to be used to supplement supply but the Assiniboine River remains as the primary source of raw water.

The key raw water parameters that drive treatment options are hardness, turbidity and organics. The existing lime/soda ash softening process has proven to be effective for reduction of hardness and turbidity but the reduction of organics is not sufficient to prevent the formation of disinfection by-products in excess of Canadian guidelines. A summary of the average surface water quality is shown in **Table 9.1**.

Table 9.1: Typical Surface Water Quality

Parameter	Value
Alkalinity	213 mg/L as $CaCO_3$
Hardness	360 mg/L as $CaCO_3$
TOC	13 mg/L
Iron	2.18 mg/L
Manganese	0.15 mg/L

Organics reduction can be enhanced via numerous means including supplemental primary treatment (pre-oxidation, pre-clarification), additional post treatment (ozonation, activated carbon filtration), or membrane filtration. Other processes such as ion exchange and membrane filtration are also potential substitutes for the existing softening process.

9.1.2 50/50 Surface/Groundwater Blend

The exact groundwater quality parameters are not yet fully defined and the amount of groundwater available will not be known for some 5 years. The blend ratio and the blended water characteristics can only be estimated at this time. This scenario assumes the blend will be such that the organics removal achieved through softening alone will be sufficient to allow for disinfection with free chlorine without exceeding THM guidelines. No additional pre- or post-treatment would be required.

Two approaches for blending can be considered: blending of raw water and blending of treated water. In the former case, the two raw water supplies would be combined into a common line feeding the WTP. The combined flow would split into the various treatment trains. As described for the as-is situation, the expansion is assumed to be based on lime/soda ash technology however membrane treatment would also be possible. In the latter case, the two raw waters would be directed to specifically assigned treatment plants. While physically located at the same site, the processes would be optimized for the unique water characteristics of each supply. A key assumption would be that the two supplies would be available year-round. This option is not preferred as it does not allow for easy use of the older plant infrastructure (Plant 2), requires the plant operators to run parallel plants differently, and does not allow for simple modification of the blend ratios. This last point is arguably most important as the ability to completely avoid the Assiniboine River supply during short periods of very poor quality or contamination is a key driver of developing the groundwater supply. The recommended approach is thus to blend the two raw waters and split to parallel treatment plants. The plants do not have to be based on identical technology but for the purposes of planning, this has been assumed to be the case.

In terms of design concept, the plant expansion would be virtually identical to the options presented in the as-is situation with the exception that no pre or post treatment would be required. The layouts are similar but the total footprint and cost are reduced.

A summary of the water quality for a blend of 50 % groundwater and 50% surface water is shown in **Table 9.2**.

Table 9.2: Typical Water Quality of a 50% Groundwater, 50% Surface Water Blend

Parameter	Value
Alkalinity	231 mg/L as $CaCO_3$
Hardness	339 mg/L as $CaCO_3$
TOC	8.0 mg/L
Iron	1.8 mg/L
Manganese	0.13 mg/L

9.1.3 Groundwater Supply

While the likelihood of going to a 100% groundwater supply may be low, there is a reasonability probability that the proposed groundwater investigations will show that the City can utilize groundwater for a significant fraction of its water supply needs. If future water demands are reduced through wastewater reuse or changes in industrial user needs, likelihood of a 100% groundwater supply being feasible would increase. For the purposes of this analysis, a blend ratio of at least 75% groundwater to 25% surface water has been assumed. Practically, as long as any surface water is used the need to treat elevated turbidity and pathogens will exist. Softening needs may vary depending on changing City targets and final groundwater hardness levels. It is unlikely that softening could be avoided entirely without a significant change in treated water hardness targets. As such, treatment options are virtually identical to those presented in the 50/50 blend as no additional organics reduction is required. Raw water blending would still be recommended over post-treatment blending.

A summary of the water quality for a blend of 75 % groundwater and 25% surface water is shown in **Table 9.3**.

Table 9.3: Typical Water Quality of 75% Groundwater, 25% Surface Water Blend

Parameter	75% Groundwater Blend	100% Groundwater
Alkalinity	239 mg/L as $CaCO_3$	248 mg/L as $CaCO_3$
Hardness	329 mg/L as $CaCO_3$	318 mg/L as $CaCO_3$
TOC	5.5 mg/L	3.0 mg/L
Iron	1.6 mg/L	1.37 mg/L
Manganese	0.13 mg/L	0.116 mg/L

In the event that a 100% groundwater supply is proven, treatment options could change. In the case of continued lime softening, the options would be identical to the 50/50 blend. If, however, a membrane softening option was considered, the pre-treatment requirements would be significantly reduced as the high turbidity and organics associated with the Assiniboine River would be eliminated. If the treated water hardness target was also increased, treatment could be limited to a simple direct filtration plant (granular media or membrane filtration).

There are many possible combinations or pre-treatment, softening and post-treatment technologies that could be potentially used at the upgraded WTP. When the source water becomes established, a short-list of treatment technologies will be developed from which further design criteria and lifecycle costs can be derived.

Technologies were evaluated on the following basis:

- Pre-treatment technologies;
- Softening technologies; and
- Post-treatment technologies.

9.2 Pre-Treatment Technologies

A variety of pre-treatment technologies exist to either remove TOC or oxidize THM precursors. Such technologies are wide-ranging, including combinations of chemical oxidation, enhanced coagulation, solids-contact clarification, and dissolved air flotation. For the purposes of exploring the potential future WTP designs, the options evaluated here include enhanced coagulation, chemical oxidation and ozonation.

9.2.1 Enhanced Coagulation

Particles present in raw water supplies can be comprised of silt, sand, microorganisms, minerals, NOM, etc. Most of these particles have a natural surface charge that repels other particles and stabilize the particles in colloidal suspension. The use of chemicals (coagulants) destabilizes colloidal materials, entrapping them within a floc particle. Once in particulate form, floc is more easily removed, a process referred to as “conventional coagulation”

The current WTP combines is softening and coagulation process, resulting both processes running inefficiently. Coagulation typically requires lower pH levels (pH 6 to 8) to allow for suitable floc formation, whereas softening requires higher pH levels (pH 10 to 12) to precipitate hardness. Optimization the coagulation processes would include pH adjustment and a possible increase in the coagulant dose.

The term “enhanced coagulation” was introduced through the USEPA *Disinfectants and Disinfection Byproducts Rule*, to suggest a change in focus of coagulation from being optimized for particulate removal to being optimized for organics removal (but not at the expense of particulate removal). It is defined by the USEPA as “the process of obtaining improved removal of DBP precursors by conventional treatment.” TOC is usually considered to be a surrogate for DBP precursors. If the treatment process achieves a prescribed TOC removal, then changes are not required. If the targets are not met, then a prescribed process is undertaken to determine the optimum conditions for TOC removal. Typically bench-scale jar testing is conducted in order to determine TOC removal rates can be achieved from the existing system before large-scale pilot tests are conducted.

The Actiflo® system (**Figure 9.1**) is an example of a high-rate enhanced coagulation process, originally designed to provide turbidity reduction for the WTP. Raw water, coagulants, microsand and polymer are mixed into the water in a series of chambers designed to enhance floc formation. The microsand provides a surface area that enhances flocculation and also acts as a weight to aid in the rapid settlement of captured particles, which are removed in a clarification chamber. Clarified water is collected at the surface through perforated water pipes.

Figure 9.1: Actiflo® System (from above)

Typically, two Actiflo® units are installed, each having the processing capability to treat average demand flow. Having a second, fully redundant unit decreases the amount of time the treatment plant will be offline should the system require maintenance. The systems include rapid mix/coagulation/settling chambers, coagulant/polymer dosing system, plate settlers, effluent launders and mixing equipment. A layout of the potential Actiflo® pre-treatment option is shown in **Figure 9.9**.

9.2.2 Chemical Oxidant Addition

Chemical oxidants are highly reactive chemicals that use to inactivate or remove unwanted constituents in water. Oxidants can be used to achieve various water objectives, such as reducing the presence of odour-causing compounds, lowering iron and manganese levels, and controlling biological growth. Oxidants typically used in water treatment include chlorine, chlorine dioxide, ozone, $KMnO_4$and hydrogen peroxide.

During pre-treatment, an oxidant such as $KMnO_4$ is typically added to water for taste control and oxidation of organics and DBP precursors. The current WTP adds $KMnO_4$ to the raw water for this purpose, although several plants add $KMnO_4$ after coagulation/softening once a large portion of the organics have been removed in order to decrease the oxidant demand of the raw water. During oxidation, $KMnO_4$ forms solid magnesium oxide; removal of the magnesium oxide precipitate is typically tied to downstream processes, such as softening or filtration.

Potassium permanganate can be supplied as a dry crystalline product using a dry chemical feeder (hopper) or as a concentrated liquid using chemical dosing pumps and injectors. Both chemical products present inherent safety hazards to personnel, either through the formation of corrosive dust or through the spillage of corrosive liquids. Appropriate air filtration, spill containment and safety equipment must be employed when maintaining this treatment process.

9.2.3 Ozonation

Ozone is a powerful oxidant, as well as a disinfectant, and is able to accomplish several treatment functions, including taste & odour control and oxidation of DBP precursors and other substances. Whenever ozone (or any other oxidant) is added to water, there is an initial “demand” during which easily oxidized compounds consume ozone as they are oxidized. If additional ozone is added beyond this point, a residual begins to form. Typical ozone doses are determined based on the initial ozone demand and the contact time required for disinfection. Ozone doses may vary greatly between two locations, although applied doses in the range of 2-4 mg/L are not unusual. An ozone-destruct unit is typically installed in conjunction with ozonation systems to scrub any ozone residual from exhaust gases.

As ozone is an inherently unstable compound that will degrade on its own, it is generated on-site shortly before use. This is accomplished by exposing oxygen gas (O_2) to electrical discharges, which recombines the oxygen to form ozone (O_3). The efficiency of ozone generation is dependant on the amount of oxygen fed into the ozone generation system. If air (21% oxygen) is used as a feed gas, less ozone would be produced than if purified oxygen (90%-99% oxygen) was used for a similar amount of energy. Purified oxygen is typically supplied through the use of liquefied oxygen (referred to as ‘LOX’) delivered to site, which must be refrigerated.

Ozone can be dosed into water in several ways, but two approaches are common in WTP design:

- Use of conventional ozone contactors, fitted with fine bubble diffusers, as shown in **Figure 9.2**. The contactor itself is a concrete tank with internal baffling to divide the contactor into cells, foster efficient hydraulics and minimize short-circuiting. Fine bubble diffusers are placed in the first cells to inject ozone in small bubble form to maximize ozone transfer efficiency. The remaining cells provide contact time for the oxidation reactions to proceed.

Figure 9.2: Conventional Ozone Contactors

- Use of sidestream ozone injection, whereby a sidestream of the main flow is injected with ozone using an eductor device, such that the ozone is dosed under vacuum. The sidestream is then re-blended with the main flow and contact time is provided either through a concrete contactor or a pipeline contactor.

Ozone is both a very strong oxidant and disinfectant, and can assist in removal of taste and odour by several mechanisms:

- By direct oxidation of pre-formed taste and odour causing compounds present in the raw water.
- By causing the death of micro-organisms, including algae which can impart or cause taste and odour. Note that this may reduce taste and odour but may also increase it, as algae cell death causes cell lysis and the possible release of intracellular taste and odour causing compounds.

Upstream ozonation has been shown to greatly enhance coagulation processes such as coagulation. Ozonation has also been found to foster organics removal in biologically activated filtration processes, as described in Section 9.4.

9.2.4 Pre-treatment Evaluation

Large-scale treatment processes such as enhanced coagulation have been found to significantly reduce the organics loading on downstream processes, as well as address other issues such as high turbidity and colour. Chemical oxidation through the use of ozonation or $KMnO_4$ may address a portion of the DBP formation potential, although such processes are typically not used to singularly address this issue. The extent to which pre-treatment technologies would be necessary in the future WTP is dependent on the source water quality.

One of the main reasons for conducting pre-treatment is the need to reduce the organics loading on downstream processes. The use of surface water in the upgraded WTP will likely present a significant source of TOC, which suggests a greater need to rely on source water pre-treatment. Many of the processes described above have been used in in various combinations in treatment plants to address DBP formation.

9.3 Softening Technologies

Hardness generally results from dissolved calcium and magnesium in water. Hard water has a tendency to form scale deposits and scum and has been associated with boiler encrustation and pipe tuberculation. The GCDWQ note that water hardness greater than 200 mg/L has the perception of being considered poor but tolerable by consumers; hardness in excess of 500 mg/L is generally considered unacceptable. Three main softening options were evaluated to address water hardness in the long-term; cold lime softening, membrane softening and ion exchange softening.

9.3.1 Cold Lime Softening

In cold lime softening processes, lime is added in order to remove calcium hardness in the form of a calcium carbonate precipitate. Lime addition typically results in a pH level above 10.3, when calcium carbonate solubility is at its lowest, removing calcium hardness. Magnesium hardness is mainly removed through the formation of solid magnesium hydroxide which typically starts to precipitate at pH levels 10.6-11.2. To accomplish this, additional lime is added to the treatment process in order to increase the pH above conventional lime softening processes, known as excess lime softening. Depending on the desired amount of magnesium removal, the final pH level may vary. Lime is added as a chemical slurry to a lime softening clarifier basin, which allows coagulation, softening and sedimentation to occur after a period of contact time.

Lime can be added as solid quicklime, or as liquid calcium hydroxide (hydrated lime). Use of quick lime would allow for greater raw chemical storage on-site but would also require the using of slakers to generate a lime slurry before addition to the softening process. The overall lime softening process consists of chemical silos for storage of lime, slakers (if hydrated lime is used), storage tanks to hold the lime slurry, a pumping or gravity feed system for the slurry, and clarifiers. Carbon dioxide contact chambers are typically installed downstream of cold lime softening processes to lower the pH before further treatment. Sludge handling and disposal process are also required.

The City currently uses solids contact units for lime softening, as shown in **Figure 9.3**, and is therefore familiar with the process. Currently, this system is not run optimally, as both clarification and softening are conducted in the same units. The potential may exist to optimize one of the existing solids contact units for softening.

Figure 9.3: Existing Solids Contact Unit

Lime softening is well-established and able to remove a broad range of contaminants, such as organic matter. Unlike ion exchange softening, no sodium is added to the treated water, allowing residential users to eliminate home softeners and thereby curtail a significant source of sodium in raw sewage and wastewater treatment plant effluents.

Lime softening in the upgraded WTP would markedly increase the solids productions and associated chemical and sludge handling costs. Lime softening is also significantly more labour intensive as a process than simple clarification. There is also the potential for calcium carbonate precipitate to bypass the clarification process and influence the filtration ability of any downstream filtration process. Additionally, while the process is not subject to irreversible damage by accidental operation, hardness removal can easily be upset by rapid variations in feed water flow. A layout of the potential cold lime softening option is given in **Figure 9.10**.

9.3.2 Membrane Softening

Membrane softening removes calcium and magnesium hardness using Reverse Osmosis (RO) membranes. The membrane units at as molecular sieves, selectively retaining larger ions such as calcium (Ca^{2+}) and magnesium (Mg^{2+}) while water to pass through uninhibited.

The membrane units act as molecular sieve, selectively retaining larger molecules while allowing water to pass through uninhibited. Membranes are categorized by pore size, ranging from microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), to reverse osmosis. Typically, membrane filter units have a higher capital cost than other treatment options; however, they require little supervision and minimal operator training. Membranes are typically replaced approximately every 5 to 7 years.

Before RO filtration, water must be first run through a pre-treatment step (such as a UF membrane) in order to protect the membrane material. Pretreated water is pressurized to 350-100 kPa and sent through the membrane system. At these pressures, water molecules are forced through the membrane material while larger dissolved ions are retained. The purified stream (the permeate) is then directed to post-treatment. Several membrane elements can be run in series to achieve the desired level of purification.

The remaining solution (the retenate) is concentrated during the filtration process and directed to waste. Raw water demand is approximately 20% to 30% greater than the treated water demand due to the reject water from the membrane treatment system. Reject water would be discharged into the sewer after which it is eventually sent to the Wastewater Treatment Facility. Discussions with Manitoba Conservation have also suggested that direct disposal into the Assiniboine River may be a viable option for disposal of reject water.

A typical RO membrane system can consist of two membrane trains; each train could potential provide treatment for 50% of the maximum design flow to allow for continuous treatment when one train goes offline. Each RO train also contains a high pressure pump to pressurize the incoming water to the required operating pressure for the membrane elements. A chemical feed system for antiscalent and pH adjustment (acid addition) is included upstream of the RO skid. To protect the RO membranes from excessive fouling or damage, cartridge filters are installed prior to the membrane trains.

A layout of the potential membrane softening option is shown in **Figure 9.11**. A typical RO membrane system is shown in **Figure 9.4**.

Figure 9.4: Typical RO Membrane Units

The membrane clean-in-place (CIP) system is a manually operated system that cleans the membrane units periodically as needed. The CIP system consists of a CIP tank, CIP/permeate flush pump, heater and an educator. Chemicals are manually loaded into the CIP tank and diluted with non-chlorinated RO permeate water. The concentrated cleaning chemicals are introduced into the CIP tanks via an educator connection.

The treated water from a membrane system (permeate) is very low in dissolved ions, rendering the water extremely soft and unstable. The permeate is usually stripped of its alkalinity from the pre-treatment and membrane filtration, requiring the need for alkalinity addition and/or corrosion inhibitors. Permeate can also be blended with partially treated water to enhance final water quality. As it is unnecessary to completely remove all hardness from the raw water, a split stream configuration can be used to stabilized the membrane-treated water.

9.3.3 Ion Exchange Softening

Ion exchange is a process in which ions in a process stream (such as calcium and magnesium) are passed through a resin and exchanged with other ions (such as sodium). Once all the ion exchange sites on the resin have been taken up by unwanted compounds, the resin is regenerated before being put back into use. The ion exchange resins are typically regenerated by running a concentration salt solution through the resin, driving the absorption process in reverse and creating a concentrated waste stream. The waste stream created from the regeneration process may be considered to be significant given the required amount of regeneration cycles needed for operation.

Based on the raw water quality of the Brandon WTP, the high amount of hardness in both the groundwater and surface water make the use of ion exchange softening untenable. During average flow conditions, several trucks of salt would be required to regenerate the resins every week. This results in substantial operation and maintenance costs for the delivery of salt. The backwash water generated from each regeneration cycle eliminates the potential for water reuse due to the high salt content. Additionally, introduction of sodium into potable water source may also prohibit its use for sensitive users, particularly in hospitals and aquariums. For these reasons, the use of ion exchange softening units was not considered further.

9.3.4 Softening Evaluation

Of the two viable softening options, membrane treatment will generally have higher capital costs than lime softening, although this option may also reduce the need for various pre- and post-treatment processes. In terms of residuals management, each treatment option produces some form of liquid or solid waste. Solid waste generated from the lime softening process tends to be more labour intensive that the brine generated from the RO membranes.

The benefit of each of these options is dependent on source water quality used by the upgraded WTP. As both the surface water (SW) and groundwater (GW) sources present an average hardness in the range of 150-350 mg/L as $CaCO_3$, some measure of softening will be required. The extent of this softening may vary based on the desired effluent water quality target. If mainly ground water is used, minimal softening may be required in the upgraded plant, which may not justify the cost of installing the membrane system. A review of the expected water quality based on the various softening options and groundwater blends are given in **Table 9.4** to **Table 9.8**. **Appendix J** includes some of the water quality data regarding the development of these tables.

For planning purposes, it is proposed that the City carry forward the concept of continued lime/soda ash softening with physical and hydraulic space allocated for possible pre-treatment and post treatment. As shown in **Figure 9.13**, a 50% expansion can be sited to the west of the existing Plant 3. As the groundwater supply is proven out and the amount of groundwater available confirmed, space allocations for the supplemental processes can be reconsidered. Further, as initial design of the expansion commences, it is recommended that the costs for membrane softening be revisited to validate the continued use of lime/soda ash as the most cost effective technology. Cost estimates of the softening options are shown in **Table 9.9**.

Table 9.4: Hardness Comparison, mg/L as $CaCO_3$

SW Treatment	GW Treatment	Blend Ratio (%GW)			
		25%	50%	60%	75%
Softening SW	Unsoftened GW	191	234	250	276
	Softened GW	149	149	149	149
	RO Treated GW	112	75	60	37
RO Treated SW	B1: Unsoftened SW	80	159	191	239
	B2: Softened SW	37	75	89	112
	B3: RO Treated SW	0	0	0	0

GCDWQ: 80-100 mg/L provides acceptable balance between corrosion & encrustation; < 200 mg/L required to prevent scaling in treatment works.

Table 9.5: TOC Comparison, mg/L

SW Treatment	GW Treatment	Blend Ratio (%GW)			
		25%	50%	60%	75%
Softening SW	Unsoftened GW	6.1	5.1	4.7	4.0
	Softened GW	5.8	4.4	3.9	3.0
	RO Treated GW	5.4	3.6	2.9	1.8
RO Treated SW	B1: Unsoftened SW	0.8	1.5	1.8	2.3
	B2: Softened SW	0.4	0.8	1.0	1.2
	B3: RO Treated SW	0.0	0.0	0.0	0.0

Recommended range for control of disinfection by-products: 3-5 mg/L.

Table 9.6: Iron Comparison, mg/L

SW Treatment	GW Treatment	Blend Ratio (%GW)			
		25%	50%	60%	75%
Softening SW	Unsoftened GW	0.5	0.8	0.9	1.1
	Softened GW	0.2	0.2	0.2	0.2
	RO Treated GW	0.2	0.1	0.1	0.1
RO Treated SW	B1: Unsoftened SW	0.3	0.7	0.8	1.0
	B2: Softened SW	0.1	0.1	0.1	0.2
	B3: RO Treated SW	0.0	0.0	0.0	0.0

GCDWQ: Aesthetic objective: ≤ 0.3 mg/L.

Table 9.7: Manganese Comparison, mg/L

SW Treatment	GW Treatment	Blend Ratio (%GW)			
		25%	50%	60%	75%
Softening SW	Unsoftened GW	0.04	0.06	0.07	0.09
	Softened GW	0.01	0.01	0.01	0.01
	RO Treated GW	0.01	0.01	0.00	0.00
RO Treated SW	B1: Unsoftened SW	0.03	0.06	0.07	0.09
	B2: Softened SW	0.00	0.01	0.01	0.01
	B3: RO Treated SW	0.00	0.00	0.00	0.00

GCDWQ: Aesthetic objective: ≤ 0.05 mg/L.

Table 9.8: Total THM Comparison, µg/L

SW Treatment	GW Treatment	Blend Ratio (%GW)			
		25%	50%	60%	75%
Softening SW	Unsoftened GW	107	92	85	74
	Softened GW	98	75	67	57
	RO Treated GW	88	59	42	23
RO Treated SW	B1: Unsoftened SW	14	28	35	44
	B2: Softened SW	6	14	18	23
	B3: RO Treated SW	0	0	0	0

GCDWQ: Maximum Acceptable Concentration, 100 µg/L.

TTHM data determined using the USEPA WTP Model v.2.1. Assumed SUVA = 2.48, as given in the MIEX Treatability Study (Orica Watercare Inc., 2010), pH = 7.7, Cl_2 Dose= 5 mg/L, Bromide= 0.1 mg/L and DOC ≈ TOC.

Table 9.9: Cost Estimates, Softening Options

Description	Lime Softening	Membrane Softening
Capital Costs		
Building	$16,856,000	$11,636,000
Process Equipment	$7,638,000	$14,925,000
Chemical Systems	$629,000	$236,000
Instrumentation and Controls	$764,000	$1,677,000
Electrical	$1,146,000	$3,435,000
Mechanical	$1,146,000	$1,295,000
Subtotal	$28,179,000	$33,204,000
35% Contingency	$9,863,000	$11,621,000
15% Engineering	$4,227,000	$4,981,000
Total Capital Costs	**$42,269,000**	**$49,806,000**
Operation and Maintenance Costs		
Annual Treatment Chemical Cost	$1,206,000	$122,000
Annual Power Consumption	$200,000	$729,000
Annual Operator Costs	$612,000	$612,000
Annual Maintenance Costs	$202,000	$1,107,000
Estimated Annual Operating Cost	$2,220,000	$2,570,000
20-Year Net Present Value (4% discount rate)	$30,171,000	$34,927,000

9.4 Post-Treatment Technologies

A variety of treatment options are available for final organics removal in treated water. Such processes are typically located before chemical disinfection to limit the production of DBPs. These include Granular Activated Carbon (GAC) filtration, Biologically Activated Carbon (BAC) filtration and membrane filtration, which are evaluated here.

9.4.1 Granular Activated Carbon

GAC performs similarly to most filters, yet are also able to remove dissolved contaminants through adsorption onto the media. Water flow is typically downwards through a packed media bed, with backwash cycles conducted periodically to remove solids that have accumulated within the filter bed. Such systems typically include a series packed bed contact chambers, transfer pumps, backwash pumps, flow control valves and associated piping and controls.

Figure 9.5: Gravity Filtration System (Image from Napier-Reid Ltd.)

GAC filter beds can vary in depth, with from 0.2-8 m, with typical bed depths in the range of 0.5-4 m. Increasing the GAC bed depths generally allows for greater contact time, increasing the filtration efficiency of the overall process. The ‘empty-bed contact time’ is the length of time is takes water at a constant flow to pass through the GAC media, which typically takes 5-24 minutes.

The adsorption of GAC is limited by the amount of free surface area remaining at any given time, with GAC breakthrough determined by the point at which an appreciable level of contaminant is measured downstream of the filters. At this point the media must be replaced or regenerated. GAC media regeneration is typically conducted in tandem with replacement, with the spent media shipped to an off-site location and new media places within the filtration system. As the operations costs of regenerating/replacing GAC media tends to be significant, GAC filtration tend to be used when TOC levels are in the range of 2-6 mg/L (Edzwals, J.K. (editor), 2011). Higher TOC levels tend to rapidly deplete the media.

9.4.2 Ozone with Biologically Activated Carbon

As described previously, ozonation processes are uses to oxidize water constituents for various reasons such as odour and taste control. Ozonation cleaves long chain organic molecules into shorter chain organic molecules which are more easily assimilable by micro-organisms as a food source. This conversion of TOC into assimilable organic carbon (AOC) usually fosters biological activity downstream of the ozonation step. When ozone is used in combination with granular media filtration, and particularly carbon filtration (due to the high effective surface area of GAC compared to conventional media), this usually results in the filter converting into a biologically active mode, whereby the filter media serves as a medium for growth of organisms which consume contaminants present in the feedwater. Anthracite or GAC media that is operated in this manner is referred to as Biologically Activated Carbon (BAC).

The success of BAC filtration depends upon the maintenance of a healthy biomass growing on the carbon. Under normal conditions of varying seasonal water quality and temperature, this will generally result in seasonal variations in the size of the biological populations and their metabolic activity. A key issue is water temperature, as biological activity would be expected to reduce dramatically in cold waters.

During seasons where the biomass is in decline due to reduced nutrient load in the feed water, or cooling water temperatures, cell death and sloughing may occur from the filter media, which must be managed by backwashing. Biological filters tend to need more backwashing than GAC contactors by virtue of the cycle of growth and death of the biomass on the filters.

BAC filtration may present significant cost savings when compared to GAC filtration, as it avoids the need to replenish/regenerate the GAC media substrate while still achieving organics removal. To fully reap the benefits of this process, biomass must be maintained at adequate levels when DBP formation is at its highest during the summer months. A layout of the potential biological filtration and ozonation option is shown in **Figure 9.12**. A similar layout can be used for GAC filtration alone if the ozone units are removed.

9.4.3 Membrane Filtration

Typically, NF or RO membranes are required for TOC removal. Given the significant capital costs of installing a membrane system, RO filtration and would likely be used for both softening and TOC removal.

Operation of a RO membrane system is similar to that described in Section 9.3. A typical RO membrane system can consist of two membrane trains, each with the ability to 50% of the maximum daily flow. A chemical feed system for antiscalent and pH adjustment and a CIP system for membrane cleaning would also be installed. Pre-treatment of the feed stream using an UF membrane would also be required.

9.4.4 Post-Treatment Evaluation

The choice of post-treatment technology would be dependent on quality of treated water after softening. The use of membrane filtration would negate the need for any additional treatment until disinfection, although this presents significant capital costs. GAC for TOC removal has shown to be effective in waters where the inlet TOC was below 3 mg/L; higher dosages have been found to overload the media. Thus, proper operation of upstream enhanced and cold-lime softening process would be required to sustain the GAC media for appreciable periods of time. BAC filtration would require careful management of the media environment to allow for biological growth, although the reduction in operation and maintenance costs compared to the other options may prove to be significant if properly operated.

Many of the post-treatment technologies evaluated here can also be used for DBP removal, although the varying chemical characteristics of DPBs would require different operational targets. RO membrane filtration tends to remove a large array of DBPs, although less efficiently than TOC due to the smaller molecular size of some DBPs.. Technologies such as air stripping could be used to remove THMs, which are volatile and can be removed through vaporization.

9.4.5 Ultraviolet Disinfection

UV disinfection has very rapidly gained prominence in the drinking water industry as the preferred technology for *Cryptosporidium* inactivation. UV disinfection systems for drinking water treatment are almost universally mounted within a closed reactor, usually within a pipe spool. Several UV lamps are arranged within the reactor, spaced in such a fashion as to ensure a good distribution of UV dosage across the cross-sectional area of the pipe. The lamps are usually fitted with a cleaning device, usually in the form of a wiper to keep the lamp clean and minimize wastage of electrical power. UV dosage sensors are also mounted within the reactor for use in control of UV dosing. Dosages of 40 mJ/cm^2 are used in the design of UV disinfection systems to achieve 3-log removal *Giardia lamblia* and

Cryptosporidium, although actual dosages may vary based on additional parameters such as water quality, lamp fouling and lamp aging (Earth Tech, 2005).

As mentioned in Section 2.2, the current UV disinfection system may not be calibrated to meet current *Cryptosporidium* inactivation targets. Research by organizations such as the Water Research Foundation and the American Water Works Association regarding this topic are on-going, several interim measures may be established (AWWA/IUVA Working Group, 2012). These include:

- Relying on a conservative UV disinfection design, such as applying higher overall UV doses;
- Applying generic Action Spectra Correction Factors (ASCF) for UV dosing. ASCFs are used to obtain equivalent UV doses when validation testing is conducted with surrogate organisms. When organisms such as the MS2 phage are used to evaluate *Cryptosporidium* inactivation, ASCFs are typically not applied. By instead applying a generic ASCF for all surrogate organisms, any potential issues with inadequate UV doses may be mitigated.
- Applying a site-specific ASCF. This would include monitoring the water quality of the effluent to account for any site-specific UV absorbance phenomena to determine an appropriate ASCF, if any.

It is recommended that the capacity of UV disinfection system be evaluated once the relevant work by the American Water Works Association is completed.

Figure 9.6: Inline UV Reactor (Image from Calgon Carbon Corp.)

A critical aspect in UV design and operation is the potential impact of water quality on process performance. These impacts usually manifest themselves in one of three ways:

- Reduction in UV transmittance due to the presence of other UV-absorbing substances in the water, such as NOM, or particulate matter. The higher the concentrations of these substances, the more UV light is absorbed during the optical path between the lamps and the target organisms, and the higher the applied UV fluence (dosage) needs to be to provide the target dosage. The practical implication of this phenomenon is that the cost of UV disinfection is directly linked to water quality, and wherever practical UV disinfection should be placed as late in the overall process train as possible to maximize feed water quality to the UV reactors;
- In cases where UV disinfection was applied to water containing particulate matter resulting in turbidities above 5 to 8 NTU, the effectiveness of the process can be at risk due to physical masking of target organisms by entrapment within particulate matter; and

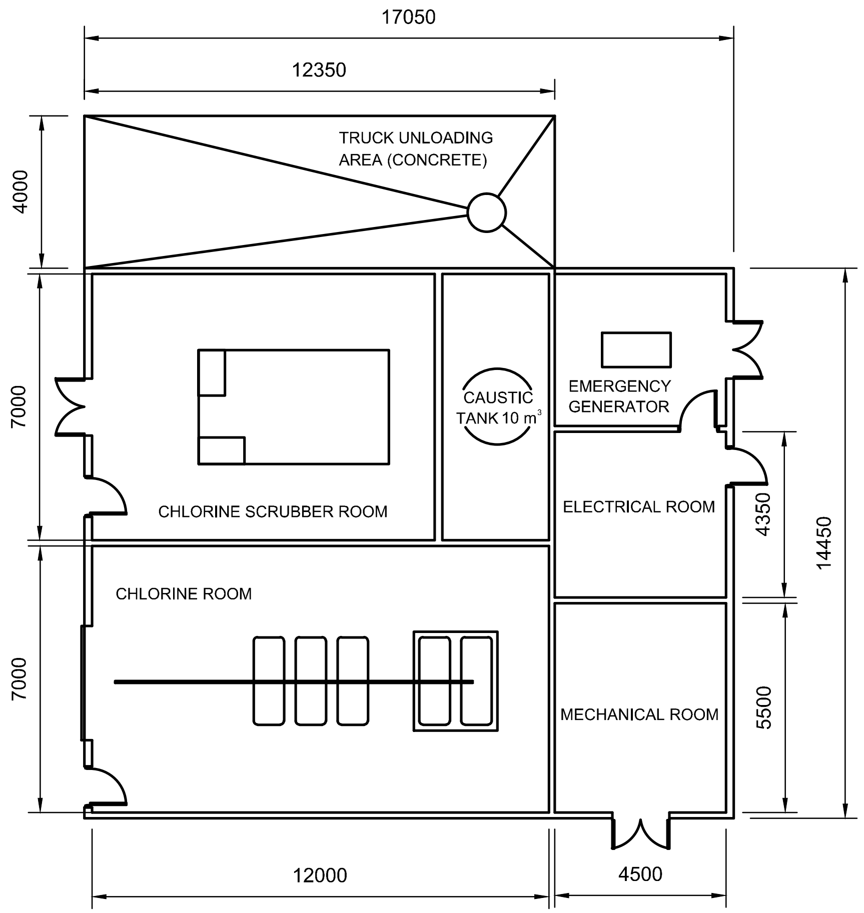
- Some contaminants present in water can lead to physical fouling of UV lamps due to precipitation reactions on the lamps themselves (which operate at a high surface temperature), or the gradual accumulation of polymeric substances such as bio-polymers on the lamp surface. The formation of this foulant layer on the lamp surface serves to absorb UV light, and will increase the UV applied dose required to ensure the desired target dose. Lamp cleaning devices are specifically designed to address these phenomena, but care should be taken in design of UV systems for waters high in hardness, iron, manganese or algae to fully understand these fouling implications.

By ensuring the upstream processes meet turbidity targets, and by determining the *Giardia lamblia* and *Cryptosporidium* log inactivation Credits of upstream processes, the appropriate UV disinfection system can be selected. UV disinfection should be installed to achieve *Giardia lamblia* and *Cryptosporidium* inactivation targets.

In addition to enhanced inactivation of pathogens using UV disinfection and chlorine/hypochlorite/chloramines, some upgrades to the plant are plausible which would enhance the physical removal of pathogens. This might include:

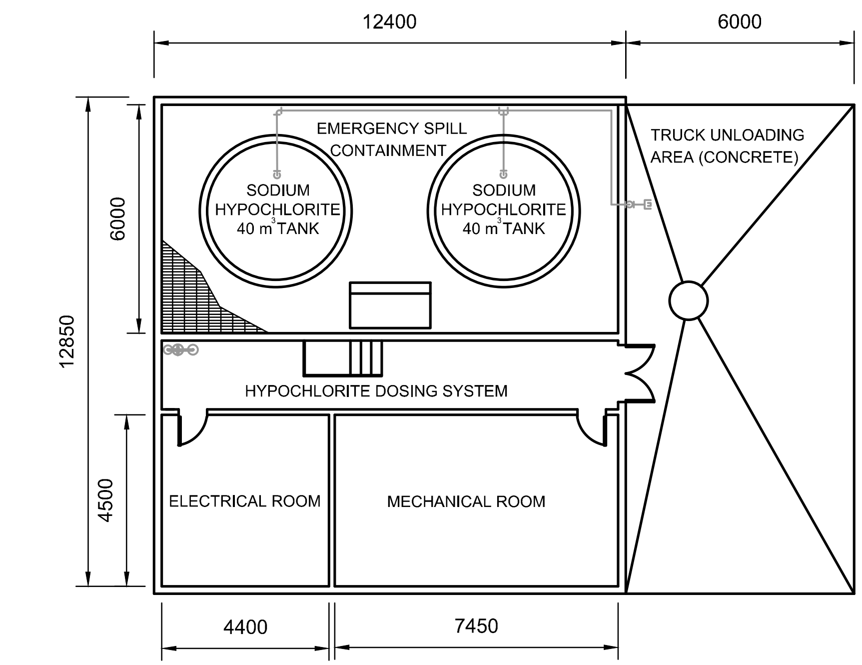
- The use of enhanced coagulation, which has been demonstrated to provide at least 2-log removal *Giardia lamblia* and *Cryptosporidium* in pilot trials.
- The use of membrane filtration (such as UF). Since the membranes used in drinking water applications are engineered with pore sizes below the nominal size of both *Giardia lamblia* cysts and *Cryptosporidium* oocysts, the technology is able to routinely surpass granular media filtration in overall removal efficiency;

- Granular media filters achieve the removal of particulate matter and pathogens by a variety of mechanisms. Removal of pathogens in the size range of *Giardia lamblia* and *Cryptosporidium* by physical size exclusion, i.e. whereby the cysts are physically trapped within spaces between media grains and removed likely does occur, but probably to a limited extent, as the size of the interstitial spaces between media grains is much larger than the typical size of *Giardia lamblia* and *Cryptosporidium* cysts. However, for UF and NF membranes, nominal pore sizes are physically smaller than these cysts, and removal by size exclusion is the main removal mechanism. This results in membranes offering a higher effectiveness in physical removal of *Giardia lamblia* and *Cryptosporidium* than is typically achievable with granular media filters.



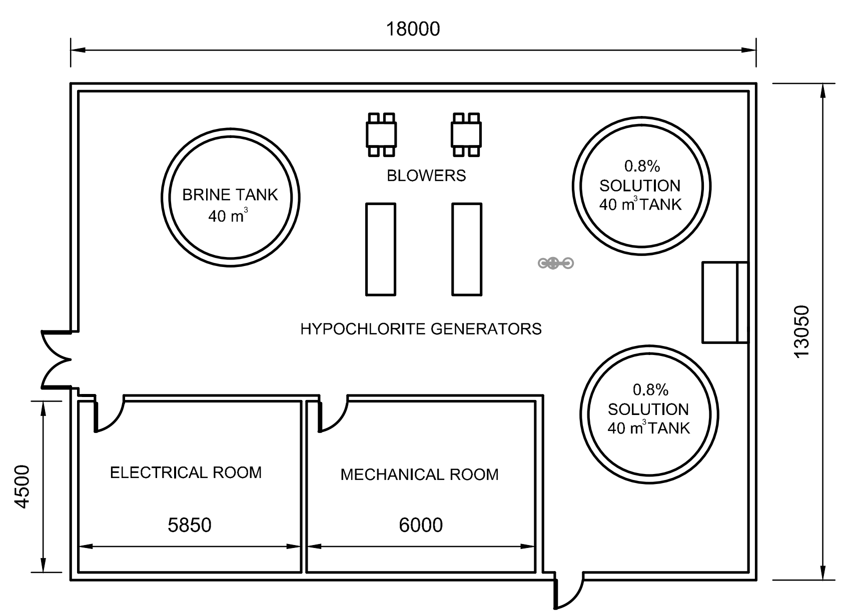
CHLORINE GAS DISINFECTION

Scale 1:200



LIQUID HYPOCHLORITE DISINFECTION

Scale 1:200



ON-SITE HYPOCHLORITE GENERATION

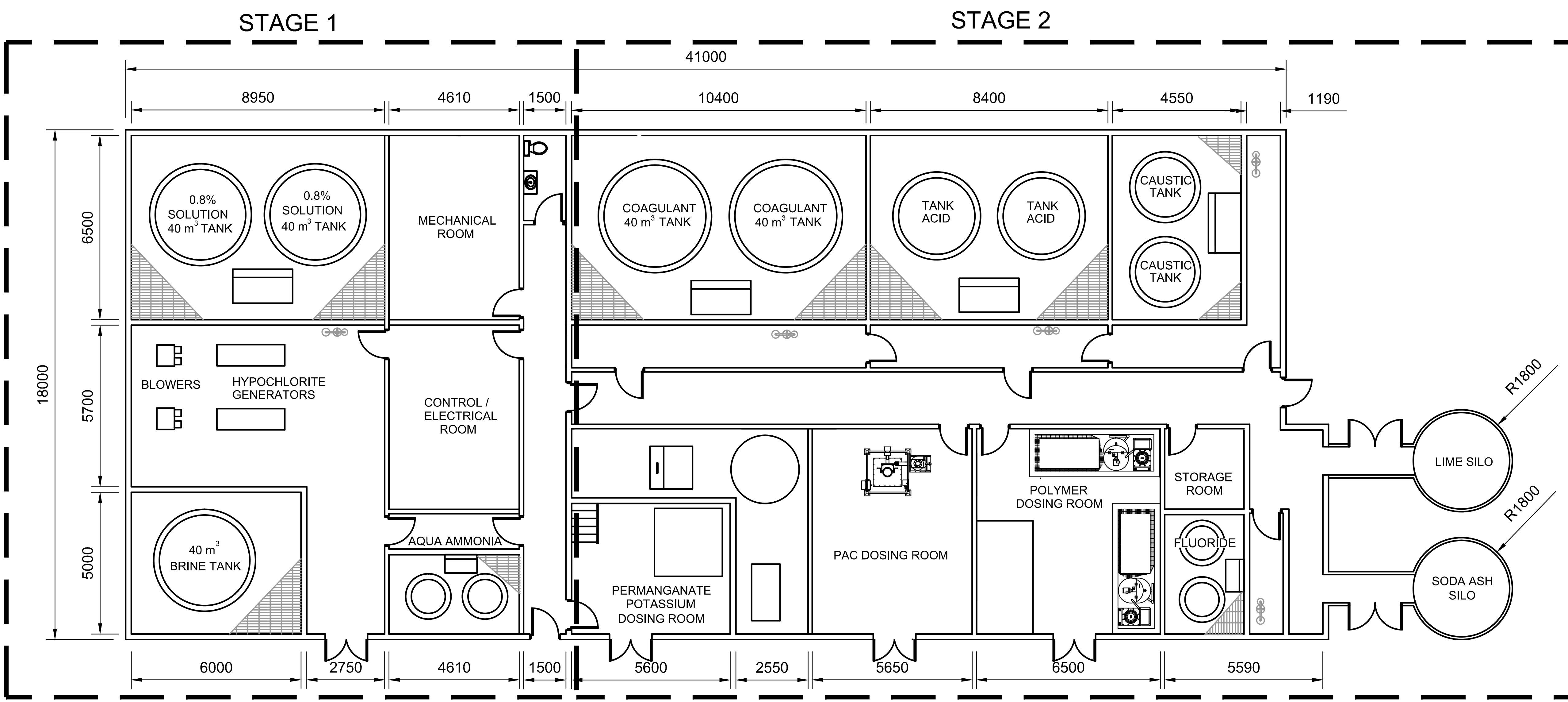
Scale 1:200

ALL DIMENSIONS IN mm
UNLESS OTHERWISE STATED

CONCEPTUAL CHLORINATION LAYOUTS

Figure 9.7

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081 2013-05-16



MAIN LEVEL PLAN
N.T.S.

ALL UNITS IN mm UNLESS OTHERWISE STATED

CHEMICAL STORAGE FACILITY CONCEPTUAL LAYOUT

Figure 9.8

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Water Utility Master Plan
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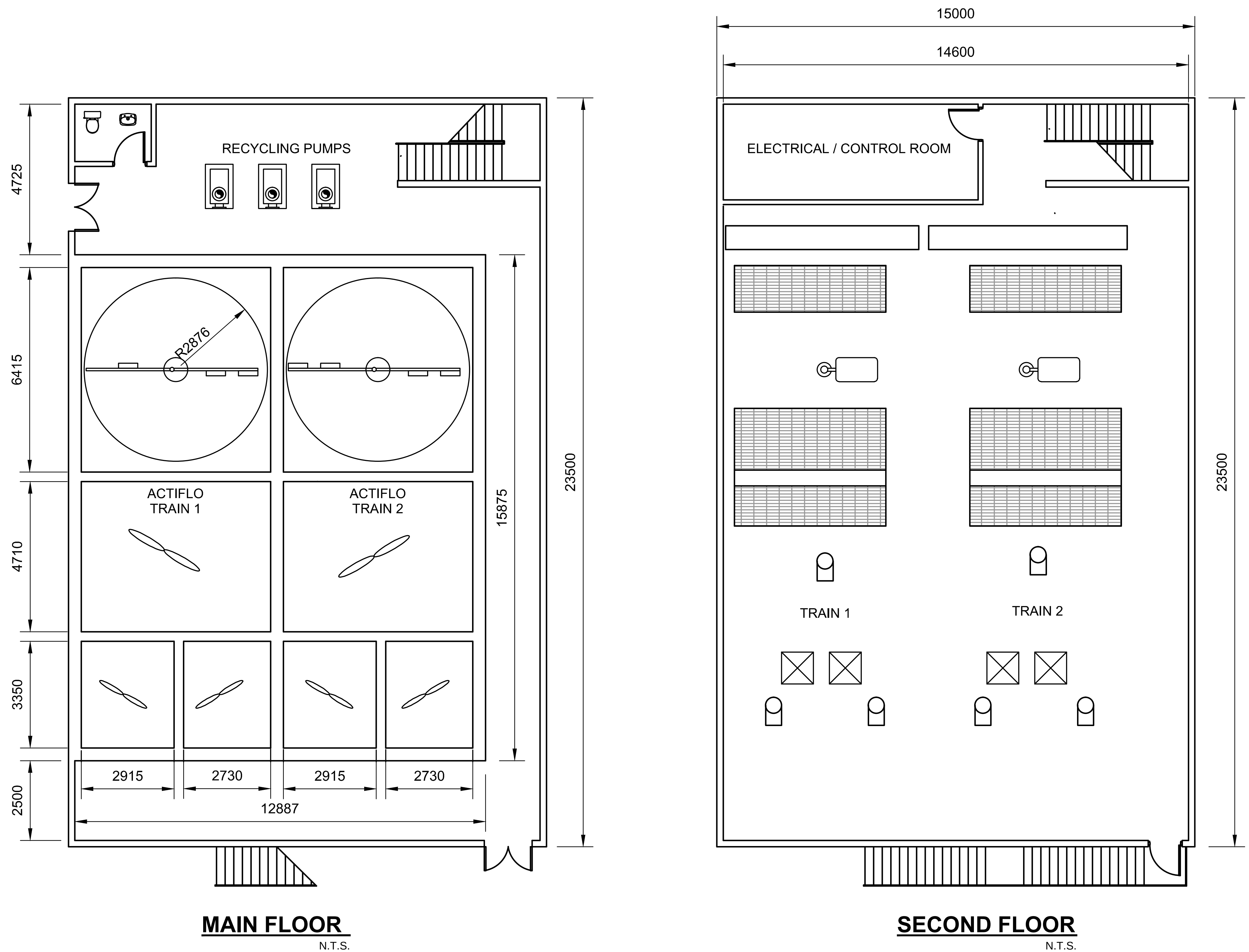
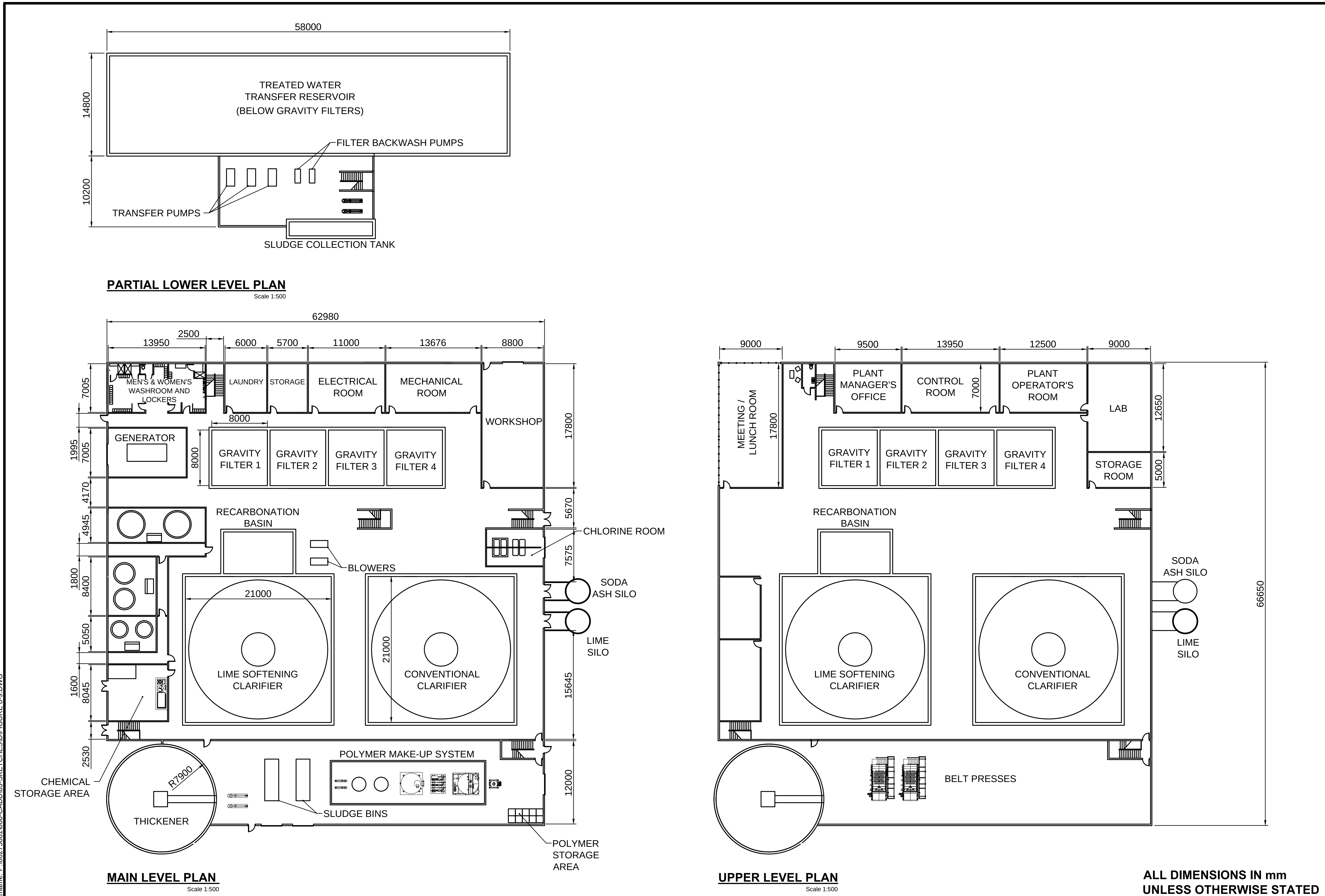
Figure 9.9

ACTIFLO PRE-TREATMENT OPTION



ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED

City of Brandon
Water Utility Master Plan
Brandon, Manitoba
Project No.: 60275081 2013-05-16



COLD LIME SOFTENING OPTION

Figure 9.10

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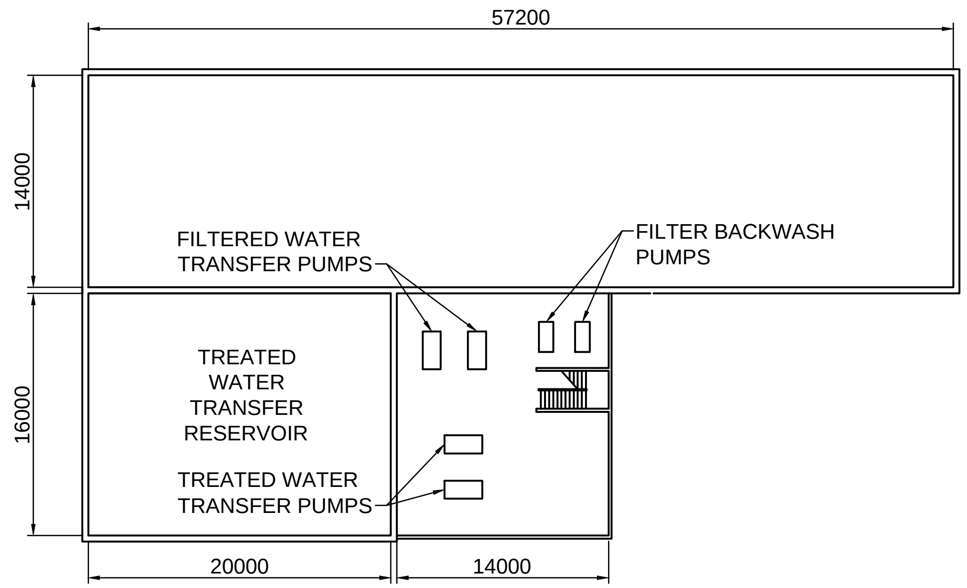
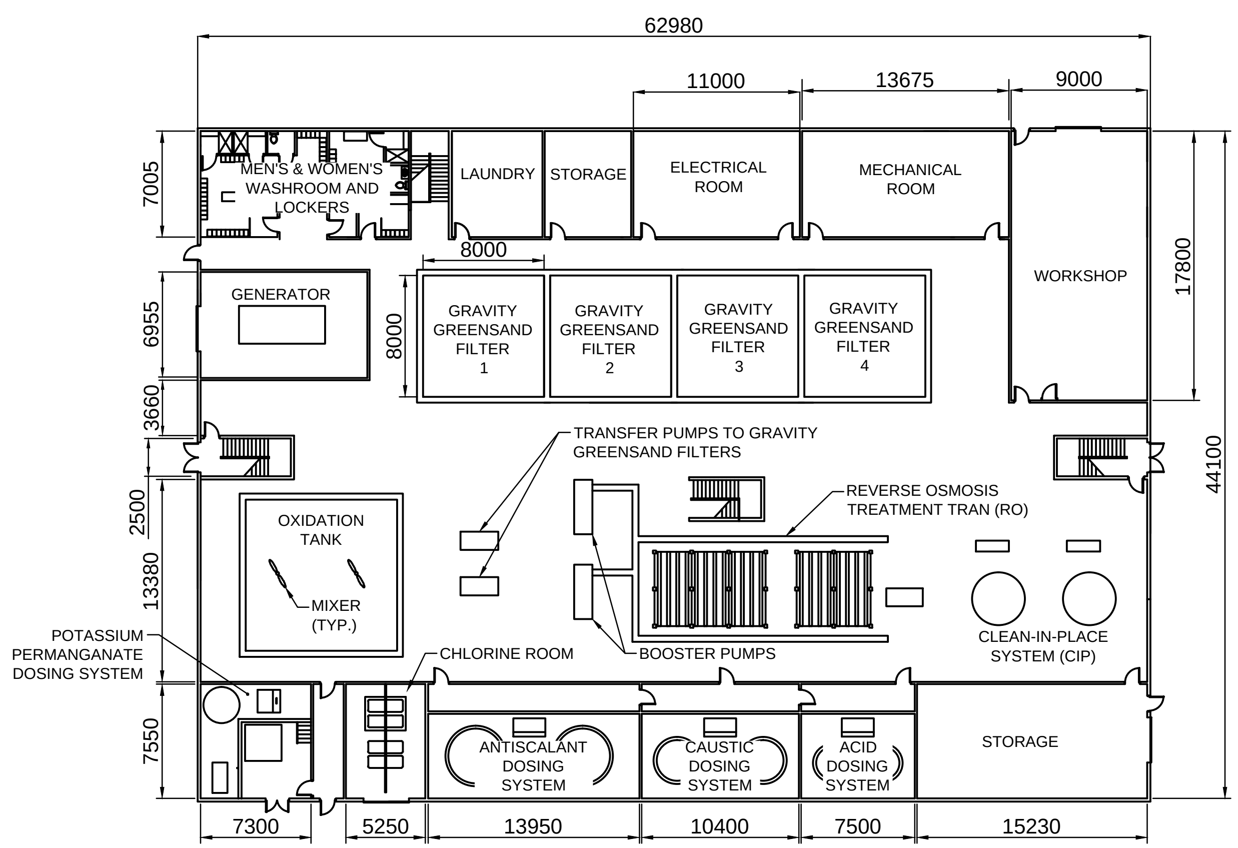


PARTIAL LOWER LEVEL PLAN

Scale 1:500



MAIN LEVEL PLAN

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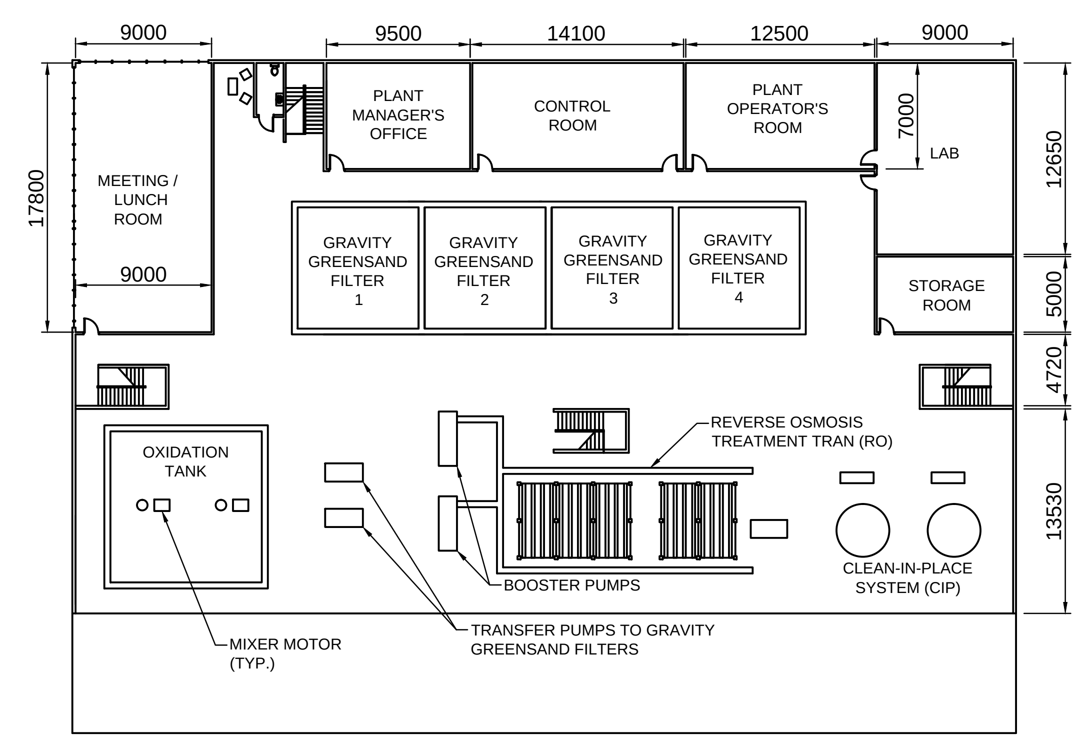

UPPER LEVEL PLAN

Scale 1:500

ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED

MEMBRANE SOFTENING OPTION

Figure 9.11

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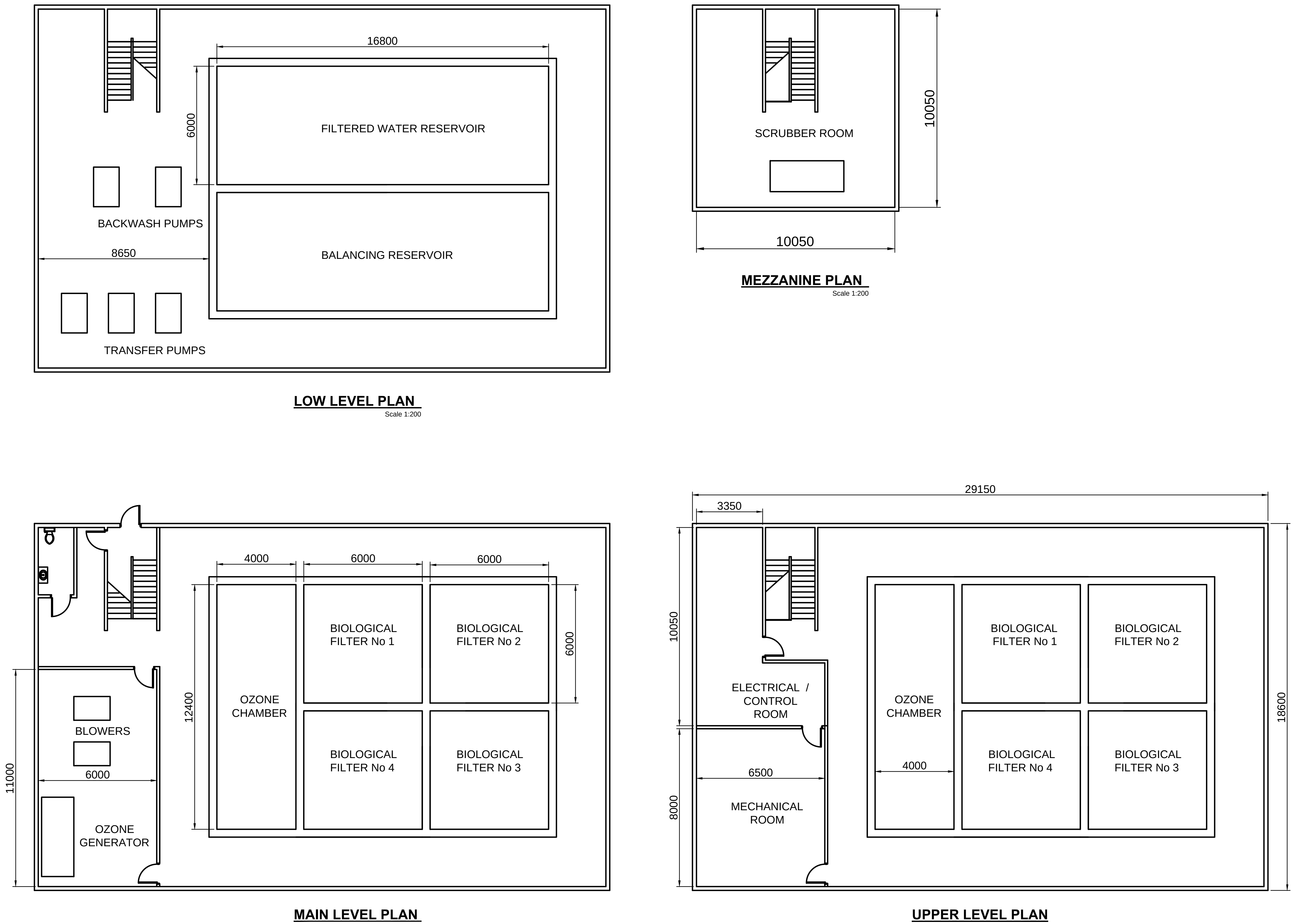
ANSI B 279.4mm x 431.8mm
Approved: _ Checked: _ Designer: _ Project Management Initials:

Last saved by: LAPOINTEP1(2013-12-16) Last Plotted: 2013-12-16
Filename: P:\60275081\000-CADD\03-SKETCHES\D\FIGURE 8-10.DWG

OZONATION AND BIOLOGICAL FILTRATION OPTION

Figure 9.12



ALL DIMENSIONS IN mm
UNLESS OTHERWISE STATED

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Water Utility Master Plan
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City of BRANDON

Figure 9.13

EXISTING WATER TREATMENT PLANT EXPANSION

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Water Utility Master Plan
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Project No.: 60275081 2013-05-16

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Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

10. Project Implementation

10.1 Project Implementation

The primary goal of the Master Plan is to provide direction for water utility upgrades over the next 20 years. The decision tree presented in **Appendix K** outlines major decisions, timelines, and costs until the year 2018 when a new major plant expansion will be completed (2018-2020). Due to the age and condition of the existing facility and its inability to meet DBP regulatory limits, if funding becomes available to the City the new major plant expansion should be advanced. Overall, a total of $58.5 M of plant upgrades/improvements have been identified and are listed in **Table 10.1.**

Table 10.1: Capital Cost Estimates (2014-2020)

Description	2014	2015	2016	2017	2018-2020
Groundwater Investigation					
Existing Wells	$150,000	$150,000	$150,000	$150,000	
Hydro Wells	$200,000	$50,000	$50,000	$50,000	
Koch Well Development			$500,000		
Upgrades					
• Sodium Hypochlorite		$1,645,000	$1,645,000		
• Code and Condition Assessment (Risk 1-5, Plants 1/2/3)		$6,250,000	$4,500,000		
• Incoming Service					
• New Intake				$6,300,000	
• New Plant 4/Chemical Building/Distribution Network					$38,150,000
Engineering					
• Hypochlorite	$490,000				
• Code and Condition Upgrades	$900,000	$675,000			
• Incoming Service					
• Intake Upgrade			$400,000		
• Preliminary Design of New Plant 4				$3,000,000	
• Detailed Design of New Plant 4/Chemical Building					

Prior to the 2018 expansion, there are several short-term upgrades needed to meet health and safety related upgrades, such as chlorine gas replacement, and chemical spill containment. These types of work need to proceed irrespective of the long term plant concept.

The City of Brandon has decided it would like to begin transitioning from using Assiniboine River as its primary source water to using a combination of groundwater sources. This requires development of a comprehensive testing program to confirm long-term viability of potential groundwater sources. Consultation with other users, licencing negotiations and approvals will also be needed.

Over the long-term, it is expected that changes will occur such as new regulations (lower maximum contaminant levels, new contaminants), changes in consumer habits and expectations, new fiscal constraints etc. This Master

Plan is intended to be a living document, updated on a yearly basis. This will allow new information to be documented and any changes to be made logically without undue costs.

10.1.1 Short Term Implementation Plan (2014-2017)

Short-term upgrades focus on those items needed to meet health and safety related upgrades. To consistently meet DBP regulatory limits a new plant expansion will be required. At this time it is not known whether funding will be available for a plant upgrade needed to meet these regulatory limits. For this reason, the short term implementation plan will focus on health and safety related issues, however, it is recommended that if funding becomes available, the new plant expansion be advanced into the short term.

One safety related concern is associated with the chlorine gas system. The code and condition assessment allocated the chlorine system a risk Grade 5 and recommended it be decommissioned and replaced with a system which poses less risk to the community.

The results of the triple bottom line (TBL) assessment of chlorination options indicated on-site sodium hypochlorite generation system is the preferred option.

It is recommended that preliminary and detailed design of the hypochlorite system take place in 2014 with construction and commissioning completed by 2016.

In parallel with the design and construction of the new hypochlorite system, it is recommended that the City embark on series of groundwater investigations beginning in 2014. It is recommended that the results of these investigations be reviewed annually, and depending on the findings may continue until the year 2017. After the year 2017 the City will have enough information to determine whether blending groundwater with Assiniboine River water is a viable long term option. It is estimated that the cost to drill a new Hydro well will be $150,000 (2014). Annual groundwater investigations for the City's existing wells and the Hydro well are expected to be about $200,000 per year.

In addition to the groundwater evaluation, the City plans on entering into discussions with Koch to determine the feasibility of providing Koch reclaimed water in exchange for the City's use of groundwater. An agreement in principle with Koch should be made by the end of 2016, allowing for proof of concept trials to be conducted and approval from the regulator obtained. An allowance of $500,000 has been allocated in 2016 for constructing new high capacity wells in the vicinity of the Koch site.

10.1.2 Long Term Implementation Plan (2018-2020)

In **Section 7**, it was recommended that the WTP remain on the existing site, and that long term planning be based on that decision. This provides the City the flexibility of using Assiniboine River water, groundwater, or a blend of each. It also allows the City to stage construction on the existing site, knowing that certain elements (i.e., disinfection, chemical dosing, etc.) are required independent of the source water. This process ensures a minimization of sunk cost investment over the long term.

By the end of 2016, enough work will be complete on the groundwater evaluations and discussions with Koch to determine the quantity of groundwater available to the City. The quantity of groundwater used in the long term will influence the use of the existing Assiniboine River water intake. The New Intake Conceptual Design Report (CH2MHILL) recommended the existing intake be replaced by a new settling pond at a cost of $6.3M. Other options such as upgrading the existing intake are expected to cost significantly less. Therefore, depending on whether surface water will remain the primary drinking water source will dictate the level of cost invested in the new intake structure. For budgetary purposes, a cost of $6.3 M was carried in **Table 10.1**, however, this value will need to be revised at the conclusion of the groundwater studies.

10.1.3 Budgetary Planning (2014-2020)

Based on the implementation schedule described above, budgetary estimates were prepared from 2014 to the year 2020 and are listed in **Table 10.1**. These estimates are based on outline layout drawings, supplier quotes, and our understanding of the local Manitoba market. All costs are in 2013 dollars.

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Appendix A

- Code and Condition Summary Technical Memorandum

City of Brandon

Code and Condition Report Technical Memorandum

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Project Number:

60275081

Date:

November, 2012

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The attached Report (the “Report”) has been prepared by AECOM Canada Ltd. (“Consultant”) for the benefit of the client (“Client”) in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the “Agreement”).

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- may be based on information provided to Consultant which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
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AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

November 7, 2012

Patrick Pulak, P. Eng.
Deputy Director of Engineering Services & Water Resources
Development Services Division, Engineering Department
City of Brandon
P.O. Box 960 410 – 9th Street
Brandon, MB R7A 6A2

Dear Mr. Pulak:

Project No: 60275081

Regarding: Code and Condition Report

AECOM is pleased to submit the Draft Technical Memorandum on the Code and Condition Assessment for the Water Treatment Plant. This Memorandum is a deliverable of the Water Utility Master Plan. We look forward to meeting with you to discuss this memorandum and addressing any comments you may have.

Sincerely,
AECOM Canada Ltd.

Keith Sears, Ph.D., P.Eng
Project Manager
Keith.Sears@aecom.com

KS:td
Encl.
cc:

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AECOM Signatures

Report Prepared By:

Keith Sears, Ph.D., P.Eng.
Project Manager

Report Reviewed By:

Ray Bilevicius, MSc., P.Eng.
Associate Vice-President

Table of Contents

List of Tables

1. Introduction

The primary objective of this Technical Memorandum is to assess what existing infrastructure could be retained as part of the future upgrades, what equipment should be considered for decommissioning, and what assets should be fast-tracked for replacement or refurbishment.

1.1 Method of Evaluation

There are a number of methods available to determine the condition of infrastructure assets. AECOM's approach for the Brandon Water Plant to follow the UK Office of Water Services (OFWAT) rating system for non-linear assets (surface assets such as treatment facilities), which rates the condition of assets according to a five point grading scheme, as shown in **Table 1.1**.

Table 1.1: OFWAT Condition Grades for Wastewater/Water Plant and Equipment

Condition Grades	Description
Condition Grade 1	Sound modern structure, operable and well-maintained.
Condition Grade 2	As 1, but showing some minor signs of deterioration. Routine refurbishment and maintenance required.
Condition Grade 3	Functionally sound, but appearance significantly affected by deterioration, structure is marginal in its capacity to prevent leakage, mechanical and electrical plant and components function adequately but with some reduced efficiency and minor failures.
Condition Grade 4	Deterioration has a significant effect on performance of asset due to leakage or other structural problems. Mechanical and electrical plant and components function but require significant maintenance to remain operational.
Condition Grade 5	Serious structural problems having a detrimental effect on the performance of the asset. Will require major overhaul/replacement of the asset in the short term.

This standard can be effectively utilized on a range of facilities, is easily taught to staff making the assessments (current assessment as well as in the future), and can be applied consistently to future iterations of the model.

Since asset condition only makes up a portion of an investment decision, it is also important that asset risk be taken into account. For example, some assets can be allowed to fail without serious ramifications, while other asset failures may result in catastrophic damage, and even jeopardize public health and safety. To ensure that risk is factored into the asset replacement decision, AECOM has also assigned a risk rating for mechanical, structural and electrical assets within the evaluation sample, based on a five-point risk rating system, as illustrated in **Table 1.2**.

The service life of an asset is the period over which it is expected to provide the entity with service, and is usually expressed in terms of time. Service life must be realistically assessed in light of the following:

- Over what period does the utility expect to gain service potential from the asset?
- What has been the past experience of such assets in use?
- Is the past experience an appropriate benchmark, given technological advances?

- What is the opinion of operations and maintenance staff about the asset's remaining service life?
- Are there specific risk-based factors that could affect the asset's remaining useful life?

The remaining service life of the assets can then be determined based on the following parameters for each asset:

- Expected service life
- Apparent asset age (combination of actual age and asset condition)
- Asset risk rating

Table 1.2: Risk Rating Criteria for Asset Management Planning Purposes

Risk Grade	Risk Level	Category	Definition
1	No Risk	Environmental	No Risk
		Public Safety	No Risk
		Workers Safety	No Risk
		Equipment	No Risk
		Process	Plant running below design capacity and 100% redundancy available
2	Minimal Risk	Environmental	Minor site only
		Public Safety	No Risk
		Workers Safety	No Risk
		Equipment	Minor repairs, no new parts necessary
		Process	100% redundancy available
3	Low Risk	Environmental	Minor, local area
		Public Safety	No Risk
		Workers Safety	No Risk
		Equipment	Repairs and new parts necessary
		Process	Backup available, between 99% and 25% redundancy available
4	High Risk	Environmental	Major, Large Area affected
		Public Safety	Possible Risk
		Workers Safety	Minor Injury
		Equipment	Necessary to replace equipment
		Process	Reduced Capacity or <25% Redundancy Available
5	Extreme Risk	Environmental	Environmental Disaster
		Public Safety	High Risk of Injury
		Workers Safety	Major Injury or Death
		Equipment	Entire process to be replaced
		Process	Equipment currently running over design capacity with no redundancy

The AECOM team has conducted the code and condition assessment on major equipment, buildings, tank and utilities, including mechanical and HVAC systems, instrumentation and electrical subsystems. As the scope of this condition assessment is intended to provide planning level information on whether there are any issues with existing major infrastructure and subsystems at the WTP that would pose a risk. AECOM has limited its reviews to infrastructure that is readily visible without the aid of specialized equipment, such as video, the need for destructive and non-destructive tests, taking equipment out of service, confined space entry and other special procedures.

The assessment is grouped by technical discipline as follows:

- Architectural
- Structural
- HVAC Mechanical
- Electrical and Instrumentation
- Process Mechanical

The Architectural assessment is a code evaluation, while the Process, Structural, HVAC Mechanical, Electrical, and Instrumentation sections evaluate the related equipment in each process area.

The following activities were undertaken during this task:

- Developed code and condition assessment framework
- Developed risk rating criteria
- Completed site audits and visual inspections by each discipline and holding discussions with Operations and Maintenance staff. Only those assets that can be inspected visually without the aid of specialized equipment, or do not pose a major issue for on-going operations of the WTP, were inspected during this task. The site audit and inspections were conducted September 17, 2012.
- Reviewed maintenance records and other pertinent information (inspection reports, etc), where appropriate.
- Prepared Class D (indicative/conceptual) cost estimates for replacing/refurbishing infrastructure identified for decommissioning and replacement

2. Architectural

2.1 Existing Construction

The Brandon Water Treatment Plant facility is comprised of four distinct additions, each area added throughout the years to enhance the treatment of water. The four areas are; Plant No. 1 constructed between 1905 and 1946, Plant No. 2 constructed in 1958, Plant No. 3 constructed in 1975, and the Sludge Dewatering Facility constructed in 1997.

Plant No. 1 from 1905 to 1946 is a three storey building mainly constructed of concrete, brick and steel. The Lower Level construction consists of concrete floors with wythe brick walls. This floor contains the following rooms; Filters, #1 Solid Contact Unit (open to above), Chlorine Storage, and Process Room. The Upper Level construction consists of concrete floors with wythe brick, masonry and concrete walls, and a riveted steel truss roof and wood decking on edge. This floor contains the #1 Solid Contact unit that is open to below. The Third Level contains the Carbon Storage Room and is constructed of concrete floors with wythe brick, masonry and concrete walls, and a riveted steel truss roof and wood decking on edge.

Plant No. 2, 1958 addition is a two storey building mainly constructed of concrete, brick and steel. The Lower Level construction consists of concrete floors with wythe brick, masonry, concrete walls, and ceramic tile. This floor contains the Main Entrance (open to above), Lunch Room, Washroom, Filter Area (open to above), #2 Solids Contact Unit, Storage Silos Room and the Main Workshop. The Upper Level construction consists of concrete floors with wythe brick, and masonry walls, with a steel joist and steel deck roof structure. This floor contains Offices, Operator Room, Laboratory, Filter Area (open to below), and Storage Silos Room. The Main Workshop is an interconnected space with a mezzanine. The Storage Silos Room is an interstitial space constructed of Clay Blocks separated from the rest of the building. The Main Workshop is an interstitial space constructed of masonry walls, glulam roof beams and wood decking roof structure.

Plant No. 3, 1975 addition is a two storey building mainly constructed of concrete floors with masonry, concrete, and gypsum board walls, the exterior has metal cladding and brick veneer. The Lower Level construction consists of concrete floors with gypsum board, masonry and concrete walls. This floor contains the Boiler Room, Workshop, #3 Solids Contact Unit and Filter Area (open to above). The Upper Level construction consists of concrete floors with masonry, concrete and gypsum board walls. This floor contains the Alum Storage, Feeder Room, Recarbonation Equipment Room, and #3 Solids Contact Unit and Filter Area (open to below).

The Sludge Dewatering Facility, 1997 addition is a two storey building mainly constructed of concrete, masonry and steel, the exterior has metal cladding and brick veneer. The Lower Level consists of a Polymer Room and a Truck Bay. The Upper Level consists of Service Room for the Polymer distribution.

2.2 Observations

The assessment of the Brandon Water Treatment Plant is separated by areas. These areas are defined by use and occupancy, year of construction, and travel distance to exits. An existing building code analysis helps to identify areas of non-conformance and their impact to Life Safety within the parameters of the National Building Code of Canada 2010 (NBCC).

2.2.1 Existing Building Code Analysis

Major Occupancy Classifications: Group F, Division 3 (WTP)
Building Area: 4,585 m^2
Building Height: 3-storey (with interstitial spaces)
Number of Streets: 3
Building is Sprinklered: No, but contains existing standpipes at two locations
Building Occupancy Load: 9 persons

NBCC Section 3.2 Building Fire Safety

Building Area and Construction Relative to Occupancy:
Construction Article: The building is regulated under 3.2.2.79., Group F, Division 3, up to 6 storeys
Non-combustible or Combustible: The F-3 building is of non-combustible construction .
Floor Assemblies: F-3, 1 hour FRR
Mezzanines: F-3, 1 hour FRR
Roof Assemblies: F-3, 1 hour FRR
Carbon Storage roof not permitted to be of Heavy Timber
Support Elements: F-3, 1 hour FRR

The existing construction of primarily concrete, brick and masonry will meet these fire rating requirements.

NBCC Section 3.2.3 Spatial Separation (Limiting Distance to property line and adjacent structures)
Limiting distance for all four sides of the building was not calculated as aggregate area of openings was not established and with all exterior finishes of non-combustible construction with inherent fire resistant ratings of at least 45 minutes.

NBCC Section 3.2.4 Fire Alarm:
A fire alarm system is not required, building not sprinklered.

NBCC Section 3.2.5 Provisions for Firefighting:
Access for Fire Department Vehicles: Yes
Hydrants Location: North/East corner of property.
Sprinkler or Standpipe: Current configuration taking into account interconnected floor spaces, size and use this building should be sprinklered.

NBCC Section 3.2.7 Emergency Lighting:
Emergency lighting is not present and is required.

NBCC Section 3.2.8 Mezzanines and Openings through Floor Assemblies:
The Main Workshop has a mezzanine.
The Storage Silo has a service mezzanine.
The Main Entrance Staircase not separated; therefore, classified as an interconnected floor space.

NBCC Section 3.4 Exits
The building has multiple floor areas that are served by numerous staircases and exits. Each area is required to be divided into floor areas not more than 200 m^2 with each area having a maximum travel distance of 15 m to each exit, provided the occupant load is less than 60 persons.

Area requirement for one exit within each area complies for 9 persons but maximum travel distance of 15 m to each exit does not comply.

NBCC Section 3.4.5.1 Exit Signs
Exit signage is installed throughout the building, but do not comply with NBCC. All Exit signs must by self-illuminated and contain the proper colors and pictogram as outlined in Section 3.4.5.1 of the NBCC.

NBCC Section 3.4.6.5 Handrails
Main Entrance Handrail doesn't allow for a continuously graspable length and does not conform to the profiles and sizes outlined in NBCC.

NBCC Section 3.4.6.6 Guardrails
Existing Guardrails do not comply with height requirements (1,070 mm) of NBCC.

NBCC Section 3.7 Washrooms:
Existing condition; one water closet provided to service 9 occupants.
NBCC requirement; one universal (barrier-free) water closet must be provided with an occupant load less than 10.

NBCC Section 3.8 Barrier-Free Design:
Existing condition: no barrier free design integrated into existing building
NBCC requirements; 50% of the entrances are required to be barrier-free.
A barrier-free path of travel must be provided to the second floor.
One universal (barrier-free) water closet must be provided with an occupant load less than 10.

2.3 Risk Assessment

2.3.1 Main Entrance

Existing Main Entrance (Photo 2.1) contains an open staircase between the Lower Level and Upper Level and also provides access to exit through a lobby. These conditions are not permitted in an unsprinklered building and would need to be corrected by either a fire separated staircase or providing sprinklers for the entire building. The installation of a sprinkler system would permit many of the existing conditions, as this document will identify.

Existing exit signage (Photo 2.2) and handrails need to be replaced as they do not comply with part 3 of NBCC. A barrier-free entrance and access to the Upper Level is required to comply with NBCC. Door from Main Entrance to #3 Accelerator area is required to swing towards the path of egress and should be replaced with a 45 minute rated door. Openers are required at front entry door.

Photo 2.1: ↑
Existing Main Entrance

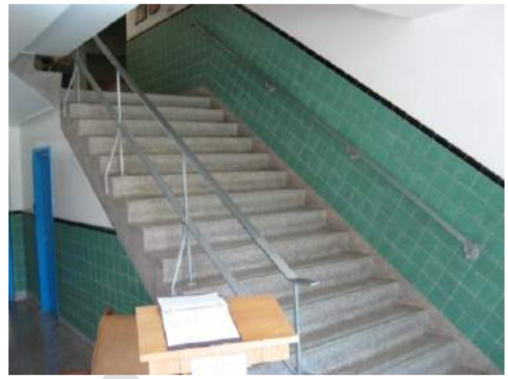

Photo 2.2: ↑
Existing Exit Signage and Handrail

Table 2.1: Architectural Risk Assessment – Main Entrance

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Replacement Costs
Lower/Upper Level					
Main Entrance	No Sprinkler System (Refer to Mechanical)	New N/A	5	Workers Safety	Refer to Mechanical
	Handrail	1	3	Equipment	$ 5,000
	Exit Signage	1	5	Workers Safety	Refer to Electrical
	Accessible Stair Lift to other floors	New N/A	1		$ 8,000
	Rated Door	New N/A	5	Workers Safety	$ 2,000

2.3.2 #2 Accelator and Filters

This area is a service space for process equipment and is required to have two exits as stated in Clause 3.3.1.3.(7) of NBCC. Two exits exist, one at the Main Entrance and the other through the adjacent Workshop, but each of these exists travel distance exceed the maximum of 25 m and more exits are required. This area is separated from the adjacent Workshop by a 2 hour fire rated wall, but is not separated from the adjacent Main Entrance. The Main Entrance contains an interconnected staircase and creates a Life Safety hazard for staff exiting from the Upper Level. Existing open staircase from the Lower Level to the Upper Level creates interconnected floor space.

The travel distance to exits and the interconnected floor space issues could be remediated by installing a sprinkler system. The Main Entrance should be separated from the #2 Accelator and Filters service space by a rated wall assembly of not less than 45 minutes. This rated compartment allows for the 25m travel distance to restart at the staircase.

The existing tile appears to be asbestos as it is of the right age and size. The tile should be removed and replaced.

Photo 2.3: ↑
Existing Tile

Photo 2.4: ↑
Existing Tile

Table 2.2: Architectural Risk Assessment – #2 Accelator and Filters

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Replacement Costs
Lower/Upper Level					
#2 Accelator and Filters	Sprinkler Systems (Refer to Mechanical)	2	5	Workers Safety	Refer to Mechanical
	Rated Wall	New N/A	5	Workers Safety	$ 7,000
	Rated Door	New N/A	5	Workers Safety	$ 2,000
	Asbestos Removal		3	Environment	$ 25,000
	New Flooring	New N/A			

2.3.3 Workshop

The Workshop contains vehicle storage, truck, lawn mower and various lawn care machinery. This area is classified as a storage garage under NBCC and is equipped with the minimum separation of 1.5 hours from adjacent areas. Two exits are provided; one at the north end and one at the south end.

This area is not separated at the adjacent #1 Solids Contact Unit and Filters area and contains a natural gas generator and personal protective equipment closet.

The opening between the Workshop and the #1 Solids Contact Unit and Filters is required to be separated by a wall with a minimum 2 hour fire resistance rating and a door installed with a minimum 1.5 hour fire resistance rating complete with the appropriate hardware.

The natural gas generator (Photo 2.5) is required to be in a room separated from the adjacent areas with a minimum fire resistance rating of 2 hours.

Photo 2.5: ↑
Natural Gas Generator

Table 2.3: Architectural Risk Assessment – Workshop

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Replacement Costs
Lower Level					
Workshop	Sprinkler Systems (Refer to Mechanical)	2	5	Workers Safety	Refer to Mechanical
	Rated Walls	New N/A	5	Workers Safety	$ 15,000
	Rated Doors	New N/A	5	Workers Safety	$ 4,000

2.3.4 Boiler Room

The Boiler Room contains two natural gas steam generating boilers (Photo 2.6). The existing wall separating the Boiler Room to the Workshop has a 2 hour fire resistance rating, and the double door within that wall has a 1.5 hour fire resistance rating. Without calculating special separation and exposure protection of the existing exterior walls and openings (Photo 2.7, Photo 2.8) it's undetermined if additional fire protection requirements are required. Currently no additional work is required in this room.

Photo 2.6: ↑
Natural Gas, Steam Generating Boilers

Photo 2.7: ↑
Overhead Door

Photo 2.8: ↑
Exterior Walls – Windows and Walk-in Door

2.3.5 #3 Solids Contact Unit and Filters

This service space used for process piping and is interconnected by the staircase at the north wall of this area. The existing ceramic tiled half walls serving as guardrails does not meet the required height of 1070 mm and would need to be replaced. This area is over 200 m^2 and is required to be served by two exit staircases having a travel distance no more than 25 m. The existing staircase is required to be separated from the space by a minimum 1 hour fire resistance rating. An additional staircase is required and would be best served along the south wall along "Walkway 1" or provide a fire resistant exit way into another fire resistant compartment.

Photo 2.9: ↑
#3 Solids Contact Unit

Photo 2.10: ↑
Existing Ceramic Tiled Half Wall

Table 2.4: Architectural Risk Assessment – #3 Solids Contact Unit and Filters

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Lower/Upper Level					
#3 Solids Contact	Guardrails	N/A	5	Worker Safety	$ 30,000
Unit and Filters	New Staircase	N/A	5	Worker Safety	$ 15,000
	Rated Walls	N/A	5	Worker Safety	$ 30,000

2.3.6 Storage Silos

This area is a three storey storage room containing storage hoppers for Lime and Soda Ash distribution. Under 3.3.6.2 Storage of Dangerous Goods this is required to be separated from the remainder of the building by a 2 hour fire resistance rating. The clay block and concrete support structure provides the required wall rating and the existing 1.5 hour door rating complies. The area is required to be sprinklered, or provide a fire resistant access to another compartment increasing travel distance to staircase to maximum 25 m travel distance requirement. The room is exposed to the exterior on all four sides at 3rd level. This area is un-insulated and un-heated.

Photo 2.11: ↑
Lime and Soda Ash Storage

Photo 2.12: ↑
Lime and Soda Ash Storage

2.3.7 Alum Storage

The alum process is decommissioned; no work required.

2.3.8 Polymer Room

The Polymer Room contains equipment for the control and operation of process equipment. This area is constructed of concrete, masonry, brick and metal and is separated from Plant No. 3 by a 2 hour fire rated wall. This area is in good condition with appropriate life safety components installed and in good working order. Rated doors are required to be closed at all times (Photo 2.13). The Upper Level of this area is an interstitial space used intermittently for equipment maintenance only (Photo 2.14).

Photo 2.13: ↑
Polymer Room Door

Photo 2.14: ↑
Polymer Room Equipment

2.3.9 Truck Bay

The Truck Bay is used for sludge loading and is constructed of concrete, masonry and metal it is separated from the Polymer Room by a 1.5 hour fire rating wall rating and a 1 hour fire rated door. This area is in good condition with appropriate life safety components installed and in good working order. No further work is required.

2.3.10 Main Office

The main office is located on the Upper Level adjacent to the Main Entrance staircase, is not required to have fire ratings provided the fire rating requirements noted within the section pertaining to the Main Entrance are met. Travel distance to the nearest exit is within the maximum 25 m requirement. The existing tile appears to be asbestos as it is of the right age and size. The tile should be removed and replaced.

2.3.11 #1 Solids Contact Unit and Filters

Constructed in 1946 this room is an interconnected floor space and is served by one exit. The staircase serving the area should be enclosed and separated from the remaining building providing a safe zone within the maximum 25 m travel distance. Existing construction provides the minimum required fire rating of 1 hour. The riveted steel trusses as a structural element is required to have a 1 hour fire rating requirement. This can be accomplished by applying a spray applied fireproofing with a 1 hour fire resistance rating.

Photo 2.15: ↑
Roof Above #1 Solids Contact Unit

Table 2.5: Architectural Risk Assessment – #1 Solids Contact Unit and Filters

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Lower/Upper Level					
#1 Solids Contact Unit and Filters	Fire Protection	2	5	Workers Safety	$ 60,000

2.3.12 Laboratory

Located on the Upper Level with direct exit to the adjacent staircase travel distance comply and the door is rated to 45 minutes. The existing tile appears to be asbestos as it is of the right age and size. The tile should be removed and replaced.

Photo 2.16: ↑
Laboratory

Table 2.6: Architectural Risk Assessment – Laboratory and Office

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Upper Level					
Laboratory	Asbestos Removal	1	3	Environmental	$10,000
	New Tile	N/A			$5000

2.3.13 Lunch Room

Located on the Lower Level the lunch room location and construction complies with all NBCC life safety requirements. No further work is required.

Photo 2.17: ↑
Lunch Room

2.3.14 Washroom

The WTP is permitted to be served by one water closet to service the 9 occupants but NBCC requires that the washroom conform to universal (barrier-free) design, including one water closet and lavatory.

Table 2.7: Architectural Risk Assessment – Washroom

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Lower Level					
Washroom	Barrier Free Washroom	N/A	1		$ 15,000

2.3.15 Control Room and Control Room Office

The Control Room is located on the Upper Level and does not comply with the maximum travel distance of 25 m to an exit. By separating the Main Entrance staircase as noted no additional life safety requirements are needed. The existing tile appears to be asbestos as it is of the right age and size. The tile should be removed and replaced.

Photo 2.18: ↑
Control Room Office

Table 2.8: Architectural Risk Assessment – Control Room

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Upper Level					
Laboratory	Asbestos Removal	1	3	Environmental	$ 15,000
	New Tile	N/A			$ 7,000

2.3.16 Carbon Storage Room

Constructed in 1946 this room is used for storage of bagged bulk carbon used in the water treatment process. The location of this room is on the Third Level and as such is not permitted to have the roof constructed of Heavy Timber, 3.2.2.16 NBCC. This room is required to be separated from the remainder of the building by a 1 hour fire resistance rating at the walls, floor, roof, and all support structural elements. The floor is constructed of concrete and the walls of wythe brick all meeting the required fire resistance rating. However the riveted steel trusses and 2x on edge wood decking do not meet the required 1 hour fire resistance rating. A staircase is located within the room without any separation creating an interconnected floor space. Travel distance to the nearest exit is within the 25 m required. For this room to continue servicing as a storage room the internal staircase must be rated to 1 hour fire resistance rating, and the roof fire rated with fire Protection material or replaced.

Given the age of this room (1946) numerous life safety issues as well as being un-insulated and not serviced by HVAC it's this reviewers recommendation that it be demolished and the use be constructed elsewhere.

Photo 2.19: ↑
Carbon Storage

Table 2.9: Architectural Risk Assessment – Carbon Storage Room

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Third Level					
Carbon Storage Room	Interior Stairs	N/A New	5	Worker Safety	$ 7,000
	Rated Wall	N/A New	5	Worker Safety	$ 4,000
	Rated Door	N/A New	5	Worker Safety	$ 2,000
	Fire Protection	N/A New	5	Worker Safety	$ 50,000

2.3.17 Recarbonation Equipment

Located on the Upper Level within the 1975 construction the reviewer was unable access this room and therefore cannot comment on its condition.

2.3.18 Feeder Room

The Feeder room is for reactive process substances also contains two gas hot water heaters and would be classified as a service room under NBCC, 3.6.2.1.(1). This room is required to be separated from the remainder of the building by fire separations having a fire-resistance rating not less than 1 hour. This would require replacing the existing doors (Photo 2.20) with 45 minute fire resistance rated doors and proper hardware. Walls, floors and ceilings comply with NBCC.

Photo 2.20: ↑
Feeder Room Door

Photo 2.21: ↑
Feeder Room

Table 2.10: Architectural Risk Assessment – Feeder Room

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Upper Level					
Feeder Room	Rated Door	N/A New	5	Worker Safety	$ 4,000

2.3.19 Chlorine Storage Room

The Chlorine Storage Room and the Chlorine system are slated to be decommissioned. The area could be used for another purpose with remediation to wall and floor finishes, and door replacement. As it stands the area is inadequately protected for chlorine storage.

Photo 2.22: ↑
Door to Chlorine Storage Room

Photo 2.23: ↑
Chlorine Storage

2.3.20 Main Workshop

The Main Workshop contains has a mezzanine, an office, and a welding area. This area is constructed of masonry and gypsum covered wood stud walls with a heavy timber roof of glulams and wood decking. It's separated from the other areas by a 1 hour fire rated wall and 45 minute rated double door. This area has two exterior exits, one from the office and one from the workshop. The mezzanine over the office area has a steel guardrail and kickplate at the required height.

This area is in good condition and appears to meet the requirement for an area with welding and cutting with a 1 hour FRR and non-combustible construction.

Photo 2.24: ↑
Workshop Mezzanine

Photo 2.25: ↑
Workshop

2.3.21 Process Room

Constructed in 1946 this room which is not identified on any drawing is adjacent to the Chlorine Room and #1 Solids Contact Unit. This area contains fully below grade and partial below grade areas and is mainly used for storage of various miscellaneous parts and equipment. This room is serviced by one exit along the east wall and provisions for a second exit has been unsuccessfully met by a second exit along the south wall as this is a non-complying exit. The exit must have a proper exit staircase at the interior and exterior that includes a 1 hour fire resistance wall rating and a new 45 minute fire resistance rated door (Photo 2.27).

Photo 2.26: ↑
Process Room

Photo 2.27: ↑
Process Room

Photo 2.28: ↑
Process Room Door

Table 2.11: Architectural Risk Assessment – Process Room

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Lower Level					
Process Room	Interior Stairs	N/A New	5	Worker Safety	$ 7,000
	Exterior Stairs	N/A New	5	Worker Safety	$ 7,000
	Rated Wall	N/A New	5	Worker Safety	$ 5,000
	Rated Door	N/A New	5	Worker Safety	$ 2,000

2.3.22 Building Exterior

Plant No. 1

Building exterior is in generally good condition for its age, with some brick re-pointing and minor crack repair required. This area is not insulated and providing insulation to this area would be a major challenge as its design did not take into account modern building envelope construction. Wall penetrations have been left open providing area for birds and insects to nest. Various windows have been boarded up and in-filled with insulation, and others have been replaced with aluminum framed windows.

Insulating for the purpose of mechanically conditioning this area would still not achieve the efficiency of a new building in yearly operating costs. The overall cost of retrofitting this area as an insulated and conditioned space would in our opinion be a costly and in-efficient exercise.

Photo 2.29: 🡅
Building Exterior – Plant No. 1

Photo 2.30: 🡅
Building Exterior – Plant No. 1

Table 2.12: Architectural Risk Assessment – Building Exterior – Plant No. 1

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Plant No. 1 Exterior					
	Brick Repairs	4	3	Environmental	$ 10,000
	Wall Penetrations	4	3	Environmental	$ 2,000

Plant No. 2

This area is generally in good condition. Some small cracks are noticeable at grade level and parging delaminated at various areas.

This area requires parging and crack repairs at various locations.

Photo 2.31: 🡅
Plant No. 2

Photo 2.32: 🡅
Entrance – Plant No. 2

Photo 2.33: ↑
Plant No. 2 Exterior Small Cracks

Photo 2.34: ↑
Plant No. 2 Exterior Delamination

Table 2.13: Architectural Risk Assessment – Building Exterior – Plant No. 2

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Plant No. 2 Exterior					
	Crack Repair	3	2	Environmental	$ 5,000
	Parging Repair	3	2	Environmental	$ 7,500

Plant No. 3

Exterior of this area is in good condition. Soil degradation has led to damage of the parging, insulation, and GI skirting creating locations for water, insects and vermin to infiltrate into the building. The affected areas at grade are in need of immediate repair.

Photo 2.35: ↑
Plant No. 3 Exterior Skirting

Table 2.14: Architectural Risk Assessment – Building Exterior – Plant No. 3

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Plant No. 3 Exterior					
	Excavation	N/A			$ 10,000
	Insulation	4	3	Environmental	$ 5,000
	Parging	4	3	Environmental	$ 6,000
	GI Skirting	4	3	Environmental	$ 6,000

2.3.23 Sludge Dewatering Facility

Exterior of this area is in good condition. Soil degradation has led to damage of the parging, insulation, and GI skirting creating locations for water, insects and vermin to infiltrate into the building. The affected areas at grade are in need of immediate repair.

Photo 2.36: ↑
Building Exterior

Table 2.15: Architectural Risk Assessment – Building Exterior – Sludge Dewatering Facility

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Sludge Dewatering Facility					
	Excavation	N/A			$ 10,000
	Insulation	4	3	Environmental	$ 5,000
	Parging	4	3	Environmental	$ 6,000
	GI Skirting	4	3	Environmental	$ 6,000

2.3.24 Roof

Plant No. 1

Roofs in this area are a combination of flat roofs with a torch on roofing system and sloped roof with asphalt shingles. The reviewer was not able to gain access to review the flat roof area. The sloped asphalt shingle roofing was noted to need replacing with major wear showing at valleys and high/low areas. The soffit and fascia at the sloped roof areas appear to be rotting and the brick overhang requires re-pointing as some material looks to have fallen off and more is impending. The rain water leaders have been covered by metal cladding banding providing a conduit for water to infiltrate behind the metal cladding banding and will contribute to further decay of the existing brick and possible water entering the building.

Photo 2.37: 🡅
Roof of Plant No. 1

Photo 2.38: 🡅
Building Exterior – Plant No. 1

Photo 2.39: 🡅
Building Exterior – Plant No. 1

Photo 2.40: 🡅
Building Exterior – Plant No. 1

Table 2.16: Architectural Risk Assessment – Roof – Plant No. 1

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Plant No. 1 Roof					
	Asphalt Roofing	4	3	Equipment	$ 40,000
	Wood Soffit	3	3	Equipment	$ 20,000
	Wood Fascia	3	3	Equipment	$ 5,000
	Brick Overhead	3	5	Equipment	$ 25,000
	Rain Water Leaders	2	3	Equipment	$ 5,000

Plant No. 2

All the roofs in this area are flat with the torch on roofing system. The torch on roof appears to be delaminating from its substrate and has little or no slope to internal roof drains. The fixed service ladder at the Storage Silos does not comply with Manitoba Public Safety guidelines for fixed ladders and will need to be replaced with a ladder that has a safety cage.

Photo 2.41: ↑
Roof – Plant No. 2

Photo 2.42: ↑
Ladder – Plant No. 2

Table 2.17: Architectural Risk Assessment – Roof – Plant No. 2

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Plant No. 2 Roof					
	Torch On Roofing	2	1	Equipment	$ 80,000
	Fixed Service Ladder	1	5	Workers Safety	$ 5,000

Plant No. 3

The roof in this area contains modified bitumen roofing system and is in serviceable condition needing no additional work.

Sludge Dewatering Facility

The roof in this area contains modified bitumen roofing system and is in serviceable condition needing no additional work.

The fixed service ladder at the Storage Silos does not comply with Manitoba Public Safety guidelines for fixed ladders and will need to be replaced with a ladder that has a safety cage.

Photo 2.43: ↑
Ladder – Plant No. 3

Table 2.18: Architectural Risk Assessment – Roof – Sludge Dewatering Facility

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Costs
Sludge Dewatering Facility Roof					
	Fixed Service Ladder	4	5	Workers Safety	$ 5,000

2.4 Summary

The City of Brandon Water Treatment Plant has served the City of Brandon for over one hundred years expanding from a small building to a multi process facility encompassing four major expansions to meet the growing population over the last 100 years.

Plant No. 1 (1946) is in need of many NBCC life safety and mechanical codes as noted throughout this assessment. There will be significant challenges to upgrade an un-insulated building of this age and construction type. It should be noted that the cost to upgrade Plant No. 1 to meet the NBCC will not extend the life of the faciltity.

Plant No. 2 (1958) also shows its age meeting NBCC life safety codes. This area has additional exiting requirements not addressed in its current state. AECOM recommends adding one additional exit staircase along the north side, adding a fire sprinkler system, and separating the existing main staircase and other noted areas. Various noted cosmetic repairs to the exterior are also recommended.

For Plant No. 3 (1975) to meet life safety requirements of NBCC requires an additional exit staircase along the south side, adding a fire sprinkler system, and separating the existing staircase adjacent to the Polymer Room with a rated wall assembly. Various noted cosmetic repairs to the exterior are also recommended.

The Sludge Dewatering Facility (1997) is in good condition with no life safety issues; only noted exterior repairs required.

Total probable estimate cost for architectural components for renovation, repair and retrofit is $625,000 (plus all applicable taxes and consulting fees). No demolition or reconstruction has been allowed for.

3. Structural

3.1 General

A one day general condition assessment of the City of Brandon Water Treatment Facility was carried out on September 17, 2012. The purpose of the site visit was to assess the condition of the treatment facility's structural condition and identify deficiencies that would require correction to meet the current NBCC requirements. This section of the report presents our assessment of the Water Treatment Facility.

The treatment facility was operational with the exception of Plant No.1 and Plant No.2. The Plant No. 1 and Plant No. 2 Contactors were empty and Filters 1, 2, 3, 4, 5, 6, 7 and 8 were partially drawn down. The Re-carbonation Chamber was completely drawn down. The structural review was limited to areas that were accessible with the exception of the Re-carbonation Chamber. The Re-carbonation Chamber was entered using confined space entry safety protocols. With the exception of the Re-carbonation Chamber our review was limited to areas normally accessible and visible structural components.

Material removals and destructive testing were not carried out as a part of this investigation. Foundations were not observed and concrete tanks were not entered (with the exception of the Re-carbonation Chamber (Plant Area 2). A limited amount of hammer sounding was done on a random sampling of exposed wall and floor areas in each of the Plant areas. The raw water intake had been reviewed by others earlier in the year is not included in the scope of this review.

The structural assessment was carried out by Neil Klassen, CET of AECOM, accompanied by Plant Maintenance and Operation staff.

A previous condition assessment completed in 2004 was also reviewed as a part of our condition assessment.

The treatment facility operates as three separate treatment trains identified as Plant No. 1, No. 2 and No. 3. The buildings for each Plant area were completed at various times and they are all interconnected, refer to the attached building diagrams.

Plant No.1 was built in 1956 with some portions that Plant area dating back to 1905. Plant No. 2 was an expansion to Plant No. 1 and completed around 1958. Plant No.3 Expansion was completed around 1977. In 1997, an addition for sludge dewatering was designed and built to the north of Plant No. 3.

Our observations for each Plant area are summarized below.

3.2 Plant Area 1

Plant Area No.1 consists of buildings from two eras (circa 1905 and 1956). The 1905 structure consists of slab on grade floors and un-insulated multi-wythe masonry walls. The foundation type was not visible and could not be determined or assessed. Roof structure consists of riveted steel trusses supporting a laminated wood deck (1956). The roof structure for the older (1905) portions appeared to be wood framed but could not be verified visually. Foundations were not observed.

The slab on grade floors are uneven and contain some cracking ranging from hairline (~0.05 mm to 0.1 mm) to wide cracks (~1.00 mm to 5.00 mm). These appear to be long term cracks and no new cracking was observed.

Masonry walls in Plant Area 1 (circa 1905) exhibit signs of deterioration such as areas with significant loss of mortar bedding and some wall cracks that extend through the foundation. See Photo 3.1.

Photo 3.1: ↑
Plant No. 1 Exterior Cracking

The Plant Area 1 (circa 1956) building had a crack visible on the inside wall running from the truss top chord to truss bottom chord, occurring at all truss bearing locations. An additional crack was found extending from below the window in the west wall of the Contactor Room to near the floor. The cracking was not visible from the exterior.

Photo 3.2: ↑
Plant No. 1 Cracking at Truss

Photo 3.3: ↑
Plant No. 1 Cracking at Contactor Room

The contactor tank in Plant Area 1 was empty at the time of our site visit and observed from the access walkway above. There were no visible signs of cracking or distress. The tank walkway had been replaced since the original building construction and was made of aluminum. The contactor tank internals were also newer and both appeared in good condition.

Photo 3.4: ↑
Plant No. 1 Contactor

The filter tanks were partially drawn down at the time of our observation. Several floor cracks were observed on the east side of the filters tanks in Plant Area 1. The cracks extended from the east edge of the filter tanks at Filter No. 1 and No. 2 towards the east wall. The cracking was observed to extend below the water level inside the tank as well. The crack did not appear to be recent but was in the area above repair work (see below) that had been carried out within the last few years.

Photo 3.5: ↑
Cracking on Filter Tank Floor

The Contactor Tank and Filters Tanks in Plant Area 1 were also observed from the lower level where visible. Random hammer sounding was carried out on the tank and filters walls. No cracking or unsound concrete was observed. Discussions with the maintenance staff revealed remedial work that had been recently (within the last few years) completed to correct leaking from the clearwell. The work involved cutting an opening in the east wall (double wall) of the filters (near Filter No. 2) to access the area below the filters. The slab below the filters was removed, and new under-slab drainage installed. The slab was then replaced and the opening in the wall closed off with cast-in-place concrete. According to maintenance staff the leakage has been reduced but not stopped completely.

The Plant Area 1 (circa 1905) building is considered to be in poor condition and the (1956) building to be in fair to good condition. The Filter tank condition is considered fair with ongoing under-tank leakage creating potential for deterioration of foundation support and future tank and building damage. The Contactor Tank and walkway/internals are considered in good condition.

Roof strengthening will be required for all roof areas of Plant Area 1 to meet the current NBCC requirements.

3.3 Plant Area 2

Plant Area No. 2 (circa 1956 and 1958) consists of cast in place concrete columns/beams and structural floor/roof slab construction. Walls are multi-wythe masonry construction. Foundations for these structures were not observed.

The floor slabs are exposed in some areas and covered with tile in others. Several hairline cracks were observed on the filter walkway between filter No. 6 and Filter No. 5; these are considered to be minor.

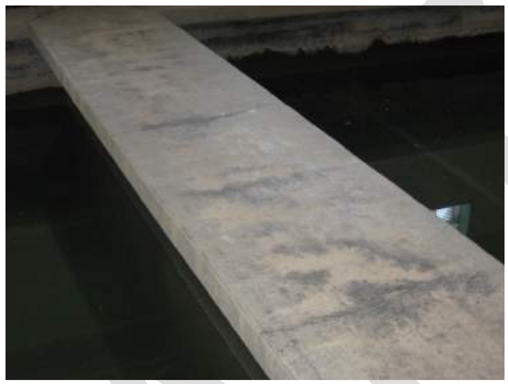

Photo 3.6: ↑
Hairline Cracking in Filter Walkway

The Contactor tank was empty at the time of our observation. Some portions of the Contactor Tank internals (baffle plates, some troughs) have been replaced. Some of the components exhibited significant corrosion

Photo 3.7: ↑
Corrosion of Internal Components of Contactor Tank

The inside face of the contactor tank was sounded near the top of the tank just below the tile line at random locations. No unsound concrete was observed. Some minor pitting of the concrete at this line was observed all around the tank.

Photo 3.8: 🡅
Minor Pitting of Contactor Tank

The Filter Tanks and Contactor Tank were also viewed from the lower level, and no significant signs of leakage were observed. Hammer soundings were taken at randomly selected locations along the Contactor Tank and Filter Tank walls in exposed areas and no unsound concrete was observed. There is evidence of epoxy–injection repairs done in various areas of the filter tanks/contactor visible from the lower level. These repairs appear to be the same repairs reported in the 2004 condition report. The repairs appear to be working; however, it should be noted that the Contactor tank was empty at the time of the review.

Photo 3.9: 🡅
Lower Level Contactor Tank

The plaster surrounding the freestanding support columns along the line between Plant No. 1 and Plant No. 2 is cracked (medium to wide cracks) from the base up on the line of the expansion joint between the two Plants. The cracking was observed on each of the columns directly in line with the building expansion joint location. The plaster was not removed to observe the extent of the cracking or its effect on the structural columns. The cracking is likely evidence of differential movement between Plant Area 1 and Plant Area 2.

Photo 3.10: 🡅
Cracking of Support Columns

The Contactor and Filter Tanks are considered to be in good condition.

With the Re-carbonation Chamber essentially empty the opportunity was taken to access the chamber and conduct a visual assessment and hammer sounding at randomly selected locations. The chamber was entered under confined space entry protocols. It had approximately 25 mm of water on the bottom. The inside of the walls and baffle walls were coated in a hardened chalky build-up. This was chipped of at randomly selected locations and hammer sounded. No unsound concrete was observed. The floor of the chamber appeared sound with no visible cracking. The ceiling of the chamber (concrete floor slab above) had a few areas where concrete had spalled off and reinforcing steel was exposed and corroded (see Photo 3.11). The wet condition of the chamber and inadequate concrete cover likely contribute to the corrosion and spalling of concrete. A detailed inspection of the ceiling in the chamber should be undertaken to determine the extent of corrosion and repairs required.

Photo 3.11: 🡅
Ceiling of Re-Carbonation Chamber

The Storage Silo Room as entered at the upper level catwalk and the following observations were made:

- The environment was extremely dusty with lime and soda ash.

- Visible portions of the building structure appeared in good condition.
- The catwalk grating was very flexible and may be undersized for its intended purpose.

The Storage Silo Room is considered in good condition.

The Chemical Feed Room and former Alum Room (containing the empty wood stave alum tank) are considered in good condition with some hairline cracking in the floor slab.

The lab room, office and main entrance all appeared in fair condition with some minor cracking and signs of distress.

Plant Area 2 work shop area is framed with glulam beams and decking. One of the beams is fitted with a fixed hoist and posted rating of 1,200 lbs. (550 kgs).

Plant Area 2 building is in fair to good condition. The Contactor Tank internals require replacement of selected components. The re-carbonation chamber ceiling requires a detailed inspection to determine extent of spalling and corrosion damage to reinforcing, and repair to these areas. A select number of columns (along the Plant No. 2 and Plant No. 3 line) should be exposed and observed to assess the condition of the structural column.

The catwalk grating in the Storage Silo Room should be replaced with a stronger and less flexible grating.

The buried clear water reservoir was not observed and we recommend a detailed inspection be carried out to assess the condition of that tank.

Roof strengthening will be required for roof structure to meet current NBCC requirements.

3.4 Plant Area 3

Plant Area No. 3 consists of cast in place concrete columns/beams and structural floor/roof slab construction. Walls are insulated masonry cavity wall with combination brick masonry and metal clad exteriors.

The Contactor tanks in this area were in operation at the time of our visit. The inside of the concrete tank was hammer sounded at randomly selected locations just below the tile line. A concrete crack and slight displacement were observed at the inside corners of the tank, just below the tile line.

Photo 3.12: ↑
Concrete Cracking at Tile Line

Photo 3.13: ↑
Concrete Cracking at Tile Line

The Contactor Tanks and Filter Tanks were observed from the lower level and hammer sounding of the tank walls was carried out at randomly selected locations. No unsound concrete was observed. Staining along the tank walls was observed as evidence of leaking at a number of locations. A hairline crack was found in the west wall of the Contactor tank.

The north wall (lower level) of the Plant No. 3 Re-Carbonation Chamber had a leak repair completed in May of 2010. The repair was not leaking at the time of our visit. The maintenance staff was unable to verify the how the patch was installed but was reported to be effective in stopping the leak.

Photo 3.14: ↑
Re-Carbonation Chamber Patch

Foundations for this area were not observed.

A hairline crack was found in the short retaining wall at the north side of the building.

Roof strengthening will be required for roof structure to meet current NBCC requirements.

3.5 Lime Sludge Dewatering

The sludge dewatering tank and building was in operation during our visit. The tank is made of cast in place concrete and there were no visible cracks or leaking. This area was considered to be in good condition.

A check should be carried out to determine if roof strengthening is required for roof structure to meet current NBCC requirements.

3.6 Evaluation

Plant Area 1 can be characterized as in fair condition. The concrete tank structures show signs of deterioration and at least one of the filter tanks has had significant leaking in the recent past. Ongoing repairs and maintenance can be expected and could rise significantly as this structure nears the end of its useful life. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly.

Plant Area 2 is in fair to good condition. Some of the contactor tank internals require replacement due to corrosion. Concrete tanks are in good condition and will require ongoing inspection and monitoring as they age. The re-carbonation tank soffit requires a detailed inspection and repair. The clear well reservoir should be inspected and assessed at the next available opportunity. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly.

Plant Area 3 is in good condition including the condition of the concrete tanks. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly.

Lime Sludge Area is in good condition based on our observation. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly.

Table 3.1 indicates our opinion of the costs of upgrades that would be required for the building to meet current codes, and risks associated with the existing structure. The opinions of costs for roof replacement for equipment replacement were based on sizes as found on drawings and documents provided by the City of Brandon. The opinions of cost are considered to be accurate to +75% and -50%. They do not include engineering fees, Provincial Taxes or Federal Taxes. The cost for the roof strengthening will vary depending on what is determined from the analysis. Costs for the re-carbonation soffit repair will also vary depending on the extent of deterioration found.

Table 3.1: Structural Risk Evaluation

Plant Area	Equipment	Condition Grade	Risk Grade	Primary Category of Risk	Estimated Replacement Cost
Plant Area No. 1					
No. 1 Contactor Tank		2	2	no apparent risk and roof strengthening (code)	
Filter Tanks 1-4		3	3	future maintenance issues with under tank leakage and roof strengthening (code)	$ 50,000

Plant Area	Equipment	Condition Grade	Risk Grade	Primary Category of Risk	Estimated Replacement Cost
Pump Rooms (1956)		2	2	roof strengthening (code)	$ 125,000
Pump Room (1905)		3	3	deteriorated condition, replacement or demolition and roof strengthening (code)	$ 500,000
Chlorine Storage		2	2	recommend inspection of material handling and roof strengthening (code)	$ 50,000
Workshop		3	3	deteriorated condition and roof strengthening (code)	$ 200,000
Vehicle Access		4	3	roof strengthening (code)	see above
Boiler Room		2	3	roof strengthening (code)	see above
Plant Area No. 2					
No. 2 Contactor Tank		2	3	Upgrade corroded internals, and roof strengthening (code)	$ 50,000
Filter Tanks 5-8		2	3	roof strengthening (code)	$ 200,000
Re-Carbonation Chamber		3	3	slab soffit inspection/repairs and roof strengthening (code)	$ 35,000
Silo Storage		2	3	upgrade catwalk and roof strengthening (code)	$ 10,000
Chemical Feed Room		2	1	no apparent risk and roof strengthening (code)	see above
Alum Storage (former)		2	1	no apparent risk and roof strengthening (code)	see above
Offices/ Operations		2	3	roof strengthening (code)	see above
Lab		2	3	roof strengthening (code)	see above
Main Entrance		2	3	roof strengthening (code)	see above

Plant Area	Equipment	Condition Grade	Risk Grade	Primary Category of Risk	Estimated Replacement Cost
Lunch Room		2	1	no apparent risk, requires roof strengthening (code)	see above
Buried Clear Water Reservoir		n/a	n/a	not observed, recommend inspection	$ 10,000 (inspection only)
Plant Area No. 3					
No. 3 Contactor Tank		2	3	roof strengthening (code)	$ 200,000
Filters 9-16		2	2	no apparent risk, requires roof strengthening (code)	see above
Re-carbonation Chambers		2	2	detailed inspect on next outage, and repair and roof strengthening (code)	$ 10,000 (inspection only)
Sludge Dewatering		2	1	no apparent risk	
Feeder Room		2	1	no apparent risk and roof strengthening (code)	see above
Compressor Room		2	1	no apparent risk and roof strengthening (code)	see above
Re-Carb Equip. Room		2	1	no apparent risk and roof strengthening (code)	see above
				TOTAL:	**$ 1,440,000**

4. Mechanical HVAC, Plumbing and Fire Protection

4.1 General

This section of the report presents our assessment of the Heating-Ventilation-Air Conditioning (HVAC), plumbing and fire protection system conditions at the Brandon Water Treatment Plant. The current condition and expected remaining service life of the equipment allows the development of a risk management approach to the maintenance and repair of the existing systems for the remainder of its useful life, or its replacement should the asset be beyond repair. Types of equipment will be generally discussed and their original design capacity will be assumed to have been adequate for the date of installation. The ability of the existing systems to meet the current Manitoba Building, Fire and Plumbing Codes will be examined and upgrades will be recommended where the existing system(s) do not comply with the current codes.

In accordance with Article 3.1.2. of the NBCC, as amended by the Manitoba Building Code Regulation 31/2011, the lower and upper floors of the Water Treatment Plant are classified as an F3 Low-Hazard Industrial Occupancy, whereas the penthouse chemical storage and handling areas are classified as an F2 Medium Hazard Industrial Occupancy. The Building has a very low occupant load, typically two persons on weekends and as many as 9 persons on weekdays. The building area is 4,585 m² and according to NBCC 3.2.2.73 and 3.2.2.80, the building is required to be of non-combustible construction with minor combustible elements permitted according to Article 3.1.5. of the NBCC. Required fire separations and fire resistance-rated assembly requirements are discussed in the Architectural and Structural sections of this report. The Water Treatment Plant is classified as a 3 storey building, and as such, the heavy timber roof found in the Plant 1 area of the building is not permitted. Based on the NBCC, the building is required to have automatic sprinklers installed throughout the facility. This will be discussed further in the Fire Protection section of this report.

4.1.1 Heating

Energy for heating the three plant areas and their processes is primarily generated on site using dual-fuel fired low pressure steam boilers. The existing boilers are a Cleaver Brooks Model CB-400-125 serial number S-63336 and a Cleaver Brooks Model CB-428-100 serial number S-40624. The CB-400-125 has a rated capacity of 1,226 kW (125 boiler horsepower) at 103 kPa (15 PSIG) steam pressure, and has natural gas input of 1,532 kW (5,230,000 BTUH) when firing on natural gas, and 2.2 l/min. (35 USGPH) when firing on No. 2 fuel oil (Diesel Fuel). The CB-400-125 boiler was installed in 1977. The CB-428-100 has a rated capacity of 981 kW (100 boiler horsepower) at 103 kPa (15 PSIG) steam pressure, and has natural gas input of 1,226 kW (4,185,000 BTUH) when firing on natural gas, and 1.8 l/min. (28 USGPH) when firing on fuel oil. The CB-428-100 boiler was installed in 1966. Both boilers were open for summer lay-up and inspection at the time of site review, so their operation cannot be commented on. The staff has indicated that there have been no tube failures or major issues with the boilers. Service reports from R. G. Sales from the years 2004, 2008, 2009 and 2011 were provided, and no major replacements of parts were noted. Minor control component replacements and burner trim adjustments were made, and the steam pressure and residual oxygen were measured. The boilers are at or beyond the end of their normal service life.

Photo 4.1: ↑
Cleaver Brooks Boiler

Photo 4.2: ↑
Cleaver Brooks Boiler

The boiler plant is currently classified as a 4th Class Plant, and as such, is monitored around the clock by stationary engineers whenever the boilers are operational. There are a minimum of two stationary engineers in the plant at any time, and they assist with the monitoring and operation of the water treatment plant as a whole. Downgrading the classification to a 5th Class Plant or replacement of the system with new hydronic boilers will present a significant savings in staff salaries, as no stationary engineers would be required to monitor the plant's heating system.

Chemical treatment is being used to reduce corrosion effects on the piping and equipment, and the stationary engineers maintain a log of their condensate and feedwater quality and the amount of fresh water added to the system. Testing of the water is performed once per shift (twice a day) and adjustments to the feed rates are made as required. The annual make-up water in 2011 was 11.9 m^3, which is relatively low considering the losses from the feedwater tank vent, volumes used for testing, surface and mud-drum blow down, and annual filling of the boilers.

Offices and some small renovated areas have been fitted with electric baseboards. The remaining areas are heated by steam convectors, radiators and steam unit heaters.

Photo 4.3: ↑
Window-Style Air Conditioner

Photo 4.4: ↑
Window-Style Air Conditioner

4.1.2 Ventilation

The existing ventilation in general is for summer cooling only operation, which is not compliant with current codes. NBCC requires that all buildings be ventilated in conformance with ASHRAE 62-2001, "Ventilation for Acceptable Indoor Air Quality" (except Addendum n). NBCC Sub sentence 6.2.2.2.(1)(a) permits buildings other than residential occupancy and having an occupant load of not more than one person per 40 m² to utilize natural ventilation or a combination of fan-forced mechanical ventilation to achieve the requirements of this standard. Despite the Brandon Water Treatment Plant operating with less than 111 persons inside the facility, the use of mechanical ventilation is far easier to control and will be more effective at delivering the ventilation over the large open areas. Heating of this ventilation air in the winter will increase the heating energy load considerably, and may exceed the capacity of the two boilers that are currently operating. Energy recovery and low energy options will need to be investigated. Conditions in the plant in the summer can be improved using mechanical cooling equipment to control temperature and moisture levels and will allow the window air conditioners that are currently in use to be removed. The mechanical equipment could be water cooled heat pumps as one example.

Photo 4.5: ↑
Outdoor Air Intake

Photo 4.6: ↑
Exhaust Fan and Intake

Photo 4.7: ↑
Exhaust Fan

Photo 4.8: ↑
Exhaust Fan

Moisture damage to walls and structure has taken place from condensation forming on cold surfaces of the structure and also from roof leakage.

Photo 4.9: ↑
Moisture-Damaged Ceiling

Photo 4.10: ↑
Moisture-Damaged Ceiling

Photo 4.11: ↑
Moisture-Damaged Ceiling

Photo 4.12: ↑
Moisture-Damaged Ceiling

There are several places in the structure where vehicles can enter the building for storage and maintenance or unloading. These vehicle access areas do not currently have ventilation to remove the carbon monoxide that will be emitted during vehicle movements. Walls also need to be erected in order to contain the exhaust fumes for effective capture. The equipment required would be a system of ductwork, fans and controls similar to that already in place within the Lime Sludge Dewatering Truck Load-out Shed.

Photo 4.13: ↑
Carbon Monoxide Sensors

Photo 4.14: ↑
Carbon Monoxide Sensors

Interconnected and interstitial spaces are not provided with 4 air changes per hour of mechanical exhaust and make-up air ventilation for manual control by the fire department as required by NBCC Sentence

3.2.8.8.(1). This could be partially eliminated by additional architectural closures around floor-to-floor stairways, but will be required in any case within the Lime and Soda Ash Silo Storage Room.

4.1.3 Plumbing

Sanitary and roof drainage piping is cast iron, and where exposed within the plant, the piping has been painted but not insulated but appears to be in good condition. Potable water and sanitary drainage systems are aging, but functional. The roof drainage piping does get leaves and other debris washed into it, but still drains eventually.

Photo 4.15: ↑
Roof Drainage

Photo 4.16: ↑
Roof Drainage

Eyewash stations are present in Plant 2 and Plant 3, but are the stored water type. The water is changed every 3 months to maintain potable conditions. The only combination Eyewash and Safety Shower is outside of the Chlorine Room in the basement of Plant 1 Area, and is fed with only cold potable water. This unit is routinely operated every 3 months. ANSI-Z358.1-2004, "American National Standard for Emergency Eyewash and Shower Equipment", which is referenced by Manitoba Workplace Safety and Health, requires that these units be maintained on a weekly basis by visual inspection for the self-contained stored water type, and by flowing the water in a plumbed unit for a period long enough to ensure that flushing fluid is available, and to maintain potable conditions.

Photo 4.17: ↑
Eyewash Station

Photo 4.18: ↑
Combination Eyewash/Shower

There are three potable water heating systems in the plant. Newer equipment for potable water heating has been installed in the Plant 2 area, and piping associated with the heaters and storage tanks is stainless steel.

Photo 4.19: ↑
Water Heaters

Photo 4.20: ↑
Water Heater

Photo 4.21: ↑
Water Heaters

Photo 4.22: ↑
Water Heater

Outside hose bibs are not fitted with backflow prevention vacuum breakers.

Photo 4.23: 🡅
Exterior Hose Bibs

4.1.4 Fire Safety and Fire Protection

The Brandon Water Treatment Plant is not generally protected by automatic sprinklers and relies largely on portable fire extinguishers and four fire hose cabinets. The distribution, sizing and positioning of the fire extinguishers does not provide adequate coverage for the plant as a whole, and especially high risks present in certain areas of the building. The Activated Carbon Bag Storage area is one of the unprotected high risk areas, as it represents a significant fire and explosion hazard, and there is approximately 27 tonnes (29.75 tons) of bagged activated carbon powder currently stored in the penthouse (3rd storey of Plant 1 and Plant 2 areas).

Photo 4.24: 🡅
Powdered Activated Carbon

Photo 4.25: 🡅
Powdered Activated Carbon

4.2 Plant Area 1

Industrial ventilation in the machine shop has been disconnected for some time and is no longer suitable for use.

Photo 4.26: ↑
Machine Shop Ventilation

Photo 4.27: ↑
Machine Shop Ventilation

Ventilation of the Chlorine Room is not up to recognized standards for gaseous chlorine, and the location of the Chlorine Room in Plant 1 Area lower floor level is no longer suitable.

Photo 4.28: ↑
Chlorine Cylinders

Photo 4.29: ↑
Chlorine Room

The Main Electrical Room has no permanent ventilation to remove excess heat and a portable fan has been employed to avoid equipment damage during hot weather.

Photo 4.30: ↑
Portable Fan in Electrical Room

There was no visible year-round ventilation within the process area on the upper level of the Plant 1 area. There is a large wall exhaust fan on the south wall over the filter area that is likely used for summer cooling.

Ventilation to control humidity in the plant air during the winter is recommended to prevent structural damage and formation of mold. The interconnected spaces between the Upper Level and the Lower Level require the installation of a smoke control ventilation system that can exhaust 4 air changes per hour from the two levels as stipulated by NBCC Sentence 3.2.8.8.(1). The system is activated manually by firefighting personnel from a panel that would be located at the main entrance to the building.

The Maintenance Shop has vehicle access doors on the north and east sides, and therefore requires a vehicle exhaust fume removal system to be installed. Since the space is somewhat segregated from the surrounding Plant 1 areas, installation of walls to limit the exhaust volumes may not be required or practical. The door connecting the Maintenance Shop to the Lower Level of the Plant 1 area will be required to remain closed at all times. The Plant 1 area Lower Level has vehicle access doors on the west side of the plant next to the Chlorine Room as well, and will also require a vehicle exhaust fume removal system to be installed. Since the space is not segregated from the surrounding Plant 1 areas, installation of walls to limit the exhaust volumes will be required. The door connecting the vehicle access area to the Lower Level of the Plant 1 area will be required to remain closed at all times.

Ventilation for temperature control in the Electrical Room is recommended to prevent equipment failures and to maintain an acceptable temperature in the space for workers. The best system for this is ventilation with outdoor air controlled to room temperature (free cooling). This system can operate year-round provided there is air from the space used to mix with the outdoor air for preheating purposes. This equipment is commonly roof-top mounted, but can be hung in the space or placed on the floor if space is available.

The roof deck of the Plant 1 area is 38 x 89 mm (1½ x 3½”) laminated wood on exposed steel trusses, which is combustible, but is unprotected. Further high risk areas in the Plant 1 Area structure is the Electrical Room, Maintenance Shops, Paint Storage Room and Chlorine Room. Combustible commodities, flammable and combustible liquids, dangerous goods and high voltage electrical require special attention to fire safety and ventilation of fumes for staff safety.

The bulk commodities that are stored in the facility include powdered activated carbon in bags and a hopper, powdered lime (calcium oxide) in a hopper, and powdered soda ash (sodium carbonate) in a hopper. In accordance with NBCC Sentence 3.1.2.1.(1) the chemical storage and handling areas where powdered activated carbon is received, stored, handled and discharged into the process in the Water Treatment Plant is classified as an F2 Medium-Hazard Industrial Occupancy due to the dust hazard presented by the carbon and processes using carbon found inside the building.

Photo 4.31: ↑
Powdered Activated Carbon Bags

Photo 4.32: ↑
Powered Activated Carbon Storage

The National Fire Code of Canada 2010 (NFCC) as amended by the Manitoba Fire Code Regulation 155/2011 lists the requirements for indoor storage of commodities in Section 3.2. Sub sentence 3.2.1.1.1)a) of the NFCC indicates that commodity classifications shall be as defined in NFPA 13-2007, "Standard for the Installation of Sprinkler Systems". The powdered activated carbon made by Shanxi Sincere Industrial Co. in China is packaged in woven plastic bags and stored on wood pallets. The product is labeled as Shanxi Sincere 800 and a Material Safety Data Sheet (MSDS) has been obtained from the manufacturer. The product, its packaging and storage on wooden pallets translates in to a Class III Commodity definition under NFPA 13 commodity classification.

NFCC Table 3.2.3.2. identifies that Class III Commodities are permitted to be stored indoors in unsprinklered buildings provided that the height of storage does not exceed 4.5 m (15 ft) and the maximum area of the storage is 250 m² (2,690 ft²). This is referred to as an individual storage area, and is dedicated to a single commodity with aisles of 2.4 m (8 ft) widths separating the commodity from any other commodities. Access aisles are also required where the individual; storage area exceeds 100 m² (1,076 ft²) in area. At the time of our review, the carbon pallets were occupying approximately 45 m² (480 ft²) and therefore did not require an additional access aisle. The Activated Carbon Bag Storage area is served by two exit stairs, but has only one 2A-10BC rated multipurpose dry chemical fire extinguisher near the primary route of exit into the Plant 2 area, leaving the Plant 1 area exit unprotected.

Indoor storage of empty wooden pallets is limited by the NFCC to a 100 m² (1,076 ft²) area and a maximum height of 1.2 m (4 ft) inside a non-sprinklered building. The preferred location for empty pallets of all types is outdoors. There were a total of six (6) empty pallets noted to be stored on edge within the Carbon Storage Room building during our review.

NFPA 499-2008, "Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Processing Areas" identifies combustible dust as a Class II electrical hazard. There are two Divisions within the Class II hazard category, Division 1 is nearest the source and extending outward in all directions to a prescribed distance and Division 2 is beyond the prescribed distance from the source of the dust. Carbonaceous dusts fall into the Group F classification and indicate the presence of 8% or more of entrapped volatiles. Therefore, the area classification according to NFPA 499 would be Class II, Division 1, Group F within 6.1 m (20 ft) of the bag feeders and then Class II, Division 2, Group F elsewhere within the penthouse, up to 3.05 m (10 ft) beyond the Division 1 area boundaries.

Carbon dust would likely be generated or present during handling of the bags during delivery and when the bags are opened to discharge into the carbon hoppers above the feeders. There are exhaust fans installed on the top of the bag breakers to extract dust released during hopper filling, but there is still sufficient dust release to consider this a hazardous area, as evidenced by the dust on surfaces. The MSDS for the activated carbon powder indicates that the storage area should have adequate ventilation, but no source of continuous ventilation was found. Make-up air for the ventilation system would require pre-heating to room temperature, and is best accomplished with hydronic heating coils circulating a glycol solution to prevent freezing in the winter. Appropriate dust masks are the required PPE for the operators handling the activated carbon.

The heating of the powdered carbon storage space is accomplished using one steam unit heater in the southeast corner, over the bagged activated carbon pallet storage. This unit heater is a standard Trane steam unit heater, and likely does not have a hazardous area-rated motor. Besides the electric motors in the room, light fixtures, electrical switches and junction boxes do not appear to provide the necessary protection from acting as an ignition source. The autoignition temperature can be another means of ignition, and the energy source can be anything with a surface temperature as low as 165°C (329°F) or hotter. With the low pressure steam having a saturated steam temperature of 121°C (250°F) or less, the surfaces of the coil in the unit heater do not provide an autoignition energy source, and is one of the safest methods of heating in a hazardous area.

Photo 4.33: ↑
Unit Heater

The MSDS provided by the Shanxi Sincere Industrial Co. indicates that extinguishing agents such as sand, powder, foam and water are not to be used. The fire extinguisher that is present is a powder agent under pressure that could propagate a dust cloud when discharged, would likely be ineffective in extinguishing the fire, and could create conditions conducive to an explosion. The recommended fire extinguisher type is carbon dioxide (CO_2). The fire extinguisher in the space should be replaced with a CO2 (BC rating) stored pressure extinguisher, and the multipurpose dry chemical stored pressure extinguisher relocated to just outside of the door to the stairwell to satisfy the structure fire protection (A rating) requirement . There should be a second CO2 (BC rating) stored pressure extinguisher installed near the exit stair that leads down to the Plant 1 Area as this is the second escape route.

The housekeeping in the Activated Carbon Bag Storage area is good and the accumulations of carbon dust on surfaces has been generally kept to a minimum. This is essential as the dust which settles on surfaces and accumulates provides the greater amount of fuel for a secondary explosion should a small dust cloud explosion occur. The secondary explosion is usually the one that damages structures most extensively, and good housekeeping will mitigate that threat to the structure. The requirements of NFPA 654-2006, “Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids” requires that rooms or buildings having a dust explosion hazard that is external to protected equipment be provided with deflagration venting to a safe location outside. Therefore, an explosion relief panel is recommended for the Activated Carbon Bag Storage area.

An electric tank-type water heater was located in the crawlspace area below the staff lockers and washrooms in Plant 1 area.

Photo 4.34: 🡅
Electric Hot Water Heater Below Staff Lockers

The surface temperature of the condensate piping will be in excess of 70°C (158°F) during operation and should be insulated to prevent incidental contact by personnel and combustible materials.

Sprinkler fire protection is required throughout the space.

4.3 Plant Area 2

Ventilation to control humidity in the plant air during the winter is recommended to prevent structural damage and formation of mold. The interconnected spaces between the Upper Level and the Lower Level require the installation of a smoke control ventilation system that can exhaust 4 air changes per hour from the two levels as stipulated by NBCC Sentence 3.2.8.8.(1). The system is activated manually by firefighting personnel from a panel that would be located at the main entrance to the building.

The Plant 2 area Lower Level has vehicle access doors on the north side of the plant next to the Boiler Room, and therefore requires a vehicle exhaust fume removal system to be installed. Since the space is not segregated from the surrounding Plant 2 areas, installation of walls to limit the exhaust volumes will be required. The doors connecting the vehicle access area to the Boiler Room and the Lower Level of the Plant 2 area will be required to remain closed at all times.

The bulk commodities that are stored in the facility include powdered activated carbon in bags and a hopper, powdered lime (calcium oxide) in silos, powdered soda ash (sodium carbonate) in silos, and liquid Alum (aluminum sulphate) in tanks. Ventilation and fire protection requirements would be similar to that described in the Plant 1 area above.

There are two fire hose cabinets with fabric fire hose located on the lower level of the Plant 2 area. If the building is sprinklered throughout as required by NBCC 2010, the building as a whole does not require a standpipe and hose system by the NFCC definition. The existing available water pressure may not meet the requirements of NFPA 14, “Standard for the Installation of Standpipe and Hose Systems” and therefore, a fire pump would be required to achieve the nozzle pressure requirements. The required nozzle pressure in Standpipe and Hose Systems is 690 kPa (100 psig) at the highest nozzle. No upgrades to this system are recommended, and demolition of this system after sprinklers have been installed is appropriate.

Photo 4.35: 🡹
Fire Hose Cabinet

Roof drainage is poor in the Plant 2 Area due to plugged roof drain lines, strainers and drains being located higher than the flat roof level they serve. Some areas display ponding that degrades the roof and leads to leakage into the structure in unplanned areas. Indoor roof drainage lines are cast iron mechanical joint piping and are not insulated, which contributes to the formation of condensation, dripping and heat loss.

Photo 4.36: 🡹
Roof Drains

Photo 4.37: 🡹
Roof Drains

Potable water heating system is a natural gas-fired tankless heater with separate tank storage in the Plant 2 Area former alum storage area.

The surface temperature of the condensate piping will be in excess of 70°C (158°F) during operation and should be insulated to prevent incidental contact by personnel and combustible materials.

Sprinkler fire protection is required throughout the space.

The natural gas-fired standby generator on the lower level of the Plant 2 area is not installed within a fire-rated enclosure, and does not meet the installation requirements of CAN/CSA-B149.1-05, “Natural Gas and Propane Installation Code”. This unit will be replaced by a new diesel engine-driven generator set that is currently under construction, and once commissioned, the natural gas-fired standby generator on the lower level of the Plant 2 area will be available for demolition.

Photo 4.38: ↑
Gas Fired Standby Generator

The low pressure steam boilers are beyond their normal service life, and should be replaced to be reliable. It is anticipated that the new ventilation requirements and process heating loads will challenge if not exceed the capacity of the existing boilers, and may require a third boiler to be installed. Conversion of the system to a hydronic (liquid) heating system versus steam will permit the plant to operate as a 5^{th} Class Plant and eliminate the need for 4^{th} Class stationary engineers and shift engineers. The replacement of the boilers is recommended for reliability and to accommodate the new loads. Many options ranging from new steam boilers to fully condensing high efficiency boilers are available.

Photo 4.39: ↑
Low Pressure Steam Boilers

4.4 Plant Area 3

Ventilation to control humidity in the plant air during the winter is recommended to prevent structural damage and formation of mold. The interconnected spaces between the Upper Level and the Lower Level require the installation of a smoke control ventilation system that can exhaust 4 air changes per hour from the two levels as stipulated by NBCC Sentence 3.2.8.8.(1). The system is activated manually by firefighting personnel from a panel that would be located at the main entrance to the building.

The Plant 3 area Lower Level has vehicle access doors on the north side of the plant next to the Lime Sludge Dewatering area, and therefore requires a vehicle exhaust fume removal system to be installed. Since the space is not segregated from the surrounding Plant 3 areas, installation of walls to limit the exhaust volumes will be required. The doors connecting the vehicle access area to the Lower Level of the Plant 3 area will be required to remain closed at all times.

The bulk commodities that are stored in the facility include powdered activated carbon in bags and a hopper, powdered lime (calcium oxide) in a hopper, and powdered soda ash (sodium carbonate) in a hopper. Ventilation and fire protection requirements would be similar to that described in the Plant 1 area above.

Previous reports indicate that a small portion of the chemical process in the Plant 3 area has sprinklers installed. According to the NBCC, the whole structure requires sprinklers for fire protection.

There are two fire hose cabinets with fabric fire hose located in the upper and lower level of the Plant 3 area. If the building is sprinklered throughout as required by NBCC 2010, the building as a whole does not require a standpipe and hose system by the NFCC definition. The available water pressure may not meet the requirements of NFPA 14, “Standard for the Installation of Standpipe and Hose Systems” and would require a fire pump to achieve the nozzle pressure requirements. The nozzle pressure required in Standpipe and Hose Systems is 690 kPa (100 psig) at the highest nozzle, and the cost of a fire pump is of no benefit to the facility. No upgrades to this system are recommended, and demolition of this system after sprinklers have been installed is appropriate.

Roof drainage is good in the Plant 3 Area with limited ponding due to roof drain placement, plugging and roof deflection. Indoor roof drainage lines are cast iron mechanical joint piping and are not insulated, which contributes to the formation of condensation, dripping and heat loss.

Photo 4.40: ↑
Roof Drainage

Photo 4.41: ↑
Roof Drainage

Potable water heating systems are natural gas-fired heater with tank storage in the Plant 3 Area Recarbonation Equipment Room.

Photo 4.42: ↑
Water Heating System – Recarbonation Equipment Room

The surface temperature of the condensate piping will be in excess of 70°C (158°F) during operation and should be insulated to prevent incidental contact by personnel and combustible materials.

Sprinkler fire protection is required throughout the space.

4.5 Lime Sludge Dewatering

The truck loadout bay in the Lime Sludge Dewatering area has an exhaust fume ventilation system in place, but the sensors have failed or are in fault condition.

Photo 4.43: ↑
Truck Loadout Exhaust Fume Ventilation

Photo 4.44: ↑
Truck Loadout Exhaust Fume Ventilation

Heating and ventilating equipment in this area were in good condition and no upgrades are recommended.

The bulk commodity that is stored in the facility is liquid Alum (aluminum sulphate) in fiberglass tanks. This product is stable and does not create any special fire protection or ventilation requirements.

Sprinkler fire protection is required throughout the space.

4.6 Evaluation

The majority of the HVAC equipment appears to be 25+ years old and has already been running well beyond its normal service life based upon ASHRAE standards and first-hand experience. The normal life expectancy of HVAC mechanical equipment in a water treatment plant is 13 to 18 years. Corrosion resistant materials, (plastics and stainless steel) or equipment generally last upwards of 25 years and may be reviewed on an individual basis to determine if there is any residual value. Due to the age of the HVAC equipment, visible corrosion, and the critical nature of the mechanical systems to the safety and comfort of occupants and processes contained within the building, a recommendation grade of 4 or 5 would be applied to most of the original, existing HVAC equipment, in particular the ventilation equipment.

Table 4.1 indicates our opinion of the costs of upgrades that would be required for the building to meet current codes, and risks associated with the HVAC equipment on site. The costs for equipment replacement were based on sizes as found on drawings and documents provided by the City of Brandon.

Table 4.1: Mechanical Risk Assessment

Area	Equipment	Condition Grade	Risk Grade	Primary Categories of Risk	Opinion of Replacement Costs
Plant 1 Area					
Throughout	Heating System repairs and replacements of terminal units and piping.	3	4	Equipment	$ 50,000
Carbon Storage Room	Heating System – Requires explosion proof equipment	5	5	Equipment	$ 10,000
Chlorine Storage Room	Decommission and demolish existing Chlorine Room ventilation system	4	5	Equipment	$ 25,000
Carbon Storage Room	Ventilation System for control of airborne contaminants and explosion risk	5	5	Equipment	$ 15,000
Throughout	Ventilation System	5	5	Equipment	$ 370,000
Main Workshop	Vehicle Exhaust Fume Capture and Exhaust	5	5	Equipment	$ 20,000
Throughout	Fire Extinguishers	3	4	Equipment	$ 1,500
Throughout	Sprinkler System	5	5	Equipment	$ 220,000
Carbon Storage Room	Explosion Venting	5	5		$ 40,000
				Plant 1 Area Subtotal	**$ 751,500**
Plant 2 Area					
Boiler Room	Boilers and related equipment	3	4	Equipment	$ 250,000
Throughout	Heating System repairs and replacements of terminal units and piping.	3	4	Equipment	$ 50,000
Chemical Feed (3RD)	Heating System – Requires explosion proof equipment	5	5	Equipment	$ 10,000
Throughout	Ventilation System	5	5	Equipment	$ 300,000
Chemical Feed (3RD)	Ventilation System for control of airborne contaminants and explosion risk	5	5	Equipment	$ 15,000
Workshop	Vehicle Exhaust Fume Capture and Exhaust	5	5	Equipment	$ 20,000

Area	Equipment	Condition Grade	Risk Grade	Primary Categories of Risk	Opinion of Replacement Costs
Throughout	Fire Extinguishers	3	4	Equipment	$ 1,500
Throughout	Sprinkler System	5	5	Equipment	$ 180,000
Chemical Feed (3RD)	Explosion Venting	5	5	Equipment	$ 20,000
Workshop	Decommission and remove natural gas standby generator	3	5	Equipment	$ 5,000
Throughout	Decommission and remove Standpipe and Hose Cabinets	3	5	Equipment	$ 2,500
				Plant 2 Area Subtotal	**$ 854,000**
Plant 3 Area					
Throughout	Heating System repairs and replacements of terminal units and piping.	3	4	Equipment	$ 70,000
Chemical Feed (3RD)	Heating System – Requires explosion proof equipment	5	5	Equipment	$ 5,000
Throughout	Ventilation System	5	5	Equipment	$ 390,000
Chemical Feed (3RD)	Ventilation System for control of airborne contaminants and explosion risk	5	5	Equipment	$ 10,000
Pipe Gallery	Vehicle Exhaust Fume Capture and Exhaust	5	5	Equipment	$ 20,000
Throughout	Fire Extinguishers	3	4	Equipment	$ 1,500
Throughout	Sprinkler System	5	5	Equipment	$ 240,000
Chemical Feed (3RD)	Explosion Venting	5	5	Equipment	$ 20,000
Throughout	Decommission and remove Standpipe and Hose Cabinets	3	5	Equipment	$ 2,000
				Plant 3 Area Subtotal	**$ 758,500**
Lime Sludge Dewatering					
Truck Bay	Vehicle Exhaust Fume Capture and Exhaust System Repair	4	5	Equipment	$ 5,000
Throughout	Fire Extinguishers	3	4	Equipment	$ 1,000
Throughout	Sprinkler System	5	5	Equipment	
				Lime Sludge Dewatering Subtotal	**$ 6,000**
				TOTAL:	**$ 2,370,000**

5. Electrical & Controls

5.1 General

A one day general condition assessment of the City of Brandon Water Treatment Facility was carried out on September 17, 2012. The purpose of the site visit was to assess the condition of the treatment facility's electrical, automation and communication systems and identify deficiencies that would require correction to ensure safety and ongoing operational functionality of the facility. This section of the report presents our assessment of the Water Treatment Facility.

Inspections were limited to visual inspections only.

The Electrical assessment was carried out by Kent McKean of AECOM, accompanied by Plant Maintenance and Operation staff.

A previous condition assessment completed in 2004 was also reviewed as a part of our condition assessment.

Our observations for electrical and controls equipment within the overall Water Treatment Plant area is summarized below:

5.2 Evaluation

Electrical

The 2004 Existing Facilities Detailed Assessment Report provided an in-depth review of the WTP electrical system. Some of key findings in that assessment are the described below.

The WTP electrical exterior sub station is serviced from two Manitoba Hydro stations. The North feeder is a 33kv feed that is connected to the 1976 set of station transformers with a secondary voltage of 2400 volts. The south feeder is a 33kV feed that is connected to a 2000 kVA pad mount transformer with a secondary of 2400 volts. This transformer was installed in 1996.

Plant #1 Electrical System

Feeder #1 enters the building through a pull box located in the east side in the old metering room (converted to maintenance office space). The switchgear for Plant #1 (HV Main Distribution Section #1) is located in the area directly south of the maintenance office. This switchgear contains load break fused switches that feed the remote 2.4kV motor starters for low lift pumps 4, 5 and 6 and backwash pump 7, 2.4kV motor starters for low lift pumps 9 and 10, 300kVA 24kV-600V transformer for VFD distribution feeding transfer pumps 1 and 2 and miscellaneous 120/208 volt distribution panels in the Plant #1 area. This distribution also contains a 2.4kV fused load break switch for a 225kVA transformer with 120/208 volt secondary that feeds a 120/208 distribution, emergency 40kVA natural gas generator, intake structure, plus 120/208 volt panels. Most of this distribution system appears to have been installed in the 1976 upgrade with the exception of the transfer pump's VFD drives equipment, which was installed in approximately 2001.

Plant #2 and #3 Electrical System

Feeder #2 enters the Building with Feeder #1. It then runs from the pull box in a 3" steel conduit to HV Main Distribution Section #2 located in the High Lift Pump Room of Plant #2. At present the two high lift pumps (#4 and #5) 2.4kV starters, back wash 2.4kV starter and 225KVA transformer with 120/208 secondary to feed Distribution "AA" located in Compressor Room. This HV Distribution also contains a fused load break switch for the adjacent HV Cubical Distribution. This HV Cubical appears to have been a main service distribution prior to the 1976 upgrade. Its primary function at this time is to feed the Motor Control Centre for a chemical feed system.

A summary of the conditions of the facility's electrical equipment is summarized as follows:

1. There is no "real" power supply redundancy. If the water plant loses power to any one area on the feeders into the facility or on the exterior distribution, the Plant loses all capability of making or distributing water at the Plant.
2. With the current wiring layout, a minor fault within any Plant has the potential to knock out the entire Plant. A coordination study should be performed to determine high-risk areas.
3. The Facility has two power feeds coming from the utility. However, with the current configurations, there is a "bottleneck" at the substation into the facilities switchgear.
4. For this size of facility, the 2.4 kV is not current engineering practice. Typical installations would include providing 5 kV step down to 600 V for the main equipment, and 120 / 208 for all small tools and controls. Any future upgrades should make provisions for this type of power configuration.

A new diesel engine-driven generator set is currently under construction and therefore, the cost associated from this work is not included in this technical memorandum. The cost associated with the remaining electrical have been updated to current 2012 dollars. A summary of these costs are presented in Table 5.1.

Sludge Dewatering Electrical System

The feeder for the sludge dewatering system is fed from a Fused Load Break switch, installed in the 1997 addition, in the existing exterior switch yard on the east side of Plant #1. The feeder is installed on the exterior of the WTP to the 500kVA transformer, with 600 volt secondary, in the Sludge Dewatering Facility. The 600A. 600 volt Motor Control Centre provides electrical service to all the sludge dewatering area including process motors, lighting and general power.

5.2.1 Radio Communications

The existing radio communications system was indicated by plant personnel to be unreliable and intermittent. Communications with pumping stations drop out semi-regularly. There is no documentation of the existing systems, maintenance records or system map. Standard practice to resolve communication loss is to remove PLC power for 1 minute to reboot the main PLC in the WTP control room.

The site Electrician stated that City of Brandon (CoB) IT department is starting to replace parts of the system with an Ethernet IP radio based system.

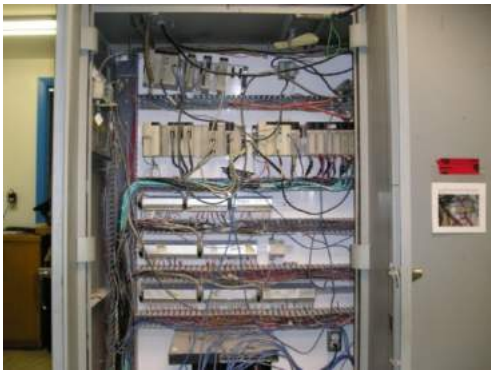

Photo 5.1: ↑
Control Room PLC Cabinet

Photo 5.2: ↑
Communications Fault Reset

5.2.2 PLC Networks

The existing FIP (field bus network) based PLC Network (within the WTP) is unreliable and intermittent. Communications between PLC's within the WTP randomly drop out. There is also a second Ethernet based PLC Network (the extent of the Ethernet network is not documented, and it is not known what the data split is between the FIP and Ethernet networks).

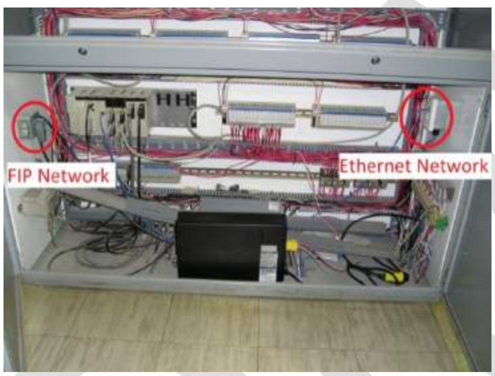

Photo 5.3: ↑
PLC Network Connections (Typ.)

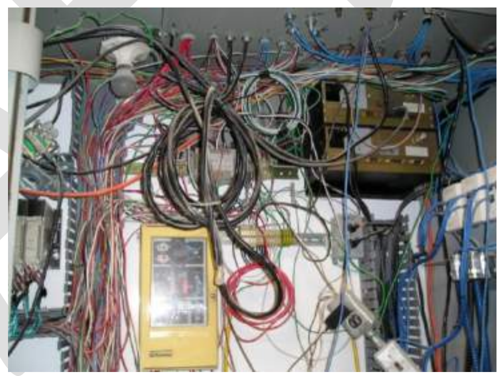

Photo 5.4: ↑
Wiring Condition Within Cabinets (Typ.)

5.2.3 PLC Systems

The existing PLC system(s) within the WTP consists of multiple semi-independent PLCs of different manufacture and age (some of which are obsolete). Most but not all of these PLCs are interconnected via the FIP and/or Ethernet communications network(s). There does not appear to be complete or accurate documentation of these PLC systems. PLC programs do not appear to have documentation. Wiring diagrams are missing or incomplete for PLC panels. Wiring within many PLC cabinets is poorly marked and generally The PLC interconnection network is only partially documented (DWG # 03-0754-01).

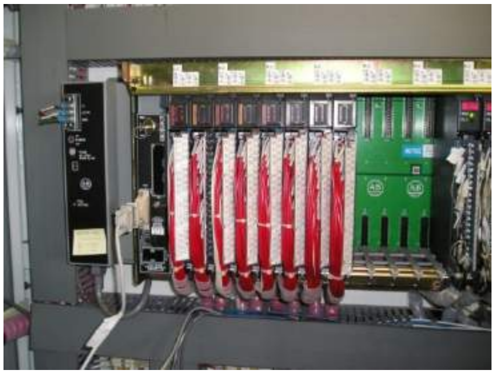

Photo 5.5: ↑
Obsolete PLC Systems

Photo 5.6: ↑
Current PLC Systems

5.2.4 VFD Line/Load Filter Systems

A problem with the VFD line/load filters was recently identified (3 to 4 weeks prior to this investigation). Multiple failures of capacitor modules were identified in multiple filters (in some filters, more than 50% of the capacitor modules had failed). Failed capacitor modules have been replaced. Until this problem was discovered, there was no planned maintenance of the VFD line/load filters. It is not possible to determine if these failures occurred gradually over several years or if some unidentified event caused multiple simultaneous failures. The site Electrician stated that a maintenance plan is now in place and VFD line/load filters are to be checked on a monthly basis. If multiple failures are identified in the next couple of maintenance cycles, further investigation will be required to identify the cause of the failures.

5.2.5 Existing GenSet

The existing 40kW Natural Gas powered GenSet is undersized but is scheduled to be replaced in the near future (work has already begun).

5.2.6 Existing Grounding and Ground Grid

A physical inspection/test of the existing grounding system should be conducted. Without ongoing maintenance, degradation of the plant grounding system may have occurred and could be causing electrical equipment and/or worker safety issues.

5.2.7 Carbon Storage/Handling

Carbon storage/handling room electrical equipment and lighting fixtures do not meet code requirements for the classification of the area (refer to Mechanical for detailed classification requirements).

Photo 5.7: ↑
Powdered Activated Carbon

Photo 5.8: ↑
Powdered Activated Carbon

5.2.8 Chlorine Detection/Alarming

Chlorine detection equipment (located outside the chlorine room) was turned off and may not be operational. (January 12, 2004 Earth Tech inspection report noted that a new W&T Accutec 35 chlorine leak detection unit was installed in the chlorinator room. This unit was not noted during this inspection)

Photo 5.9: ↑
Chlorine Alarm

Photo 5.10: ↑
Chlorine Cylinders

5.2.9 Fire Protection

A sprinkler system is required to protect the WTP, therefore a Fire Alarm control panel will be required to monitor the sprinkler system and provide annunciation. In addition to monitoring the sprinkler system, smoke/heat detectors and fire bells should be considered for the WTP office and control room areas.

5.2.10 Risk Assessment

Table 5.1: Electrical & Controls Risk Assessment

Area	Component	Condition Grade	Risk Grade	Primary Categories of Risk	Estimated Replacement Costs
Water Treatment Plant					
Areas 1-3	Electrical Co-ordination Study	4	5	Workers Safety	$ 10,000
Area 1	Feeder No. 2	3	4	Public Safety and Environmental	$ 55,000
Area 1	Station Transformer Testing	3	4	Public Safety and Environmental	$ 11,000
Area 1	Incoming Service	3	4	Public Safety and Environmental	$ 4,500,000
Fire Alarm Control Panel	No Sprinkler System (Refer to Mechanical)	New N/A	5	Workers Safety	$ 30,000
Chlorine Room	Chlorine Detection Equipment	4	5	Equipment	$ 1,000
Carbon Storage/Handling	Lighting and Electrical Equipment	5	5	Workers Safety	$ 50,000
Existing Grounding System	Electrical Service and Equipment	4	4	Workers Safety and Equipment	$ 10,000
PLC Systems	Documentation	4	4	Public Safety and Environmental	$ 40,000
PLC Networks	Documentation	4	4	Public Safety and Environmental	$ 30,000
Radio Communications	Documentation	4	4	Public Safety and Environmental	$ 10,000

5.3 Conclusions

The lack of documentation for the Water Treatment Plant Control System (consisting of the following sub-systems; PLC programs, PLC networks, Control Panel wiring & Radio communications) presents a cumulative risk. Each system on its own has the potential to cause disruption of the WTP. Because these systems are co-related and each system is dependent on the reliable operation of each of the other systems, it is vitally important that the individual systems as well as the overall Control System, in its entirety be understood and well documented. Because of the lack of documentation and as a result, a lack of understanding of the overall Control System, a failure of one or more of these sub-systems could result in significant down-time for the WTP, in the order of days, if not longer, resulting in a loss of potable water to the City of Brandon.

The carbon storage/handling room/area represents a significant safety risk to the facility and to personnel. Carbon dust produces an explosive environment and the electrical equipment and lighting in this area is not rated for this hazard. An electrical fault, such as a motor starter arcing, or the accidental breaking of a fluorescent lamp could result in a catastrophic explosion.

6. Process

6.1 General

A one day general condition assessment of the City of Brandon Water Treatment Facility was carried out on September 17, 2012. The purpose of the site visit was to assess the condition of the treatment facility's process mechanical systems and identify deficiencies that would require correction to ensure safety and ongoing operational functionality of the facility.

Inspections were limited to visual inspections only.

A previous condition assessment completed in 2004 was also reviewed as a part of our condition assessment. Most of the deficiencies noted at that time no longer exist; many of the mechanical devices have been replaced in the interim.

6.2 UV disinfection

Plant 1 has only one inline UV reactor, and lack of redundancy can be a problem. A conceptual design to realign the pump discharge piping through the ceiling and have a parallel two-reactor system in the room above has been prepared by another firm. The budget cost is reportedly $600,000.

Plant 2 has two UV reactors and therefore some degree of redundancy is available. This system is shared by Plant 3.

Although the UV is working within the mandated guidelines, there has been some new research into whether the presently accepted dose rates for potable water disinfection using medium pressure reactors may be too low, and the indicator organism may not be an appropriate indicator after all. While the system is presently performing to present standards, these standards may become more stringent, at which time the systems may need to be upgraded.

6.3 Pipe Corrosion

There are varying degrees of process pipe corrosion throughout the plant, from none at all on the newer stainless steel systems, to fairly extensive oxidation and paint delamination on older carbon steel systems. In particular, a given pipe can appear to be more corroded towards the dead ends of galleries with little or no ventilation where there is a humidity gradient. This is most evident at the south end of filter outlet piping gallery in Plant 3.

No overt leaks or evidence of leaks were observed, so it appears that none of the pipe systems have failed to date. It is unknown if the corrosion in these high humidity areas has compromised the integrity of the pipe walls, and most piping appears to be in 1 or 2 condition. Specialized materials testing and inspection may be required for these areas to determine if replacement or repair is needed.

6.4 Chlorination

The chlorine dosing system was last upgraded about 10 years ago. All of the PVC piping appears to be in good condition, and the system works well. It should be noted, however, that replacement of PVC piping is generally recommended after 10 years of service in chlorine applications. There is concern with the hoist used to move the cylinders; the north-south segment is seen to flex or move when the canisters are lifted into position. This needs to be fixed as soon as possible.

Notwithstanding the chlorine system's condition, it should be decommissioned and replaced with a safer process. The transportation and storage of 1-ton tanks of gaseous chlorine presents a high risk to the community.

6.5 Chemical Systems

The lime and soda ash systems have all been replaced in the past 3 or 4 years. The lime process currently in use (slaking) is the only one suitable for the varying quality of the product received; however, a slurry system is more effective for the treatment process, but needs a consistently high quality product which is not presently available.

Each train has its own dedicated chemical handling and feed systems, and the manual handling to move the chemicals to and from each location is onerous. A centralized loading, preparation, and feed system would be more efficient. Presently, everything is delivered at various locations around the building. This is advantageous as it allows multiple simultaneous deliveries (easier to schedule). However, it is disadvantageous in the more complex handling and conveyance procedures.

There is no dedicated chemical storage area with proper environmental controls, safety equipment, and containment. Chemicals are stored in drums and totes throughout the plant in any available space. A chemical spill could be inconvenient at best and catastrophic at worst. "Portable" eyewashes appear to be generously distributed throughout the facility in areas where the containers are stored. This addresses some of the immediate hazards to people, but not the environment (i.e., no spill containment)

The main lime and soda ash storage silo building is very dusty. While main silos are being filled, replenishing the feed systems throughout the plant is not possible. A load takes 5 to 6 hours to discharge, meaning that on delivery days, the in-plant feed systems may not be used if they run out. There is at least 1 if not 2 deliveries a week, so over 20% of the time (day shift) this is a problem.

6.6 Pumps

All pumps appear to be relatively new and/or well-maintained. No major corrosion or unusual mechanical noises were noted. Based on these observations, it is assumed all process pumps are suitable for their present purposes, and will only require replacement if forced by other factors (e.g. demolition of a non-compliant structure that cannot be upgraded to meet present codes). Removing the pumps prior to demolition and keeping them for reinstallation in a new plant should be assessed against the cost of purchasing and installing completely new equipment.

6.7 Solids Contact Tanks

Solids contact tank 1 was upgraded and its internal equipment replaced entirely one to two years ago, and is in excellent shape (Condition = 1). However, the architectural/structural recommendation is that Plant 1 be demolished and a new structure built. It is recommended that if this is done, removing the mechanisms prior to demolition for reinstallation in a new plant should be assessed against the cost of purchasing and installing completely new equipment.

SC tank 2 internal mechanism was in fair condition; parts have been replaced/repaired (one launder at least, and new inclined plates (now 60 rather than 45 degrees)). There is widespread surface corrosion, and it is reported that there are some perforations and leaks. This tank is normally out of service, only operated for one or two months a year when SC 3 is taken out of service for inspection and maintenance. Condition = 2 and 3.

SC tank 1 internal mechanism was in service and for the most part not visible for inspection. What could be seen appeared to be in good condition = 1.

6.8 Filters

All three filters were in service. All in-tank components visible from the surface appeared to be well maintained and in good condition. However, the piping systems in the basement

Filter 1 - piping and controls new in 1995 stainless steel. Still in excellent shape. The condition = 1. However, as for the pumps and solids contact tank, if Plant 1 is demolished and rebuilt, the condition of the equipment may be moot; it may be more economical to rebuild with new rather than salvage existing equipment for re-use.

Filter 2 - carbon steel piping appears to be original for the most part, with relatively new stainless steel components (in-line UV), Some corrosion is present, but in general, the local environment is 'fresher' environment that of filter 3 (see next). Condition 1 or 2

Filter 3 - piping and controls appear to be original (c1974); corrosion on pipes and fittings evident, and appears to be worse at the south end of the tunnel, which is a dead end and appears to receive little or no ventilation. As a result, there is a local humidity and temperature gradient, which appears to promote corrosion. Condition 2, and some limited components which may be Condition 3. No leaks or evidence of leaks were visible, but additional specialized inspection may be required to confirm if damage is significant.

6.9 Raw Water Wetwell

The top of the wetwell has four openings, 'covered' by grating. These were reported to have overflowed during 2011's high river levels. Plywood and sandbag bulkheads had to be placed over the openings to prevent extensive in-plant flooding. A permanent, more effective system such as solid watertight hatches should be installed at all tank reservoir openings that are below any recorded or anticipated high water levels.

6.10 Polymer

Polymer systems in plants 1 and 2 have been decommissioned. Polymer is fed from a "temporary" array of pumps in Plant 3 lower level.

6.11 Alum

Old wooden alum tank has been decommissioned. Alum now stored in 2 of 4 polymer tanks in Plant 3.

6.12 Thickener and dewatering

Both in good condition 1 with minor corrosion to major systems. Some minor piping has localised areas of high corrosion, but no leaks apparent. It appears there are no major concerns in this area.

6.13 General Conclusion

For the most part, it appears that most process equipment is in good shape and can be used for another 5 to 10 years; nothing appears to be on the verge of failure. Inadequacies within the system are safety related (i.e, chemical storage etc). A summary is as follows:

Dust - lime and soda ash silo room is thick with dust

Chemical storage - a dedicated area(s) with proper containment and other safety things like ventilation, adequate decontamination devices (eyewash, showers)

Chemical handling - lots delivered in 25 kg bags which need to be moved to the areas where they are immediately needed - there are three separate preparation and feed systems throughout the building.

Redundancy of UV in Plant 1 - No bypass available or redundant unit.

Adequacy of UV - present research may be re-examining the generally accepted dose rates and indicator organisms used for potable water disinfection using medium pressure reactors. If either of these parameters are changed at a regulatory level, the present systems could be rendered 'ineffective', and require replacement or expansion.

Chlorination - while the process components appear to be in good condition, other elements (see Section 3) have been found noncompliant with present codes. Even if these are addressed, a gas chlorination system in a populated area presents major risk to residents and staff, and it should be replaced a safer alternative, such as hypochlorite liquid or on-site generation.

Table 6.1: Process Risk Assessment

Area	Condition	Risk	Category	Cost	Description
UV Disinfection 1		5	Process (no redundancy)	$ 600,000	New UV reactor, new piping
UV Disinfection 2		2	Process	0	no major repairs appear to be needed
UV Disinfection 3	N/A				
Pipes	1 - 3	2-3	Equipment (localised corrosion; no visible leaks but structural effects unknown);	$ 75,000	assume replace about 20-25% of the piping
Chlorination	2 - 3	5	Worker Safety, Public Safety, Environmental	$ 600,000	replace with alternate system
		4	Equipment (hoist may be damaged)	$ 20,000	repair hoist
Silos		5	Worker safety (extreme dust levels)	$ 250,000	new ventilation/dust collection
		4-5	Process (on-site systems can't be replenished while silos are being filled)		
Lime & Soda Ash	1-2	4	Worker Safety (excessive manual materials handling)	$ 2,500,000	new centralized chemical storage and handling
Pumps	1	1-2	Process	0	no major repairs appear to be needed
SC Tank 1	1	1	Equipment (recently replaced)	0	no major repairs appear to be needed
SC Tank 2	2-3	3	Equipment (localised corrosion and some reported perforations and leaks)	$ 25,000	Localized repairs
SC Tank 3	1	1	Equipment (in-service, visible components appeared OK)	0	no major repairs appear to be needed

Area	Condition	Risk	Category	Cost	Description
Filter 1	1	1	Equipment (in-service, visible components appeared OK)	0	no major repairs appear to be needed
Filter 2	1	1	Equipment (in-service, visible components appeared OK). Exception: pipes here have the highest level of corrosion (see above)		no major repairs appear to be needed
Filter 3	1	1	Equipment (in-service, visible components appeared OK)	0	no major repairs appear to be needed
Raw Water Well	2	4	Environmental (open grating can overflow at high river levels)	$ 25,000	
		1-2	Equipment	0	no major repairs appear to be needed
Polymer			present system is 'temporary'		cost included as part of new centralized storage and handling
Alum			not centralized		cost included as part of new centralized storage and handling
Thickener	2	2	Equipment	0	no major repairs appear to be needed
Dewatering	2	2	Equipment	0	
Chemical Storage	N/A	4	Worker safety (No or limited permanent showers/eyewashes)		cost included as part of new centralized storage and handling
	N/A	4	Environmental (no dedicated area with spill containment)		cost included as part of new centralized storage and handling
			TOTAL	$4,100,000	

7. Summary

A code and condition assessment was provided for the facility, with a brief summary listed as follows:

- Plant No. 1 requires significant upgrades to meet the NBCC life safety and mechanical codes. For an un-insulated building of this age and construction type it is expected that significant challenges will be encountered. From a structural perspective the Plant area can be characterized as in fair condition. Ongoing repairs and maintenance can be expected and could rise significantly as this structure nears the end of its useful life. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly. The majority of the HVAC equipment appears to be 25+ years old and has already been running well beyond its normal service life. With regard to process, issues related to UV disinfection redundancy and chlorine disinfection are the significant areas of concern.
- Plant No. 2 also requires upgrades to meet the NBCC life safety and mechanical codes. Additional exits, a fire sprinkler system, and work to the main staircase are recommended. From a structural perspective, the area is in fair to good condition. Some of the contactor tank internals require replacement due to corrosion. Concrete tanks are in good condition and will require ongoing inspection and monitoring as they age. The re-carbonation tank soffit requires a detailed inspection and repair. The clear well reservoir should be inspected and assessed at the next available opportunity. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly. Boiler and ventilation system replacement comprise of the majority of mechanical costs. Cost associated with constructing a new chemical storage and handling facility make up the majority of the process costs.
- Plant No. 3 requires and additional exit staircase along the south side, a fire sprinkler system, and separating the staircase adjacent to the Polymer room with a rated wall assembly. Structurally, Plant Area 3 is in good condition including the condition of the concrete tanks. The existing roof will need to be analysed to determine if the structure meets the current code. Roof strengthening, if required can be significant and costly. Ventilation and a sprinkler system are the major mechanical costs. Filter piping and chemical storage are the major process items.

Costs associated with the upgrades are listed by discipline in **Table 7.1**. These preliminary costs do not include taxes or engineering and are considered accurate to +75% and -50%.

Table 7.1: Summary of Costs to Upgrade Facility to Meet NBCC (2010)

Discipline	Upgrade Cost
Architectural	$ 625,000
Structural	$ 1,440,000
Mechanical	$ 2,370,000
Electrical and Controls	$ 4,747,000
Process	$ 4,100,000
Total	$ 13,282,000
Total (Rounded)	**$ 14,000,000**

Appendix B.

- **Water Utility Performance Measurement Technical Memorandum**

City of Brandon

Water Utility Performance Measurement Technical Memorandum

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Project Number:

60275081.402

Date:

December, 2012

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AECOM: 2012-01-06

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

December 13, 2012

Patrick Pulak, P. Eng.
Deputy Director of Engineering Services & Water Resources
Development Services Division, Engineering Department
City of Brandon
P.O. Box 960 410 – 9th Street
Brandon, MB R7A 6A2

Dear Mr. Pulak:

Project No: **60275081**

Regarding: **Water Utility Performance Measurement Technical Memorandum**

AECOM is pleased to submit the Draft Water Utility Performance Measurement Technical Memorandum. This Memorandum is a deliverable of the Background Information and Project Supply Phase for the City of Brandon Water Utility Master Plan project.

Sincerely,
AECOM Canada Ltd.

Keith Sears, Ph.D., P.Eng
Project Manager
Keith.Sears@aecom.com

KS:SW:td
Encl.
cc:

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AECOM Signatures

Report Prepared By:

David Main
Director of Asset Management and National Benchmarking

Report Reviewed By:

S.R.(Ray) Bilevicius, M.A.Sc., P.Eng
Technical Reviewer

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1. Introduction

> **"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."**
>
> **William Thomson**
> **Lord Kelvin**

As the City of Brandon begins preparing a Master Plan to guide the development of its water infrastructure over the next 20 years and longer, it is timely that the utility also begin considering a process to report on utility goal attainment over the course of the planning horizon. A robust and comprehensive utility performance management program consists of a range of carefully selected Key Performance Indicators (KPIs) that can be used not only to monitor the attainment of core utility goals over time but also to enable a process of benchmarking amongst other water utilities for the purpose of identifying and implementing Best Practices. Fortunately, over the past decade, the water sector in Canada and globally is now in general agreement with regards to appropriate public water utility KPIs and KPI definitions. In Canada this process has been guided by the National Water and Wastewater Benchmarking Initiative and the CSA Plus 4010 Technical Guide for Performance Improvement for Small and Medium Sized Water Utilities. Globally, this process has been well documented by the International Water Association and in the USA through the AWWA QualServe program. As individual water utilities implement KPIs that are documented through any of these Best Practices, it becomes possible to augment performance measurement efforts with multi agency benchmarking.

The City of Brandon has provided drinking water services to local businesses, industry and residents since it was incorporated. The City operates the water treatment and distribution system for the benefit of all drinking water customers who are connected to the system. In addition to the water treatment plant, the City also maintains a small number of water wells to augment the water supply during emergency situations. The City is responsible to all of their customers as the overall water service provider. All drinking water related customer inquiries, complaints, or calls for service are directed to the City for resolution.

Just because there are few formally recognized Key Performance Measures does not mean that the City operates without specific and rigorous guidance. Like most communities in Canada, current KPIs and levels of service are a combination of regulatory requirements, policies, bylaws, and in many cases, guidelines and implied levels of service that have been set by past precedence. The discipline of utility performance management however, requires a more formalized approach to quantifying and measuring all aspects that relate to water infrastructure and more importantly, the vital services that water infrastructure provides.

The purpose of this Technical Memo is to introduce a utility performance measurement process in association with the Brandon's Water Master Plan to enable a successful continuous improvement program. The implementation of a Best Practice-based KPI program can be considered an investment in that the utility will benefit from this program in the coming years as the Master Plan becomes fully implemented. According to the CSA Plus 4010 Technical Guide:

"Water utility managers can use a Best Practice-based KPI program for a number of purposes:

- *Identify strengths and weaknesses within the utility;*
- *Improve water quality and availability;*

- *Investigate the need for changes or corrective action to improve procedures and productivity;*
- *Monitor the effect of change;*
- *Measure resource use;*
- *Provide key information to support proactive decision making, and*
- *Facilitate benchmarking – both internally and externally.*

In this way, utility managers can continuously improve their systems and services."

2. Water Utility Performance Measurement Framework

Water utilities can conduct performance measurement at many levels within their organization. Individual performance measures can be directed to measure the attainment of management processes; service standards; work practices; program/project delivery approaches; technical standards; process performance; or cost targets. A framework to organize and arrange performance indicators is required to begin the process of agreeing on a standard and consistent suite of utility management related performance indicators. These aspects can generally be categorised into 3 levels for the evaluation and application of performance measurement and benchmarking:

1. Management Level
2. Intermediate Level
3. Functional Level

The need for and focus of performance measurement differs at each of these levels, as do the key indicators and the management tools required by the individual responsible at that level. Figure 2.1 summarises these variables for the three levels and illustrates the differences associated with the individual's level of responsibility and accountability within the organisation. A solid performance measurement process requires that the Management Level be addressed first and foremost. This level also enables the process of "Metric Benchmarking" where organizations can be compared between one another. Once metrics are in place, process benchmarking can be utilized (among other tools) to assist with continuous improvement.

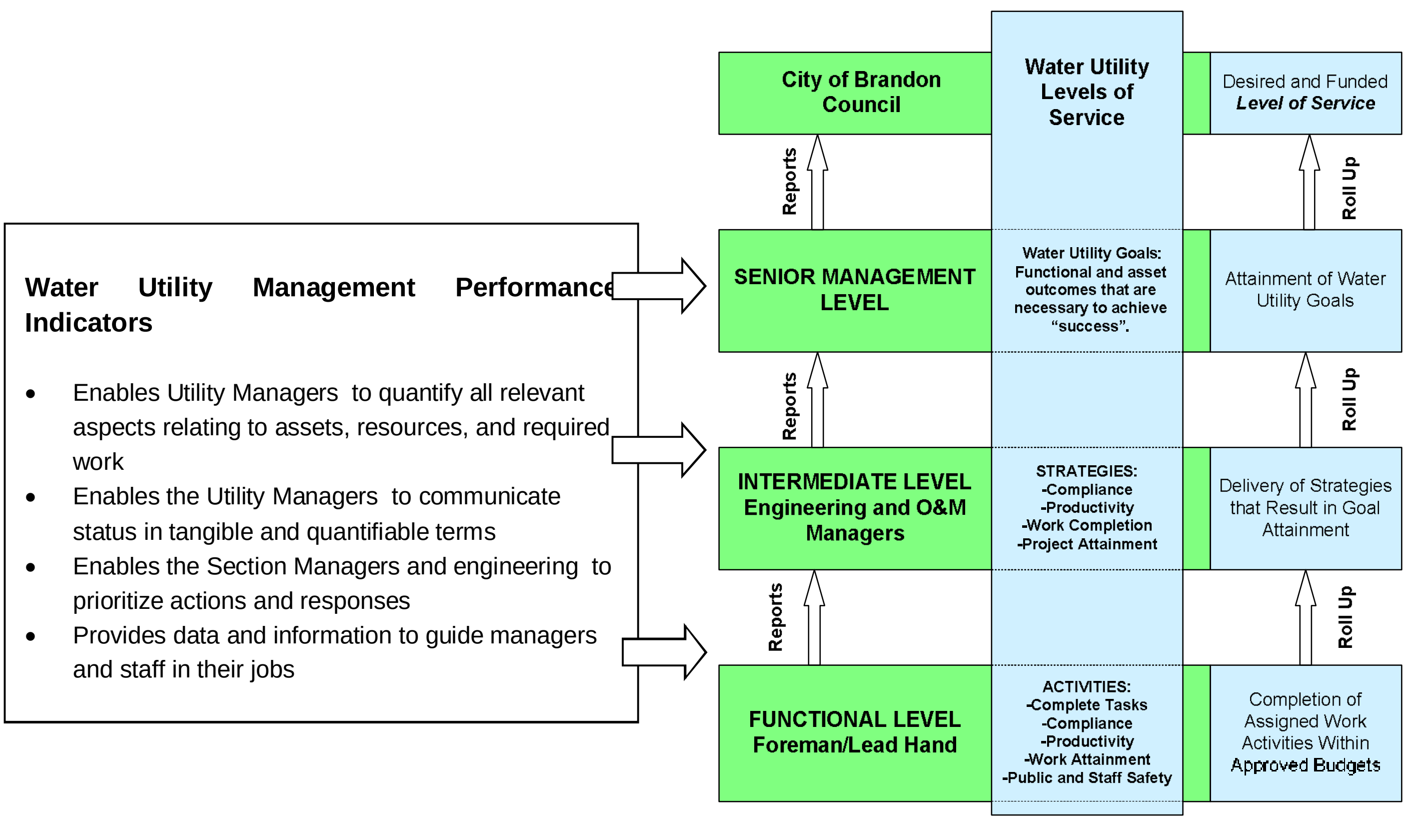

Figure 1: Framework for Relating Utility KPIs to the Utility Master Plan

Once the Management level KPIs have been identified, a solid platform exists to begin drilling down into the more detailed subsets of performance indicators. This framework will also enable all performance indicators to roll up to their respective levels of service and provide the ability to examine different technical strategies and their associated impact on rates and taxes.

2.1 Key Performance Indicators Must Relate to Core Utility Goals

Like most Canadian water utilities, Brandon's water utility is owned by the municipality. The owners are represented by Brandon City Council on behalf of the residents of the City. In order to be successful, the utility manager must have a clear understanding of what the "owner" wants to accomplish and how the infrastructure service can contribute to that owner's success. While providing clean and safe drinking water is the core goal of the utility, there are a range of conditions that the utility is responsible for conducting while meeting this goal. For example, water rates must be reasonable, the service must be reliable, and that the services must be provided in an environmentally responsible manner.

As a first step, the utility managers should confirm their organization's goals, and check them for alignment with those of the owner. In turn, each division of the infrastructure organization should set its own goals to align with the higher-level direction. This is not a one-time effort. Rather, the process should incorporate regular checks to ensure that activities can be, and are seen to be clearly addressing the owner's needs and priorities.

Managers should establish their goals through comprehensive discussions with key stakeholders such as politicians, regulatory agencies, industry, interest groups and the general public. At first, this process could reveal significantly different points-of-view. However, through consultation and involvement, stakeholders can generally reach consensus, providing a strong focus for the management process.

Once set, these goals should be relevant in the medium to long term and provide the basis for decision-making. However, as individuals change at the political or management level, the emphasis on particular goals may also change. As a result, infrastructure managers should stay attuned to the changing environment in terms of political and public opinion. This will help managers fine-tune their approach and priorities and stay aligned with the conditions of the day.

Water Utility Goals

Over the past decade, generic water utility goals have become well documented through a range of Best Practice guidance. The two Canadian standards are closely related:

The CSA Plus 4010 Technical Guide for Performance Improvement for Small and Medium Sized Water Utilities

- Protecting Public health
- Meeting user needs and expectations
- Providing service under normal and emergency situations
- Sustaining the water utility
- Promoting the sustainable development of the community and
- Protecting the environment

A variation of the goals stated within the CSA Technical Guide forms the foundation of the National Water and Wastewater Benchmarking Initiative, where the goals are stated as:

- Provide reliable water services
- Provide sufficient capacity to enable planned community growth
- Meet service requirements in an economically efficient manner
- Protect public health and safety
- Provide a safe and productive workplace
- Have satisfied and informed customers
- Protect the environment and minimize environmental impacts

Even though these goals may seem self evident to utility managers, it is vital that the entire organization including key stakeholders within senior City management have an opportunity to review and confirm goals as relevant and important. Each goal will require resources to attain. If the goal is not seen as important, resources can be deployed elsewhere in the utility.

3. Defining Key Performance Indicators

Once utility goals have been confirmed, individual KPIs can be selected on their ability to communicate information about the utility's progress in attaining each goal. In all cases, each goal will require one or more KPIs in order to measure overall goal attainment. In order to be considered as a useful performance indicator, the following attributes are important:

1. *Understandable*: Performance indicators must have a clear meaning to the utility. Sometimes, measures that are preferred by technical experts have little meaning to a non-technical audience.
2. *Relevant to actions under consideration*: Performance indicators must cover issues that are practical and of substance to both the utility and its customers.
3. *Practical:* Managers must be able to compile the data that supports the indicator and should be able to determine the impact of alternative strategies or actions on this indicator.
4. *Accurate:* The performance indicator must allow for a quality-assured process to collect, analyse and report results that would provide consistent results.

Current standards including the National Water and Wastewater Benchmarking Initiative and the CSA Plus 4010 Technical guide have documented a comprehensive range of water utility KPIs that have proven successful in many Canadian communities in meeting the above requirements. This inventory of KPIs can be narrowed or expanded based upon the requirements of the City of Brandon.

3.1 Aligning KPIs to Utility Goals

Table 1 below present a range of industry accepted water utility KPIs that are aligned to utility goals. This table is presented as an example only. As a starting point, it is recommended that the City begin with a simplified suite of KPIs and expand the list as and when required.

Table 1: Water Utility Goals and Performance Measures

Utility Goal	Performance Related Notes	Suggested Performance Measures
Provide Water Service Reliability and Response	• General expectation is that drinking water is available to customers all of the time (24 / 7) • Unplanned interruptions to water supply do occasionally happen and the City must respond rapidly • Planned service interruptions are reasonable but advance notice to customers is required • Fire flow to hydrants are required all of the time • Water must be provided with adequate pressure to meet household needs (eg: showers, etc.) • WTP must be in operation all of the time • Disasters may result in reduced levels of service and are governed by the disaster contingency plan until full service can be restored	• # of unplanned service interruptions/year • % of preventive maintenance program completed in the year • # of main breaks/ 100 km length • # of unplanned water interruptions exceeding 12 hour maximum repair time following notification • # of hydrants not able to support required fire flows • # of customers where planned service interruptions did not receive a minimum of 48 hour notice to customers • % downtime of WTP • Number of customer-days where water pressure does not meet minimum standard (40 PSI) • Number of days that the Emergency Plan is in effect

Utility Goal	Performance Related Notes	Suggested Performance Measures
Provide Adequate Capacity	• There is no volumetric limit to domestic water consumption except during summer lawn watering restriction periods • Water infrastructure must be sized to meet city demand and growth expectations • WTP must have adequate capacity to meet peak times • City must provide adequate water capacity to new developments as documented in OCP • Fire hydrants must be able to provide fire flow capacity all of the time	• # of days where water demand equalled or exceeded pressure zone capacity • Average Daily Water Demand / Existing Licence Capacity • Number of days WTP operated at > 95% Capacity
Protect Public Health and Safety	• Water quality regulations govern the required standard for drinking water quality • Provide immediate emergency response to customers when water quality issues are identified • Though not a direct health issue, customers desire that drinking water be clear, tasteless and odorless	• # of water quality tests in non-conformances of drinking water quality standards • # of days where a boil water advisory is in effect • # of days where water does not meet colour/taste standards • # of water taste/odour complaints
Protect the Environment	• Ensure that chlorinated water does not enter the drainage system or receiving water bodies • Promoting water conservation is a water stewardship objective	• # of reportable spills due to chlorinated water impacting local water body • Average residential water consumption per capita per day • Infrastructure leakage index (ILI)
Provide Good Customer Service	• Provide a Service Call centre with specific call response targets • Customer calls for services and complaints are responded to according to set standards • Utility is able to respond to emergencies rapidly when required	• % of service call responses meeting the response target • % of service calls successfully meeting the approval of the originating customer • # of water related customer complaints
Provide a Safe Workplace	• City is responsible for providing a safe workplace for all employees • Accident statistics are reported to WCB	• # of field accidents with lost time • # of lost hours due to field accidents
Meet Service Requirements with Economic Efficiency	• Customers are charged water rates to pay for water services • The utility is monitoring the cost of service to ensure that charges are fair and reasonable • Water rates reflect the full cost of providing service including O&M, capital upgrades and infrastructure replacement/renewal • The utility is being diligent at	• Annual charge for average household (through water rate and other incidental charges) • % recovery from rates of the full cost to provide service (according to asset management principles) • Total Utility Operating Cost/Population Served • O&M cost / ML treated

Utility Goal	Performance Related Notes	Suggested Performance Measures
	controlling costs and looking for opportunities to enhance efficiencies	• Energy consumed (kWh)/ ML treated • Cost of Chemicals consumed / ML treated • Pipes O&M cost / km length • Metering O&M cost / # of meters • Pump station O&M costs / total pump station hp

4. Water Utility Management Model

It takes considerable effort to gather and manage the data to populate performance indicators. A water utility management model presents a framework to help ensure that KPIs data is being converted into useful utility management information. The objective of the model is to ensure that the KPIs are operating over time to identify opportunities for enhanced performance across all of the utility goals By integrating the utility management model with benchmarking, the performance management process is augmented to help guide utility managers to other utilities that have implemented successful Best Practices.

An example schematic layout of a Utility Performance Management Model is set out in Figure 4. In this case, a set of “Goals” have been adapted from the National Water and Wastewater Benchmarking Initiative and example KPIs have been inserted to illustrate the example. Using this type of model, the utility manager can use performance measurement with benchmarking to systematically identify areas of inferior performance in their utility, best practices, innovative ideas and more effective operating procedures to improve overall performance. If benchmarking is used regularly and effectively, the process will assist managers in shifting from a reactive to a proactive operating philosophy based on continuous improvement. Desired outcomes will include emergency repairs replaced by timely preventive maintenance; regulatory exceedances replaced by regulatory compliance; and excess budget expenditures replaced by cost savings to be passed to the customer.

4.1 Elements of the Utility Management Model

Following the affirmation of a statement of **Vision** that describes what the organization is setting out to achieve, the Utility Performance Management model typically includes:

- **Goals**: Confirmed goals are documented as the highest level of organization ends. This is what the utility is mandated to achieve.
- **Key Performance Measures**: KPIs measure the progress of individual goal attainment. Performance measures describe, "when you've reached your goal". If the goal has been reached, further investment in this goal may not be necessary. If certain goals always fall short, this provides guidance for future resource allocation.
- **Strategies:** In order to improve the attainment of an individual goal, strategies must be identified and implemented. A strategy is an action or approach that can be taken in order to achieve the associated goal. Once the strategy is implemented, the effectiveness of the strategy must be measurable by the respective performance measure. Of course, achievement of the parent goal and improved operations is the desired end result. Improvement strategies can be changed to prevent or correct problems or deficiencies, to emulate best practices, or to implement innovation.
- **On-Going Measurement (Benchmarking):** Finally, ongoing benchmarking should be utilized to continually provide current and accurate feedback regarding the outcome of strategies. Successful strategies will have the effect of improving performance, while unsuccessful strategies, may not have the desired effects. With timely feedback, managers can insure that the correct selection of strategies is in place to ensure continuous improvement is occurring from year to year.

STEP 1: CONFIRM VISION	The vision describes how the utility will achieve its mission	**EXAMPLE VISION: We are committed to the social, economic and environmental well-being of our community. We are dedicated to providing our citizens quality services , delivered with care, competence and integrity**					
STEP 2: SET UTILITY GOALS	Each goal is selected to help realign the organisation with its vision	GOAL 1 Provide water service reliability	GOAL 2 Provide sufficient capacity to enable community growth	GOAL 3 Meet service requirements in an economically efficient manner	GOAL 4 Protect public health with safe and clean drinking water	GOAL 5 Protect the environment (water, air and land)	GOAL 6 Ensure customer are satisfied through high quality service
STEP 3: IDENTIFY RELEVANT PERFORMANCE MEASURES	Performance measures are objective indicators of a utility's success in achieving its goals	- % of Preventive Maintenance Program completed in a year	- Number of Days WTP Operated at > 95% Capacity	- O&M cost of water distribution in a year / km of water main	- Number of regulated microbiological tests within compliance / number of regulated microbiological tests	- Average Residential Water Consumption Per Capita per Day	- Number of water pressure complaints / 1,000 water connections
STEP 4: CONDUCT PERFORMANCE MEASUREMENT	Performance measures are tracked and benchmarked with peers and previous years	PM Program completion rate is 60%	WTP operated at 95% or more on 14 days in the last year	$6,500/km	100% Within compliance	350 litres per capita per day	3.2 Water pressure complaints per 1,000 water connections
STEP 5: MAKE PERFORMANCE OBSERVATIONS THROUGH BENCHMARKING	Identify differences between target and actual levels of performance	PMs are not being completed regularly. May result in premature asset failure	WTP capacity is limited under current conceptions patterns	Higher than average cost for systems of a similar nature	Excellent compliance with regulations.	High residential water consumption compared to national average	Higher than average number of water pressure complaints per 1,000 water connections
STEP 6: SELECT STRATEGIES & ACTIONS	Select initiatives that present the most attractive opportunity to improve performance	Optimize maintenance strategies to focus on PM completion	Investigate demand side management options to reduce peak demands	Investigate correlation between cost and high number of main breaks	Maintain high record of microbiological water quality compliance.	Evaluate opportunities for reduction through water loss program	Pinpoint areas of most pressure complaints. Investigate possibility of re-zoning supply.
STEP 7: MEASUREMENT & REPORTING	Measure whether selected initiatives improve performance. Report results.	Measure and report	Measure and report	Measure and report	Measure and report	Measure and report	Measure and report

Figure 2: Water Utility Management Model to Drive Continuous Improvement

5. Example KPI Benchmarking Results

Quality benchmarking should encompass regular annual comparisons regarding the attainment of common goals for the purpose of identifying performance gaps. Equally important is implementing the improvements, monitoring the progress, and reviewing the benefits of the implemented changes. What differentiates water utility benchmarking in Canada is that the National Water and Wastewater Benchmarking Initiative (NNWBI) program has been undertaken collaboratively, through the willing sharing of performance data, to learn about the circumstances and processes that underpin superior performance. In tandem with this, is the realization that no single organization has all the answers, and that success is measured through a wide range of criteria that may include financial; sustainability; reliability; environmental and customer service criteria.

The usefulness of benchmarking data only becomes apparent when continuous improvement actions are formulated. To start this process, the NWWBI produces a range of pictorially based graphs that depict overall group performance, which allows each utility to observe its historical trends over time. By acting in areas that present opportunities for significant improvement, a utility is able to optimize its continuous improvement investments.

First, individual graphs are produced which compare results within similar groups. Performance measures are calculated from the compiled data in each of Water Distribution, Water Treatment, Wastewater Collection, and Wastewater Treatment utility areas. In comparing the data in grouped graphs, only similar systems are compared with one another; for example, only conventional water treatment plants less than 60 ML/day are compared to avoid the large gap from economies-of-scale and because clearly conventional treatment plants cannot be compared to unfiltered or even direct or membrane filtration plants. As further comparisons and interpretations of the graphs are made, our personal knowledge of the systems help to evaluate what local factors may be considered as well as regional issues that may be of importance. Despite these unique characteristics, there are always comparable issues and factors. The following are example group performance graphs.

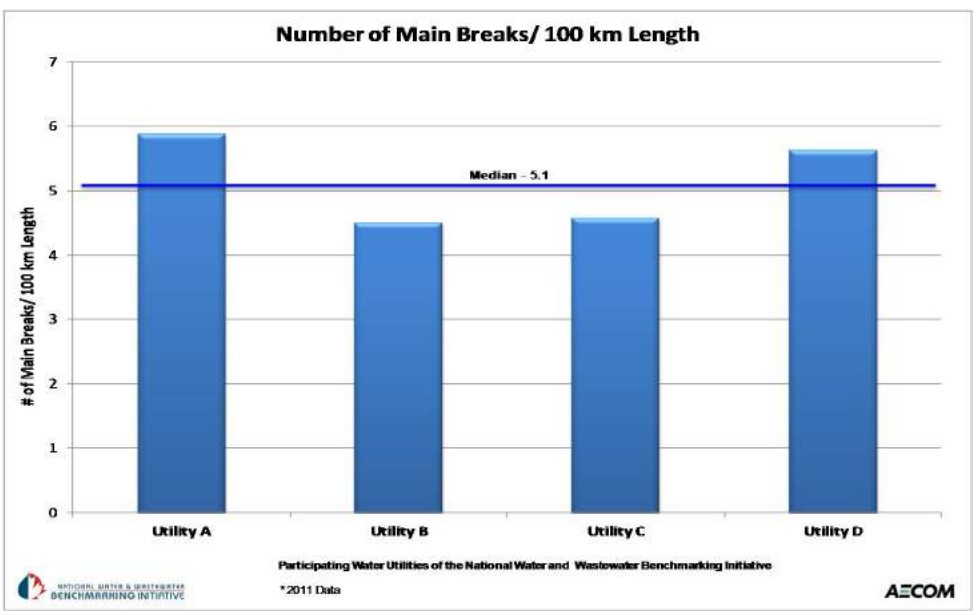

Figure 3: Comparison of Annual Main Breaks Amongst Four Utility of Similar Size to Brandon

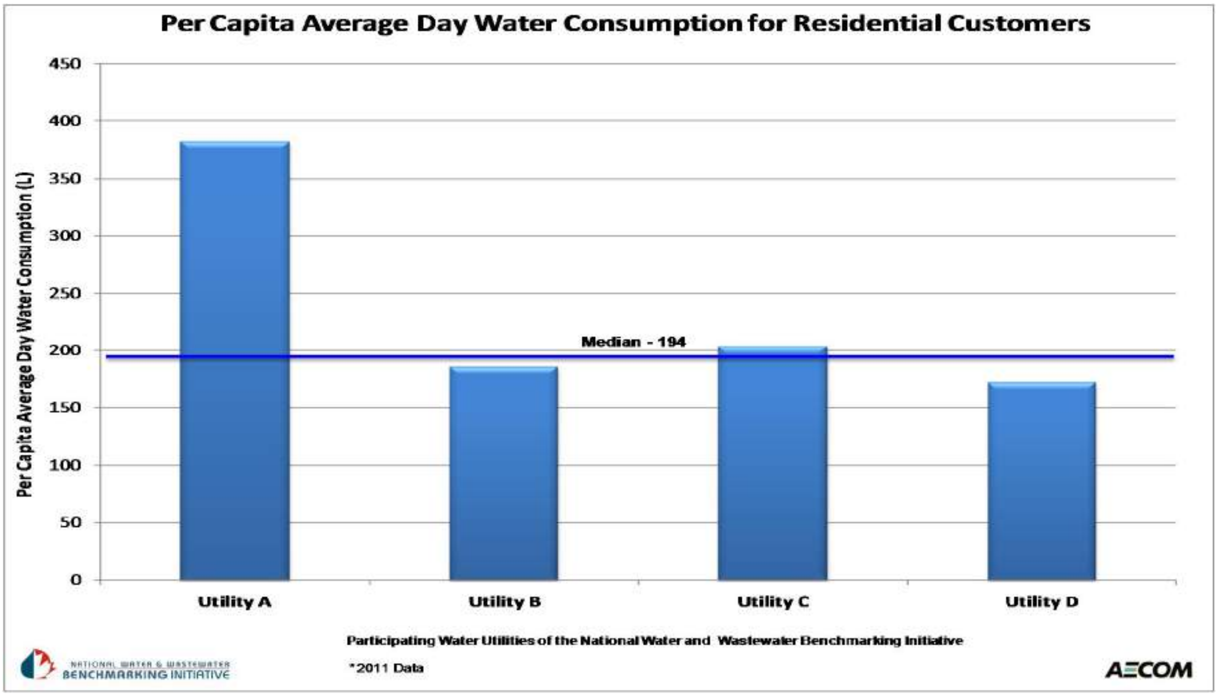

Figure 4: Comparison of Annual Water Consumption Amongst Four Utility of Similar Size to Brandon

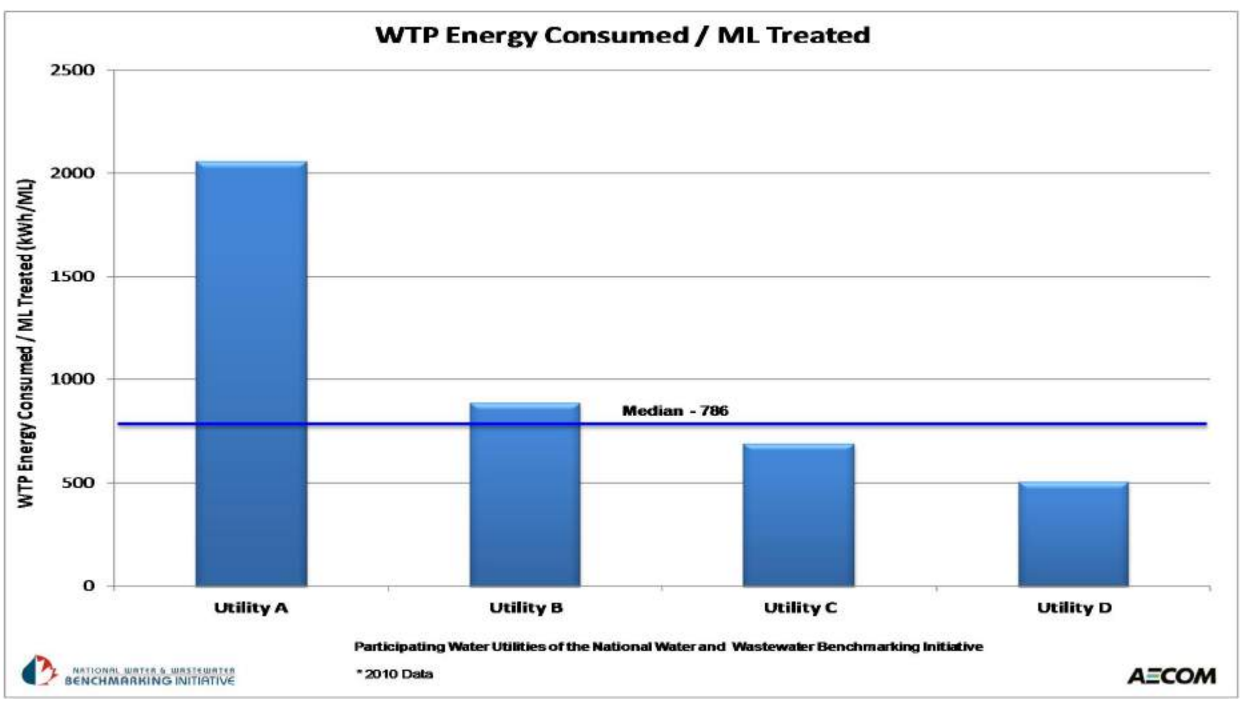

Figure 5: Comparison of Energy Consumption Amongst Four Conventional Water Treatment Plants of Similar Size to Brandon

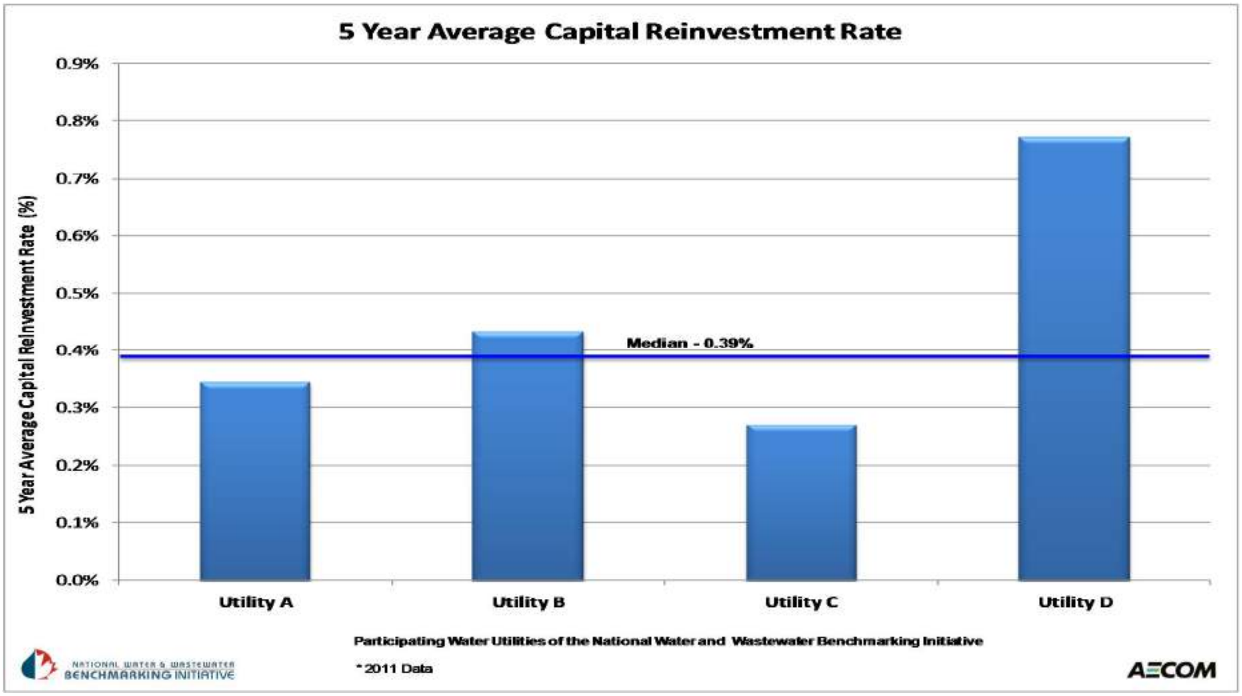

Figure 6: Comparison of Annual Capital Reinvestment Rates Amongst Four Water Distributing Networks of Similar Size to Brandon

Comparing graphs and KPIs is one thing, but performance measurement cannot end here. In order to improve any function, this information should be used to assist the overall continuous improvement program. To address the fundamental reason for undertaking performance measurement and benchmarking, the organization must be willing to accept change. Accepting and embracing change is a challenge that all organizations face. But if performance measurement and benchmarking is approached not as a numerical exercise that relies on data, automation, and computerization, but rather as a process to expand communication, teamwork, and collaboration, the door opens to the possibility of making significant improvements in both productivity and efficiency.

6. Recommendations

This Technical Memorandum has been presented to provide background information as a primer for a Best Practice based water utility performance management system that includes utility goal confirmation, KPI selection and ultimately, continuous improvement through benchmarking. It is recognized that it will take some time to establish an effective performance management program so this effort should be seen as an investment. Since the City of Brandon is beginning to advance its Water Master Plan, it is recommended that the City begin efforts in implementing a performance management system that will help measure the results of the Master Planning effort in the coming years. The information that is consolidated from a utility management model can be used to guide the introduction of new capital investments in clear association with goal needs. In addition to assisting utility management and staff, this information can also help communicate the utility strategies to City stakeholders and water utility customers. Experience has demonstrated that if customers fully understand the level of service implications on new investments in their water utilities, they are more inclined to support the investment with higher water rates.

Should Brandon want to commence a performance measure program in association with the Water Master Plan, the following is recommended at starting efforts:

1. **Begin internal discussion and communication relating to appropriate water utility goals:** The goals form the foundation of performance measurement effort. It is highly likely that the City of Brandon's water utility goals will be very similar to those of other Canadian water utilities, but it is important to review and confirm goals before taking the next steps.
2. **Begin advancing a range of Management Level performance indicators to support goal measurement:** Most important performance indicators have been identified in this Technical Memo but the full range many not be required to support the implementation of the Master Water Plan. Brandon is recommend to start simply, and advance to higher levels of detail as needed over time.
3. **Begin identifying current and potential data sources for populating the individual performance indicators:** This process could take a number of annual iterations before it is complete. Data accuracy is an important factor, as staff need to have confidence in the level of service indicator results in order to respond proactively. Our experience has shown the current data source may include some corporate data bases, but it is highly likely that some key data is storted in a range of spreadsheets that does not form part fo the formal data mangment system within the City. It is also likely that key data is still being managed at the personal level within the collective knowledge of senior operations and maintenance staff. Unless this data can be documented, utilites are at risk of losing this important information as senior staff retire.

Appendix C.

- **Triple Bottoms Line Decision Making Framework Technical Memorandum**

City of Brandon

Water Utility Master Plan
Triple Bottom Line Decision Making Framework
Draft Technical Memorandum

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

City Project Number:

60275081

AECOM Project Number:

60275081

Date:

March, 2013

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AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

March 22, 2013

Patrick Pulak, P.Eng
Deputy Director of Engineering Services & Water Resources
City of Brandon
410-9th Street
City of Brandon MB, R7A 6A2

Dear Mr. Pulak:

Project No: 60275081

Regarding: City of Brandon – Water Utility Master Plan
Triple Bottom Line Decision Making Framework
Draft Technical Memorandum

AECOM is pleased to submit the Draft Technical Memorandum on the Triple Bottom Line Decision Making Framework. We look forward to meeting with you to discuss this at your earliest convenience.

Sincerely,
AECOM Canada Ltd.

Keith Sears
Project Manager
Keith.sears@aecom.com

KS/td
Encl.

Distribution List

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AECOM Signatures

Report Prepared By: Keith Sears, Phd., P.Eng.
Project Manager

Report Reviewed By: S.R.(Ray) Bilevicius, M.A.Sc., P.Eng.
Water Specialist

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1. Introduction

A series of technical memorandums has been completed to date and includes information on the following:

1. Population and water demand projections
2. Code and condition assessment of the existing water treatment plant
3. Existing and potential future regulatory requirements
4. Benchmarking review
5. Water supply assessment

Conceptually there are a number of potential water sources which could be used to provide all/portion of the potable water needed to meet the City's needs. This includes the Assiniboine River, Assiniboine River Valley Aquifer, Brandon Channel Aquifer, and the Assiniboine Delta Aquifer. Others options can also be found in Groundwater Supply Options Technical Memorandum. The attached schematic shown in **Figure 1.1** illustrates how the potential different sources can impact the design options available to the City. Adding to the complexity is the uncertainty regarding the timeline associated with securing the various water source licences. Figure **1.2** illustrates a decision flow chart which outlines major decisions that need to be made depending on the water source selected.

As illustrated in Figure 1 and Figure 2, a broad range of process and design options will be available for the upgrading the City's water treatment facility. A systematic, step-wise method for making decisions is necessary to focus and clarify decision-making. The primary objective of this Technical Memorandum (TM) is to present a Triple Bottom Line (TBL) Decision-Making Framework that will be used in the Master Plan to guide decision-making.

Figure 1.1 Water Supply Decision Flow Chart

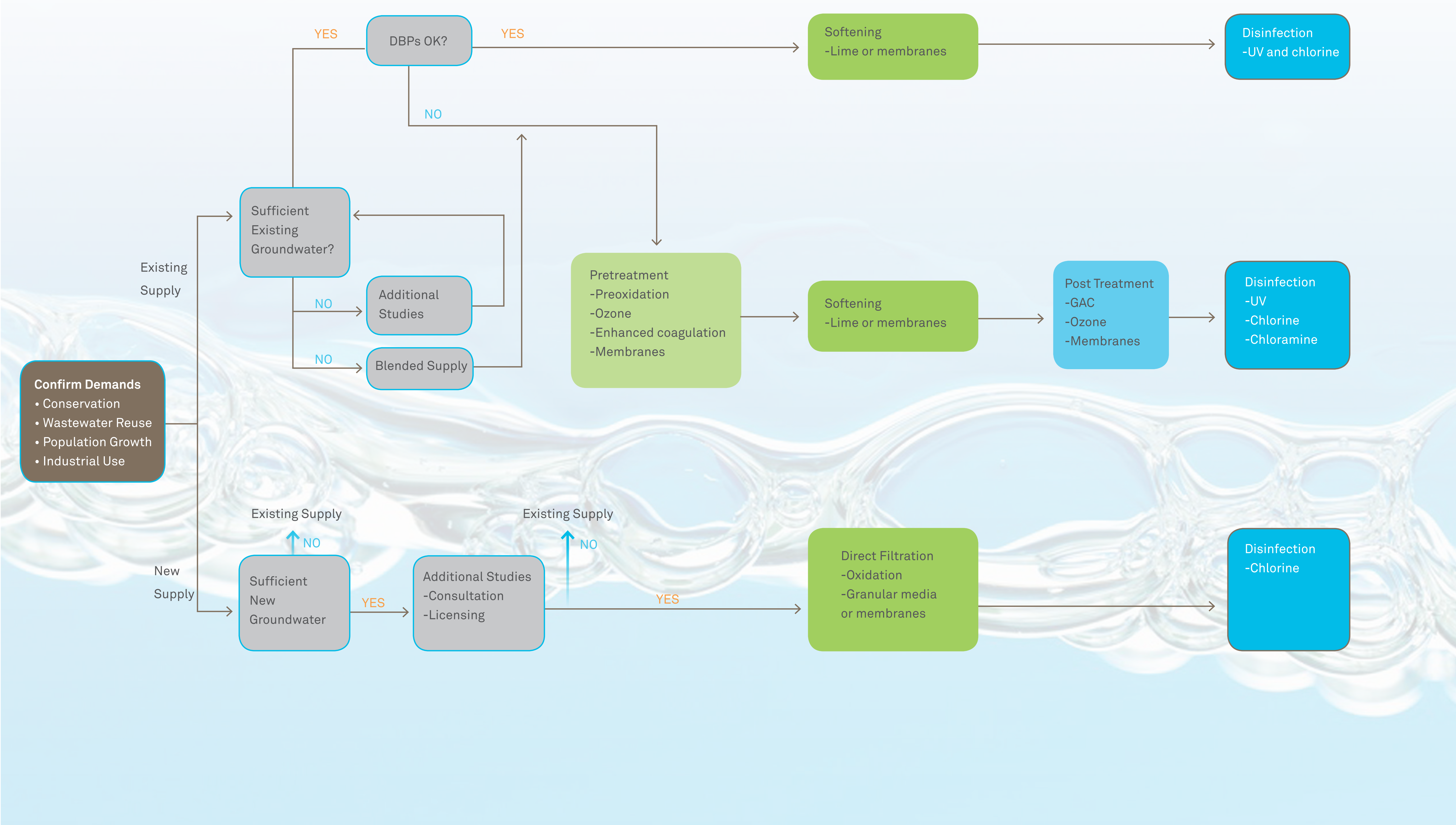
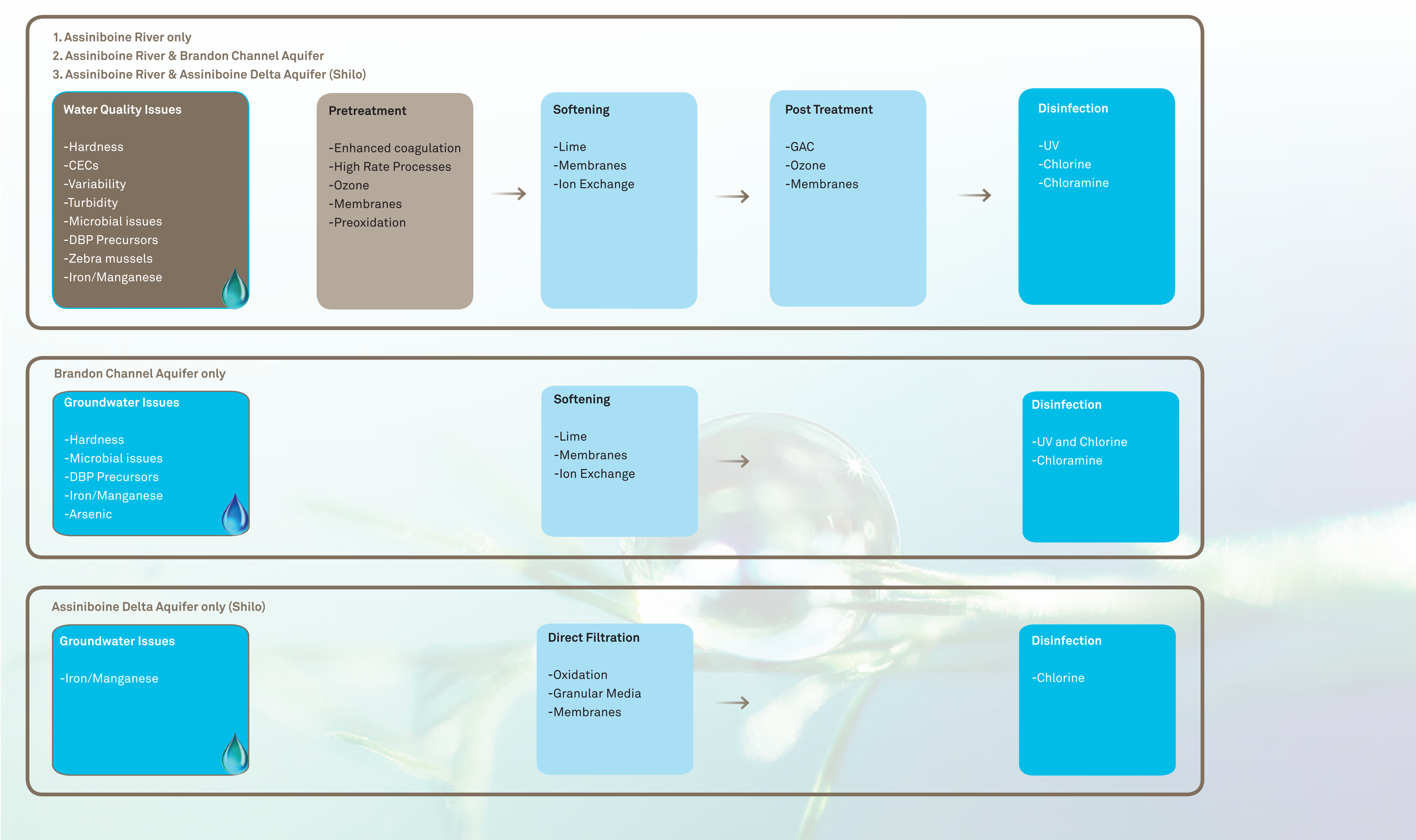


Figure 1.2 **Water Treatment Scenarios**



2. Overview

2.1 Triple Bottom Line (TBL)

The TBL model is a common and valuable instrument for assessing sustainability issues as it integrates the three classic pillars of sustainability - economical viability, environmental protection and social responsibility. In its broadest sense, TBL modeling embraces the set of interests, issues and processes that human activity should address in order to create economic, social and environmental value while at the same time minimizing undesirable consequences. The term triple bottom line was first coined by John Elkington in 1999 in his publication "*Cannibals with Forks: The Triple Bottom Line of 21st Century Business*".

The TBL model is also used in the private sector as a measure of corporate social responsibility (CSR) as a means of reporting environmental sustainability in its day-to-day activities.

At the local government level, the TBL model is widely used in the planning stages of environmental and water/wastewater programs and projects. Several Canadian municipalities have used this approach including; Regina, Saskatoon, Calgary, Vancouver and Toronto.

Although the TBL model is commonly used in local government to assist in decision-making, there is no defacto industry standard for applying the model. Melbourne Water has published a set of guidelines for applying a TBL framework for assessing project options. Guidelines have also been presented by the Cooperative Research Center for Catchment Hydrology for Urban Stormwater Management Measures to Improve Waterway Health (Taylor, 2005).

Notwithstanding the lack of a generally accepted industry standard, the TBL frameworks used at the local government level have several common features, including the use of multi-criteria analysis (MCA) and the method of weighted summation for scoring and ranking options.

2.1.1 Benefits of TBL

TBL assessment methodologies using multi-criteria analysis (MCA) can be used to determine which option, among a set of options, best meets a project's objectives, where these objectives incorporate financial, environmental and social elements. In some cases, these objectives can be clearly aligned with widely accepted objectives and principles for sustainable development, so that the assessment system can be used as a broad indicator of the relative progress of the various options towards the goal of sustainable development.

Potential benefits of using a TBL approach to evaluate among options include (Taylor, 2005):

- The framework can help to ensure an organization's visions, values and actions/projects are consistent with each other.
- The process can help to improve stakeholder relations through the use of open communication channels and participation techniques, as well as greater transparency and accountability.
- The process can help improve communication pathways within organizations by involving various functional groups or disciplines.
- The process can be designed to utilize and share the knowledge and views of technical experts as well as non-technical stakeholders, including the general public.

- The use of a TBL assessment process involving multi criteria analysis can assist with making more systematic, informed, holistic, participatory, transparent, multidisciplinary, defendable, socially acceptable, ecologically sustainable and cost-effective decisions.
- TBL assessment process can encourage innovation as new ideas are put forward in finding sustainable solutions.
- A TBL framework can allow ‘good governance’ by public organizations. Through their mandates in economic and social development, various agencies of the United Nations broadly recognize the characteristics of ‘good governance’ as participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follow the rule of law.

2.1.2 Limitations of TBL

The weaknesses that have been identified of the TBL assessment process relate to:

- The complexity that can be generated if many assessment criteria and/or stakeholders are involved.
- There is no guarantee of a ‘sustainable’ outcome.

The many benefits outweigh these limitations and the TBL assessment process is continually being used in decision-making.

3. Proposed Decision Making Framework

3.1 Proposed Approach

The proposed approach for the Master Plan is to generally follow the methodology as described in the Melbourne Water guidelines with the Multi-Criteria Analysis enhanced evaluation technique (Melbourne Water, 2007).

The proposed approach is presented in **Figure 3.1**. The steps of the process are outlined in sub-sections **3.1.1** to **3.1.3** that follow.

Figure 3.1: Proposed Decision-Making Process

3.1.1 Development of Options (Steps 1 to 3)

3.1.1.1 Step 1 - Problem Definition

The first step will be to identify the objectives and issues.

At the project kickoff meeting held on September 7, 2012 with the City, some ideas of a successful project outcome were discussed. Some of these items are as follows:

- Concerns about disinfection-by-products (DBPs).
- The desire to eliminate the hazards associated with using gaseous chlorine.
- The need to have a guaranteed water supply.
- Minimize risk of water supply contamination.
- Master plan shouldn't lose site of issue such as chemical storage and environmental protection.
- Concerns related to aging plant components/infrastructure and the impact on operation
- Proactive approach to standards and limits. Consideration should be given to future requirements (i.e., plant expandability and upgrade for future regulations).
- Consideration should be given to the impact of flooding and operations such as those experienced during the spring 2011 flood.

Since the project has progressed since the September 7, 2012 kickoff meeting and more information is known (i.e., code and condition assessment, water supply etc.), it is suggested that these items be reviewed at the next workshop and modified as needed.

3.1.1.2 Step 2 - Brainstorming

A long-list of potential alternative design concepts that could address the project objectives will be prepared.

3.1.1.3 Step 3 - Screening

A screening process will eliminate those technology options that would not be applicable, practical or feasible for Brandon. The long-list will be screened to remove those alternatives considered not feasible, based on a set of specific “must meet” criteria which defines the project requirements and constraints. If any single criterion is not met for an option, then that particular option will not be included in the list of options to be considered. Examples of these potential “must meet” criteria are presented in **Table 3.1**. Following the screening process, a maximum of four (4) options or as agreed to with the City, will be short-listed for further evaluation.

Table 3.1: Must Meet Criteria for Screening

Must Meet Criteria	
Financial	• Not cost prohibitive
Social	• Sustainable water supply
Environmental	Meets performance objectives for treated water (turbidity, THMs, hardness etc.).

3.1.2 Evaluation of Options (Steps 4 to 6)

3.1.2.1 Step 4 - Evaluation Criteria

A full range of evaluation criteria and their indicators will be established that reflect the full range of criteria within the TBL categories.

An example listing of criteria is presented in **Table 3.2**. The criteria will be developed with the involvement of the City of Brandon staff.

Table 3-2: Example TBL Criteria for Shortlisting

TBL Criteria	
Financial	• Minimize capital cost • Minimize O&M cost • Minimize cost for future expansion to meet more stringent regulatory requirements • Minimize dependence on commodities that are subject to market variability • Minimize loss of revenue from user fees • Maximize opportunities for grant funding
Social	• Minimizes risks associated with water supply • Consistent with City’s vision and policies • Protect public and operations staff health (minimize risk from air/other exposure during processing, handling, transportation and management) • Maximize quality of community life by minimizing traffic, community impacts during construction, minimize negative public opinion and

TBL Criteria	
	perception of risk. • Minimize loss of land for new facilities, compatible with existing land use, impact on property values
Environmental	• Meets performance objectives for treated water (turbidity, THMs, hardness etc.). • Ability to meet a higher treatment standard. • Minimizes risks associated with gaseous chlorine • Minimize risk associated with water supply contamination • Ease of future expansion • Minimize risks associated with flooding

3.1.2.2 Step 5 - Weighting

Each TBL category, as well as each criterion will be assigned a value weight that reflects the importance of that particular criterion relative to others and a net weight will be calculated. Determination of the net weight is illustrated in **Figure 3.2**.

Category	Weighting	Criteria	Weighting	Net Weight
Financial	F%	F-01	F1%	F% x F1%
		F-02	F2%	F% x F2%
		F-03	F3%	F% x F3%
		Σ	100%	
Environmental	E%	E-01	E1%	E% xE1%
		E-02	E2%	E% x E2%
		E-03	E3%	E% x E3%
		Σ	100%	
Social	S%	S-01	S1%	S% x S1%
		S-02	S2%	S% x S2%
		S-03	S3%	S% x S3%
		Σ	100%	
Σ	100%			

Figure 3.2: Determining Net Weighting

3.1.2.3 Step 6 - Scoring

Scores will be assigned to each alternative based on the technical, impact and cost information developed for each as well as the degree of risk and/or mitigation required. This information provides a technically sound basis for assigning a score for each criterion, specific to each alternative, on a comparative basis.

Scores will range from +4 to -4 and will assigned based on guidelines of Melbourne Water (2007) as presented below:

- +4 Very much better
- +3 Much better
- +2 Moderately better

- +1 Little better
- No change (same as existing WTP)
- -1 Little worse
- -2 Moderately worse
- -3 Much worse
- -4 Very much worse

The criteria and weighting will be used to develop a weighted score for each alternative design concept where the weighted score is calculated as follows:

Weighted Score = Score x Net Weighting

The score provides a quantitative comparison of one alternative to another. The total score is the sum of criteria categories.

Table 3.2: Example Model Input for Evaluation Step

Criteria Catergory	No.	Criteria Description	Net Weighting	Weighted Score		
				Option # 1	Option # 2	Option # 3
Financial	F-01	Capital Cost				
	F-02	O&M Cost				
	F-03	NPV of Life Cycle Cost				
	F-04	Minimize Dependency on Commodities that are Subject to Market Variability				
	F-05	Maximize Opportunities for External Funding				
Environmental	E-01	Footprint				
	E-02	Ability to Meet Future Drinking Water Requirements				
	E-03	Technology Demonstrated at Similar Scale				
	E-04	Maximize Beneficial Reuse				
	E-05	Maximize Substainable End Use				
Social	S-01	Traffic				
	S-02	Protect Public and Operations Staff Health				
	S-03	Maximize Quality of Community Life (Noise/Traffic Dust)				
	S-04	Disruption During Construction				
	S-05	Public & Stakeholder Acceptability				
	S-06	Consistent with City's Vision and Policies				
		TOTAL				

3.1.3 Selection of Option (Steps 7 to 9)

3.1.3.1 Step 7 - Ranking

The options will be ranked based on the total TBL score and assessed whether the results seem reasonable, based on past experience with similar projects.

3.1.3.2 Step 8 - Sensitivity Analysis

A sensitivity analysis will be carried out to determine the robustness of the evaluation methodology. The following scenarios will be evaluated to assess the sensitivity of the scoring to various scenarios:

- Using equal weightings on all criteria
- Full range of weightings expressed by stakeholders
- An emphasis on a specific category

3.1.3.3 Step 9 - Reporting

The decision-making process will be documented and the results of the process will be presented to the City.

3.2 Input Required from the City

The proposed Decision Making Framework requires the following input from the City at each step:

Step 1 - Problem Definition	Confirming objectives
Step 2 - Brainstorming	Reviewing and confirming long-list of alternatives prepared by AECOM is satisfactory
Step 3 - Screening	Confirming that the screening criteria and their application to the long-list is satisfactory
Step 4 - Evaluation Criteria	Identifying the criteria within each of the broad TBL categories that should be used in the analysis. AECOM will provide examples from other projects and a preliminary listing of criteria.
Step 5 - Weighting	Establish the weightings to be used in the MCA
Step 6 - Scoring	Reviewing the indicators and scoring system developed by AECOM
Steps 7, 8, 9	Reviewing the ranking, sensitivity analysis and reporting completed by AECOM

The key points in the Decision Making Framework where AECOM requires input from the City are at Step 4 (Evaluation Criteria) and Step 5 (Weighting). It is envisaged that the City will work with AECOM to develop the data to inform the Decision Making Framework.

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12. WPC Solutions Inc (2008). Final Report – City of Calgary Wastewater Treatment Master Plan Update.

Appendix D.

- **Population and Water Demand Projections Technical Memorandum**

The City of Brandon

Population and Water Demand Projections Technical Memorandum

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Project Number:

60275081.402

Date:

November, 2012

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AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

November 7, 2012

Patrick Pulak, P. Eng.
Deputy Director of Engineering Services & Water Resources
Development Services Division, Engineering Department
City of Brandon
P.O. Box 960 410 – 9th Street
Brandon, MB R7A 6A2

Dear Mr. Pulak:

Project No: 60275081

Regarding: Population and Water Demand Projections

AECOM is pleased to submit the Draft Population and Water Demand Projections Technical Memorandum. This Memorandum is a deliverable of the Background Information and Project Supply Phase for the City of Brandon Water Utility Master Plan project.

Sincerely,
AECOM Canada Ltd.

Keith Sears, Ph.D., P.Eng
Project Manager
Keith.Sears@aecom.com

KS:OVW:td
Encl.
cc:

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AECOM Signatures

Report Prepared By:				
		Owen Van Walleghem, P.Eng. Water/Wastewater Engineer		

Report Reviewed By:				
		Keith Sears, Ph.D., P.Eng Project Manager		

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1. Introduction

The main objective of this technical memorandum is to summarize available population and flow data from the City of Brandon to help develop water demand projections to be used in developing future water system design criteria. The key components of this technical memorandum are:

- Update population projections
- Review City planning/growth models
- Review water pumping and metering data
- Review water conservation program and outcomes
- Assess demand management programs
- Assess industrial demands and wastewater reuse options
- Develop range of possible water demands

2. Planning Horizon

The existing water treatment facilities in Brandon have generally served the City very well. At present, the plant is configured into 3 trains representing construction in 1946, 1958 and 1977. A number of smaller but significant upgrades to the plant have occurred in recent years and include the addition of UV disinfection and tube settlers in the clarifiers. Previous studies at the plant have identified several process/quality, safety and code related deficiencies that are to be addressed through the course of the Master Plan. Key short term drivers are the elevated disinfection byproducts in the distribution system, the continued use of gaseous chlorine and chemical storage/feed limitations. Over the life of this Master Plan, other drivers are also likely and must be addressed such as more stringent regulations and possible changes is water supply. The most significant such future issue is that of water supply; be it from the Assiniboine River, existing groundwater wells, new groundwater supplies or combinations thereof.

While the Master Plan will outline a process to address the City's water supply, treatment and distribution needs over the planning horizon, it must also specifically address the needs over the shorter term (<10 years). The near term horizon is a reflection of the major water supply decisions that will need to be made and that will significantly affect the ultimate water treatment configuration. Over this shorter term, some plant upgrades will have to proceed and will need to align with the population and water demand projections. More importantly, some of the existing infrastructure at the water treatment plant will be in need of replacement or major upgrade towards the end of this nearer term. This, in turn, will drive the need to make decisions on the longer term work at this juncture. It is at this point that major capital expenditures will be needed either at the existing plant or at a new location treating alternative raw water supplies. For the purpose of this Master Plan a planning horizon corresponding to the year 2035 has been selected. This maintains consistency between both the water and wastewater utility. A short term planning period of 10 years has been selected to address the needs over the shorter term.

In summary, there are two major milestones in this Master Plan – 2022 (short term) and 2035 (planning horzon). Population and demand forecasts have been compiled accordingly in the following sections."

3. Population Projections

The City of Brandon is the second largest city in Manitoba with a population of approximately 46,000 people. The area surrounding the City of Brandon is mostly comprised of farms and rural towns and villages. Population is commonly used in conjunction with other parameters like Industrial use as a basis for predicting water demand to be treated in the future. The City of Brandon has indicated that water planning, like wastewater planning, should be based on Statistics Canada published census reports instead of Brandon Regional Health Authority data.

Statistics Canada Census information dating back to 1941 is listed in **Table 1**. Historical population growth has varied from periods of significant growth (i.e, 1951-1975 average growth 2.3%) to periods of relatively little growth (i.e., 1975-2001 average growth 0.45%). Over the last 20 years the City has grown an annual average growth rate of 0.89%. One significant economic driver over the last 10 years has been the construction of the Maple Leaf Foods processing facility, which initially operated on a single shift from 1999 to 2007, and then increased production to the current double shift. Initial estimates outlined in the Rounds Report (1997) indicated that four spin off jobs would be created in the community for each person employed by Maple Leaf Foods.

The City of Brandon continues to be an attractive location for new businesses, however the growth of future commercial and industrial development is difficult to anticipate. The assumptions used in generating population projections and the resulting water demand will have a great impact on planning of the long term requirements for the City's utility infrastructure.

The City of Brandon currently uses a model that predicts growth to continue at 0.9%, a rate similar to that seen over the past 20 years. This is also the value that AECOM used for wastewater planning in the Phase III Wastewater Treatment Plant Upgrade. Furthermore, in discussions with the City they have indicated it is important to keep growth projections and design life between utilities consistent to avoid confusion, and to be flexible in the planning approach in the event economic conditions change. For the purpose of this Master Plan an average growth rate of 0.90% will be used, which will provide a comfortable basis on which to base long term planning of Brandon's water treatment infrastructure. To maintain consistency with the wastewater utility a design year of 2035 (23 years) has been selected as the planning horizon. This results in a population of 57,111 in the year 2035. This growth is illustrated in **Figure 1** and tabulated in **Table 1**.

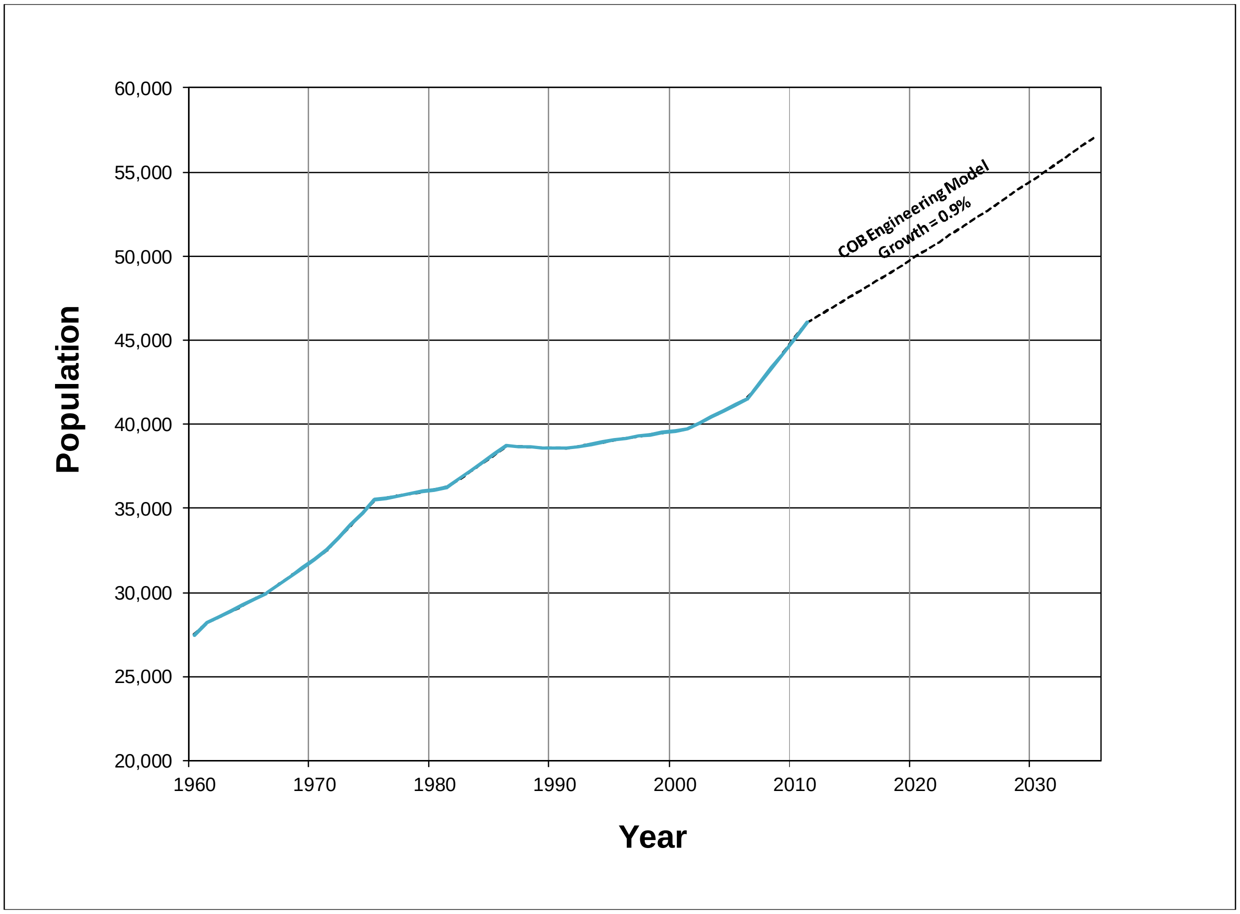

Figure 1: Historical Population and Predicted Growth

Table 1: Statistics Canada Census Populations and Project Future Population

Year	Population	Annual Percent Growth
1941	17,383	0.18
1951	20,598	1.85
1956	24,796	4.08
1960	28,166	2.72
1966	29,981	1.29
1971	32,500	1.68
1975	35,500	2.31
1981	36,242	0.35
1986	38,708	1.36
1991	38,567	-0.07
1996	39,175	0.32
2001	39,716	0.28
2006	41,511	0.9
2011	46,061	2.19
2022	**50,832**	**0.9 projected**
2035	**57,111**	**0.9 projected**

4. Review of Water Pumping and Metering Data

4.1 Raw Water System

The City of Brandon currently draws its water from two raw water sources; the Assiniboine River and the Assiniboine River Valley Aquifer (ARVA). The Assiniboine River is City's primary water source. Withdrawal from the river is governed by the Province of Manitoba, which allows the City to divert up to 14,808,000 m^3s annually at a maximum withdrawal rate of 0.59m^3/s [2].

The City's supplemental water supply comes from two wells that draw from the ARVA; the Turtle Crossing Park Well and the Canada Games Park Well. The Turtle Crossing Park well was constructed in 1996 and has an estimated capacity of 190 L/s. The Canada Games Park well was constructed in the same year, and has a slightly lower estimated capacity of 189 L/s [3]. These wells are primarily intended for emergency purposes.

Figure 2 illustrates the location of the water intake and the two supplementary wells relative to the water treatment facility.

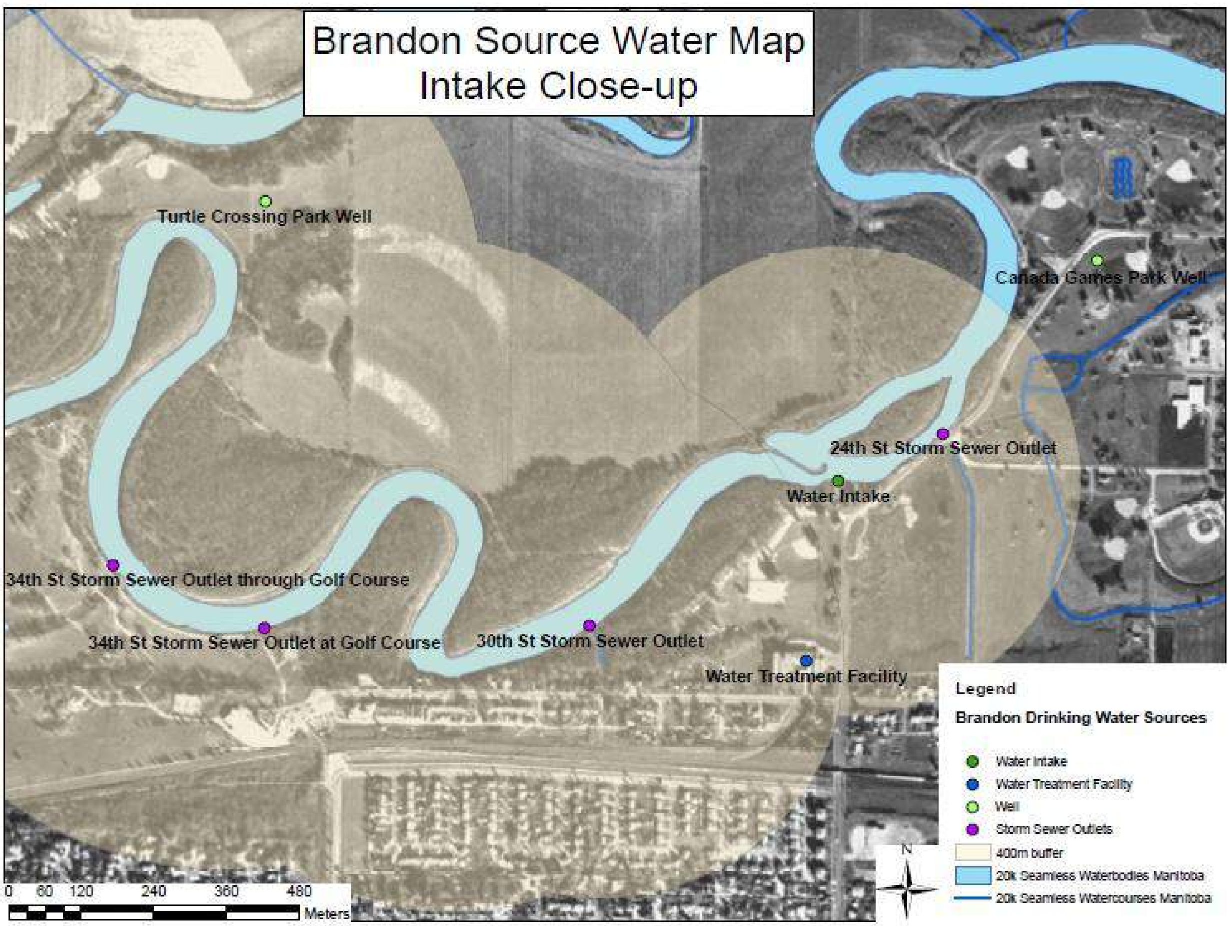

Figure 2: Brandon's Water Source Map

On average, the City's raw water consumption was relatively steady between 2000 and 2011. The average raw water use ranged between about 8,051,000 m^3 and 8,928,000 m^3 per year. Most years, all of this water was drawn from the Assiniboine River, with the exception of 2009 and 2011, when the raw water wells supplied 146,000 m^3 and

443,000 m^3, respectively. **Figure 3** illustrates the total raw water consumption by the City of Brandon between 2000 and 2011.

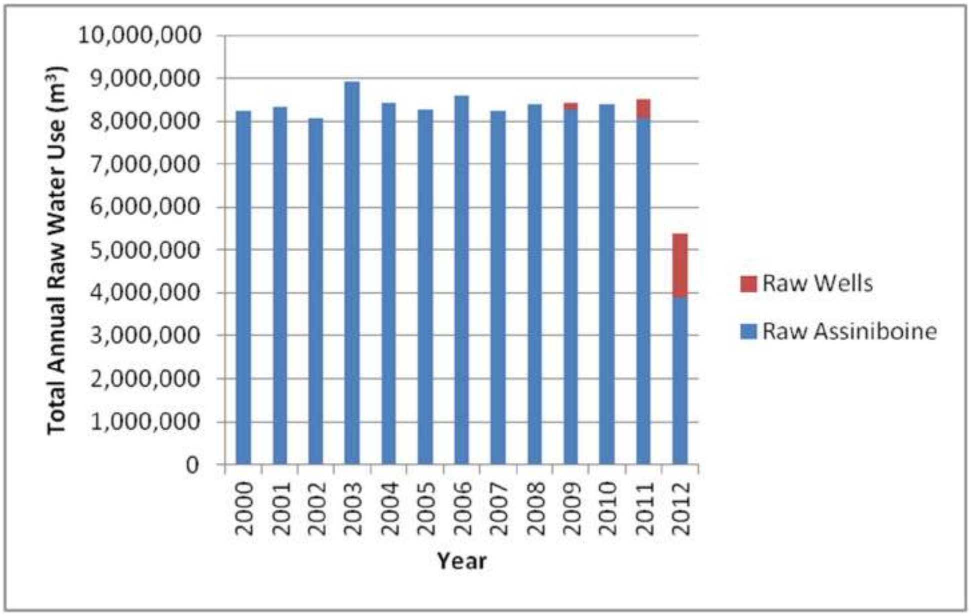

Figure 3: Raw Water Consumption [6]

The data in **Figure 3** only captures flows up to and including Aug. 22, 2012. The use of the raw water wells increased in 2013 because the City has begun blending groundwater into the river water in an effort to help reduce THMs. To date they have noted high recovery of the aquifer [136 m^3/hour (600 gpm) during dry periods and 272 m^3/hour (1200 gpm) during wet periods].

4.2 Distribution Pumping

The high lift pumps at the water treatment facility convey water to the distribution system and to the 9th Street Reservoir. At the reservoir, there are pumps which supply the main distribution system. There are also two transfer pumps inside the water plant that can pump directly to the reservoir, bypassing the distribution system. These pumps can also act as a backup for the high lift pumps. In addition, there are four booster stations located throughout the distribution system to help maintain constant water system pressure.

The average treated water use ranged between about 7,329,000 m^3 and 8,158,000 m^3 per year. This was mostly pumped to the system by the high lift pumps. In 2005, 2006, 2010 and 2011, the transfer pumps were also used. **Figure 3** illustrates the total treated water consumption by the City of Brandon between 2000 and 2011.

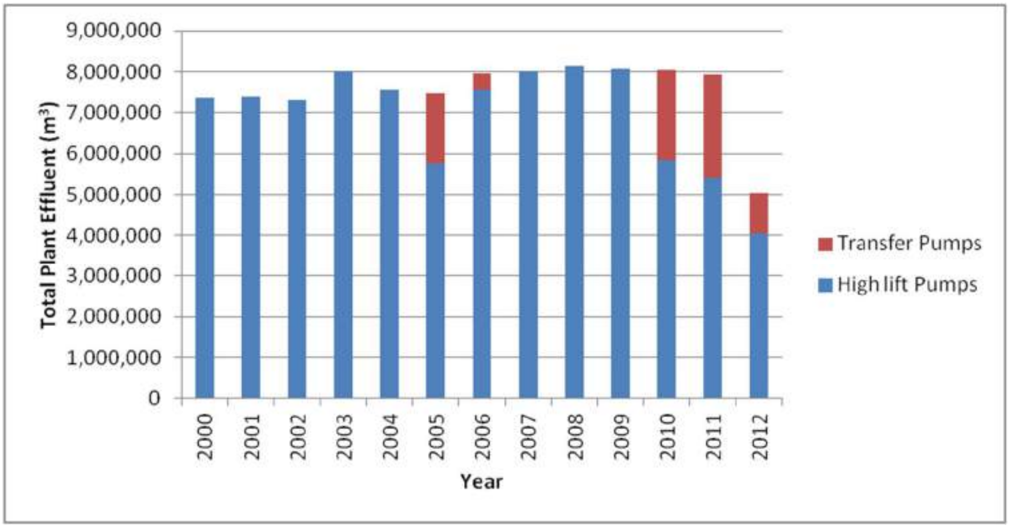

Figure 4: Treated Water Consumption [6]

The data in **Figure 4** only captures flows up to and including Aug. 22, 2012.

4.3 Max Day and Instantaneous Peaking Factors

To assist in assessing the various pumping and treatment systems, the relevant peeking factors should be evaluated.

Table 2 lists the calculated Average, Max and Peak instantaneous flows from the raw water and distribution systems from 2000 to 2012. Using these values, max day and peak instantaneous factors were determined.

Table 2: Average, Max, and Peak Instantaneous Flows and Factors

	Average Day Raw Water [m^3/day]	Max Day Raw Water [m^3/day]	Max Day Factor (Raw) [m^3/day]	Average Day Plant Effluent [m^3/day]	Max Day Plant Effluent [m^3/day]	Distribution Peak Instantaneous	Max Day Factor (Distribution) [m^3/day]	Peak Instantaneous Factor
2000	22.55	33.82	**1.50**	20.11	29.24	NA	**1.45**	NA
2001	22.84	31.96	**1.40**	20.24	30.46	NA	**1.51**	NA
2002	22.06	30.69	**1.39**	20.08	28.24	NA	**1.41**	NA
2003	24.46	39.60	**1.62**	21.98	33.96	NA	**1.54**	NA
2004	23.00	30.62	**1.33**	20.67	28.66	47.50	**1.39**	**2.30**
2005	22.65	29.02	**1.28**	20.47	33.27	55.29	**1.63**	**2.70**
2006	23.54	37.21	**1.58**	21.83	33.83	65.06	**1.55**	**2.98**
2007	22.59	31.71	**1.40**	21.92	30.08	70.43	**1.37**	**3.21**
2008	22.90	30.72	**1.34**	22.29	29.50	64.72	**1.32**	**2.90**
2009	23.10	31.37	**1.36**	22.10	29.11	68.58	**1.32**	**3.10**
2010	23.03	30.97	**1.34**	22.00	30.13	74.99	**1.37**	**3.41**
2011	23.33	47.95	**2.06**	21.71	32.70	53.66	**1.51**	**2.47**
2012	22.86	38.82	**1.70**	21.40	31.51	52.36	**1.47**	**2.45**

Notes:
NA = Not Available
In Table 2, the 2012 values only represent data up to Aug 22, 2012.

4.3.1 Maximum Day Peaking Factor

The size of the raw water system and treatment system should be based on the expected maximum average day peaking factor. **Figure 5** illustrates the daily raw water consumption and **Figure 6** illustrates the daily effluent from the water treatment plant recorded between January 1, 2000 and August 22, 2012.

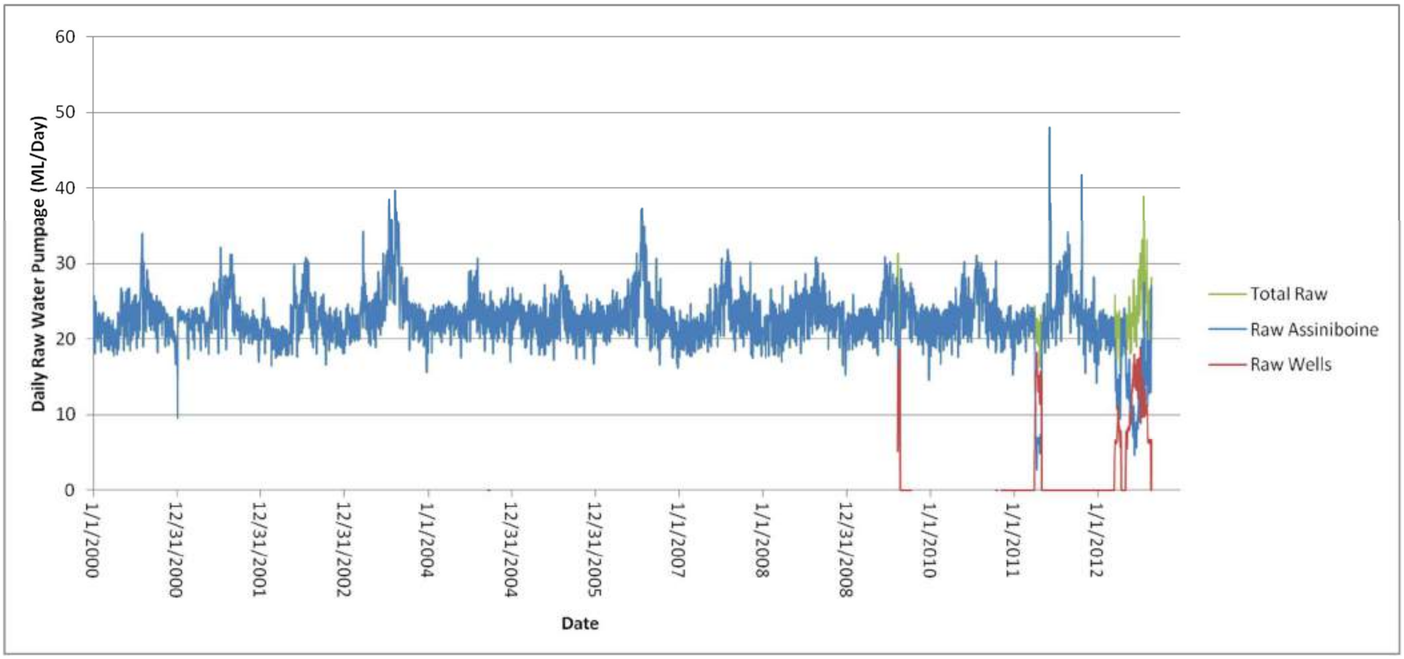

Figure 5: Daily Raw Water Consumption [6]

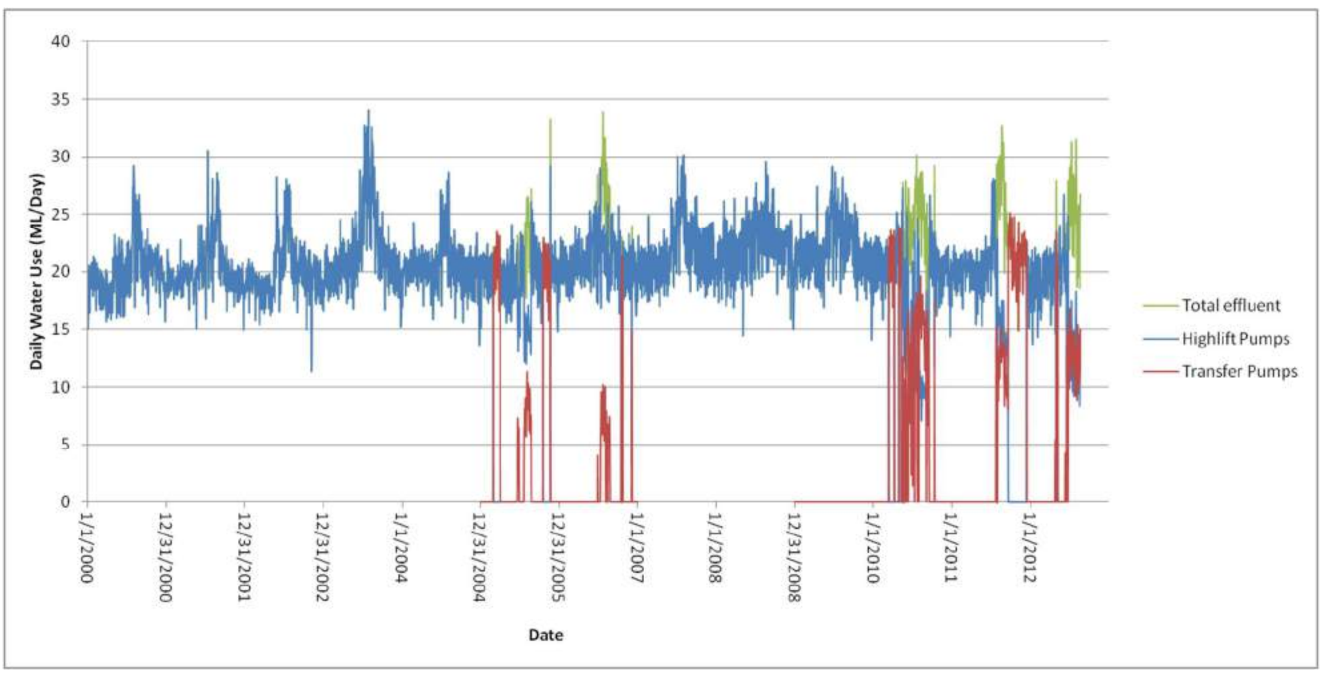

Figure 6: Daily Water Treatment Plant Effluent [6]

In 2011, three instances of high raw water consumption were recorded, however they do not appear to be consistent with trends noted in any previous year, and were thus discounted from the analysis. Therefore, the highest max day peaking factor noted in the raw water analysis was 1.7 in 2012. In the treated water, the highest max day peaking factor found was 1.63. Therefore, the raw water max day peaking factor of 1.7 will be used as the max day peaking factor for the system.

4.3.2 Maximum Instantaneous Peaking Factor

The maximum instantaneous peaking factor is useful in sizing the distribution pumping system, to help ensure that water can be supplied to the distribution system as needed during high flow events such as fires and watermain breaks. **Figure 7** illustrates the recorded distribution system instantaneous demands from when they began recording this parameter on Sept 14, 2004, up to August 22, 2012. During that time, the highest instantaneous peaking factor recorded was about 3.41.

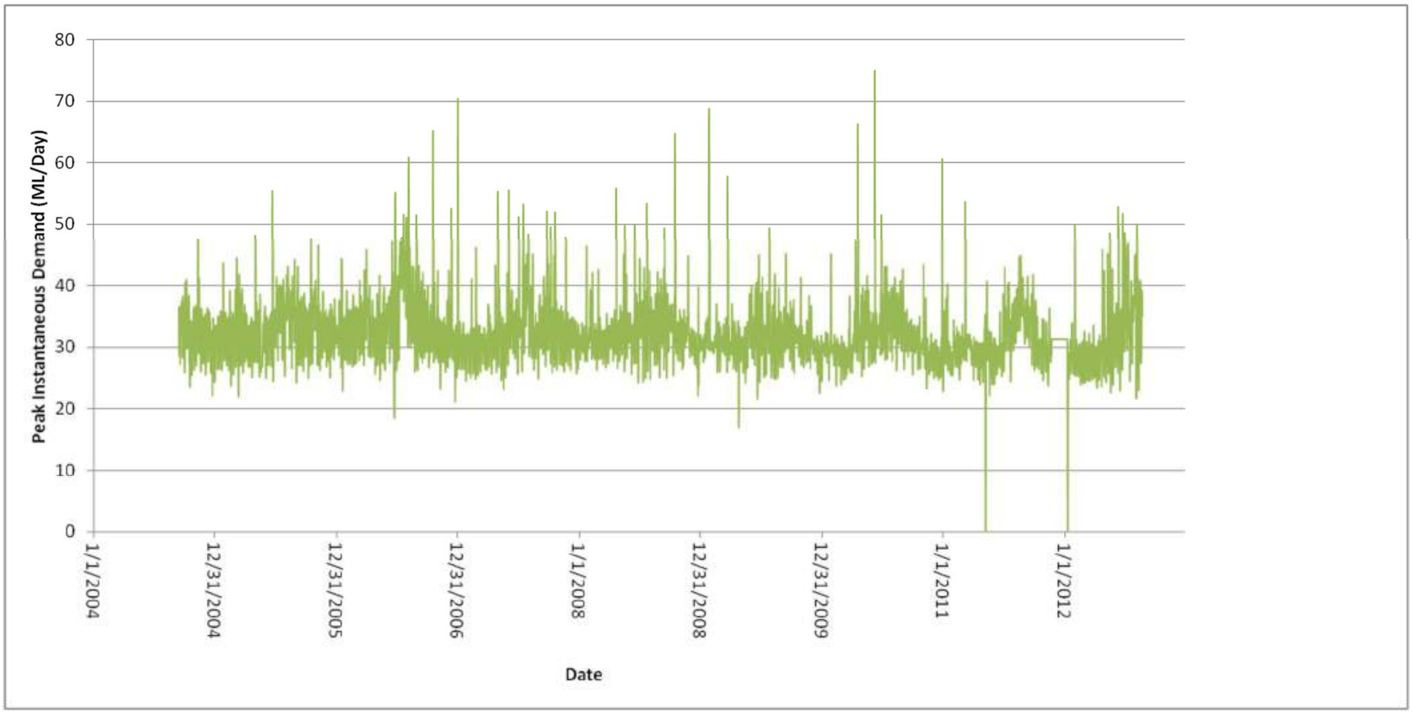

Figure 7: Distribution Peak Instantaneous Demand [6]

5. Review of Water Conservation Program and Outcomes

The City of Brandon has taken a proactive approach to reduce water consumption at both the community and corporate levels. As noted in Section 4 above, the City's water use was remained relatively constant over the past decade, despite a significant increase in population. This is a direct result of the City's efforts to manage water use.

The City has put together a draft Water Conservation Plan with the two main objectives being water conservation and water supply protection. The ultimate target of the program is to continue to reduce per capita water consumption by 10% every 10 years over a 30 year period

To meet this target, the City identified three main priorities:

1. Water Supply

Quality and quantity of water may be jeopardized by the predicted population expansion and by impacts on the City's main source of water, the Assiniboine River.

2. Infrastructure

Responsible water use to allow for fiscal planning for improvement and replacement of existing infrastructure.

3. Engagement of Stakeholders

Proactive partnerships between the city, individual citizens, community groups, businesses and industry to reduce the consumption of treated water for use in non-potable applications will be essential in overall water conservation.

The City has implemented a number of water management and conservation initiatives in recent years. The following is a list of actions that the City plans on implementing to continue building on the success of their water management program:

- **Within City operations**
  - Perform a water audit within municipal buildings
  - Incorporate monitoring water accounts into employee responsibilities
  - Install water recovery infrastructure in spray parks to water flowers
  - Purchase hanging basket reservoirs for all city hanging baskets
  - Educating staff
  - Install Low Flow fixtures in city buildings
  - Have City Departments accountable for water usage
- **Within the community**
  - Explore opportunities for grey water recovery systems
  - Promote residential holding tanks for sump pump water
  - Develop a public engagement campaign
  - Promote installation of low flow toilets
  - Promote the use of rain barrels and water saving appliances/devices
- **In the distribution system**
  - Continue an annual leak audit and sewer inspection program
  - Check backflow devices and check valves at service connections
  - Issue meter boxes to contractors
  - Complete frozen tap program within the next 5 years

- Upgrade leak detection equipment
- Upgrade water meter software
- Install cathodic protection
- Flush water pipes in problem areas of the city
- Research liner protection in problem areas of the city

5.1 Assessment of Demand Management Programs, Industrial Demands and Wastewater Reuse Options

The City supplies treated water to large companies such as Maple Leaf Foods. There are two post-secondary institutions in the City and the Brandon School Division operates fourteen schools. The City of Brandon as an organization has 12 municipal buildings and employs over 600. To date, the City of Brandon has seen improvements in water consumption resulting directly from their water conservation program.

> "Over the last eight years Brandon has been actively promoting conservation initiatives. Between 2004 and 2011 residential use decreased by 0.6%, commercial decreased by 31%, industrial increased by 45%, federal/provincial use decreased by 9.2%, municipal use decreased by 8.1%, school use decreased by 12% and church use decreased by 25%." [5]"

Figure 8 illustrates how the metered water consumption has held steady overall in recent years despite an increase in population and an increase in industrial water use of over 45%.

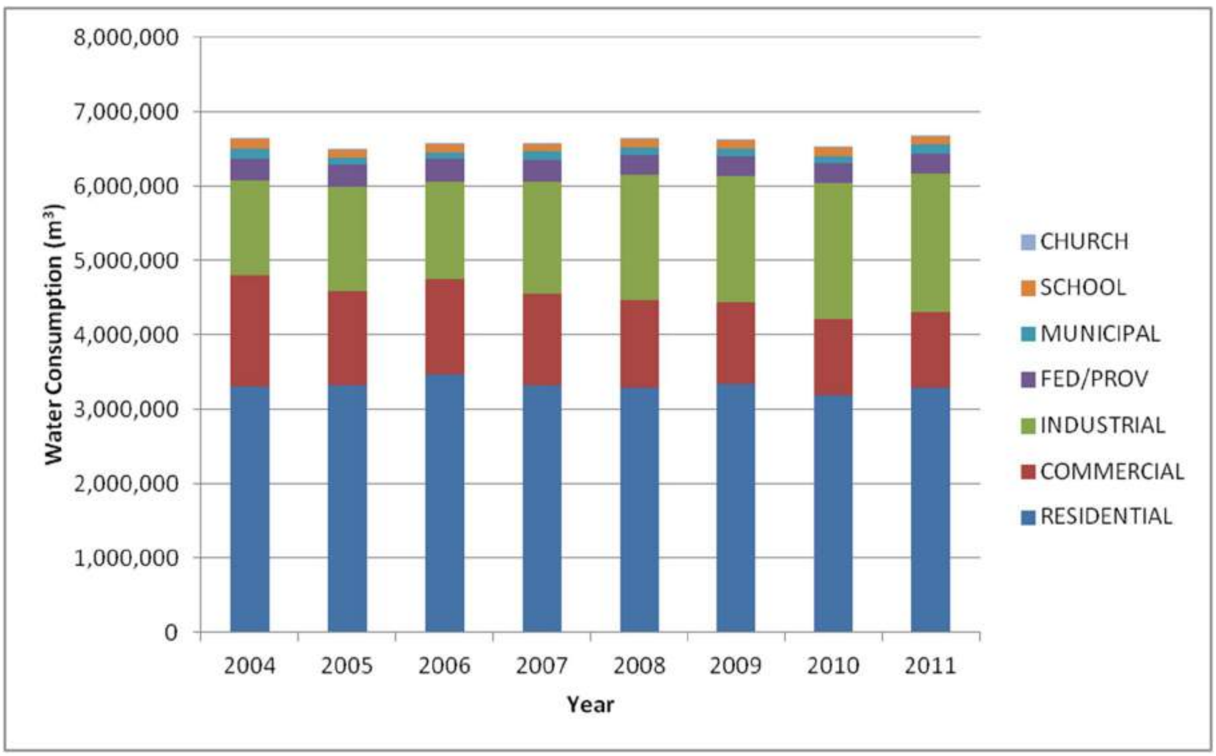

Figure 8: Metered Water Consumption from the City of Brandon [5]

In addition to the metered water consumption, the City also tracks unaccounted for water loss, which is estimated as the difference between the total water produced and the total water accounted for (which includes metered water plus estimations based water uses such as hydrant use, water main breaks, Parks and Recreation use, etc.). This value is typically between 12% and 15% of the total water produced.

5.2 Possible Water Demand Ranges

Water demand ranges are difficult to predict as they can vary year to year based on a number of factors, including changes in population, industry, weather or condition of distribution system. A simplified approach is to compare the water demand with the City's population for a number of years, and use this per capita consumption estimate to project potential future demands.

5.3 Effects of Industry

As discussed briefly in Section 5.1, industry is one of the largest and fastest growing sources of water consumption in the community. Maple Leaf Foods accounts for more than 93% of the City's industrial water consumption each year, on average, and their consumption has steadily increased.

Table 3: Industrial Water Consumption

Year	Total Water Annual Water Consumption (m3)	Maple Leaf Foods [m^3]	Total Industrial Consumption [m^3]	Total Industrial Consumption as % of Total Consumption
2001	7,407,966	1,076,551	NA	NA
2002	7,328,586	1,161,552	NA	NA
2003	8,023,443	1,318,555	NA	NA
2004	7,564,047	1,205,541	1,286,428	17.0 %
2005	7,472,638	1,333,172	1,417,799	19.0 %
2006	7,967,166	1,225,029	1,304,796	16.4 %
2007	8,001,118	1,365,577	1,493,598	18.7 %
2008	8,158,470	1,572,456	1,683,173	20.6 %
2009	8,068,168	1,604,453	1,703,537	21.1 %
2010	8,028,436	1,721,084	1,837,166	22.9 %
2011	7,925,070	1,740,495	1,864,270	23.5 %

NA=Not available

Other large industrial water consumers include Koch Fertilizer and Pfizer Canada, which account for another 6% of the industrial demand. Because these contributions are so small relative to Maple Leaf, only the effects of Maple Leaf's consumption will be discussed herein.

Table 3 shows that Maple Leaf's consumption has been increasing, whereas consumption from other users has been decreasing. These trends, in conjunction with the fact that Maple Leaf currently consumes about 23.5% of the water produced by the water treatment plant indicates that if Maple Leaf were to ever shut down production, there would be major implications to the water treatment system.

Table 4 outlines per capita consumption rates based on the population data and the consumption data provided by the City. **Table 4** also lists the difference in per capita rates when Maple Leaf's consumption is removed.

Table 4: Estimated Per Capita Consumptions

Year	Population	Per Capita Consumption, Raw (L/Day)	Per Capita Consumption, Treated (L/Day)	Per Capita Consumption, Treated (without Maple Leaf) (L/Day)
2001	39,716	575	510	435
2006	41,511	567	526	445
2011	46,061	507	471	368

The *City of Brandon Water Conservation Plan* indicates that the City will be targeting a 10% reduction in per capita consumption every 10 years over a 30-year period based on the total current water use, including Maple Leaf. Based on the various population projections from Section 3, along with the estimated per capita water consumptions, **Figure 9** provides possible scenarios for future water demand.

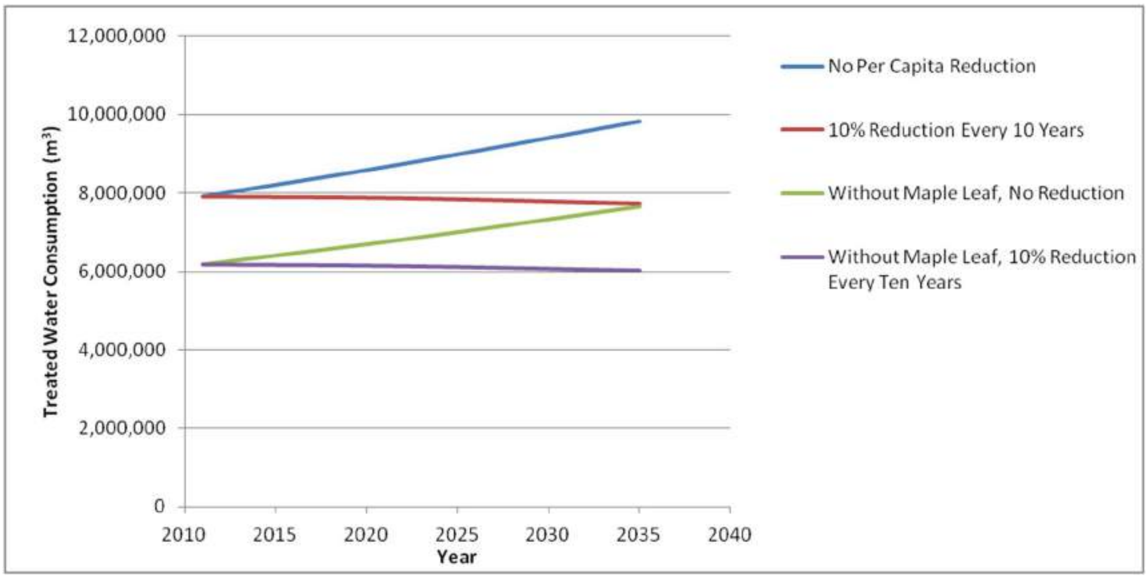

Figure 9: Estimated Future Treated Water Consumption

Figure 9 assumes that Maple Leaf consumption remains steady while the population grows. **Figure 9** also takes into account what the estimated future water consumption would most likely be if Maple Leaf were to leave the community. This is an unlikely scenario, but one that would have a large impact on the system if it were to happen.

6. Recommendations

Table 5 outlines AECOM's recommendations for future water system design parameters based on the population and flow data provided, as well as the anticipated trends in future City growth and water use.

Table 5: Design Values

Parameter	Value
2022 Population	**50,832**
2035 Population	**57,111**
Average Day, Maple Leaf 2022 [m^3/day]	4769
Average Day, Community 2022 [m^3/day]	18,699
Average Day, Total 2022 [m^3/day]	**23,468**
Average Day, Maple Leaf 2035 [m^3/day]	4769
Average Day, Community 2035 [m^3/day]	21,009
Average Day, Total 2035 [m^3/day]	**25,777**
Maximum Day Peaking Factor	**1.7**
Instantaneous Peaking Factor	**3.4**

Assumptions:

- The City expects to see an average annual population increase of 0.9%
- The more conservative value consumption values are anticipated (i.e. no decrease in per capita use year over year)
- Maple Leaf's consumption will not continue to increase beyond 2011 levels.
- System load conditions will remain consistent, therefore historical peaking factors will apply in the future.

7. Additional Resources Requested

To further develop these projections, AECOM requests that copies of the following documents referenced in the *City of Brandon Water Conservation Plan* be provided:

- Assiniboine River Water Demand Study
- Brandon's Community Strategic Plan
- Brandon's Water Supply Review -KGS
- Brandon's Integrated Water Sourcing Plan-KGS
- Brandon's Water Efficiency Plan
- Brandon's Water Supply Annual Report
- Environmental Strategic plan
- Water Efficiency Report

8. References

The following documents provided by the City of Brandon were referenced in the preparation of this technical memorandum:

[1] *2010 Brandon Growth Summary*, The City of Brandon, Brandon, Manitoba, 2010.

[2] *Table 3: Population Counts for Manitoba Census Subdivisions, 2011 Census – 100% Data, Statistics Canada 2011 Census*, Statistics Canada, Ottawa, Ontario, February 8, 2012.

[3] *Population of Brandon RHA, June 1, 2011*, Manitoba Health, Winnipeg, Manitoba. June 1, 2011.

[4] *Report for Water Treatment Facility: New Intake Conceptual Design Report*, CH2M HILL, Winnipeg, Manitoba, 2012.

[5] *City of Brandon Water Conservation Plan (Draft)*, Author L. Hargreaves, Engineering Services & Water Resources, Brandon, Manitoba, September 2012.

[6] *City of Brandon ACCECC Database Inputs, Pumpages 2000 to Aug 2012*, Excel spreadsheet file.

Appendix E.

- **Regulatory Requirements Technical Memorandum**

City of Brandon

Regulatory Requirements – Draft

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Project Number:

60275081

Date:

November, 2012

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AECOM: 2012-01-06

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

November 23, 2012

Patrick Pulak, P. Eng.
Deputy Director of Engineering Services & Water Resources
Development Services Division, Engineering Department
City of Brandon
P.O. Box 960 410 – 9th Street

Dear Mr. Pulak:

Project No: 60275081

Regarding: Regulatory Requirements Report - Draft

AECOM is pleased to submit the Draft Technical Memorandum on the Regulatory Requirements for the Water Treatment Plant. This Memorandum is a deliverable of the Water Utility Master Plan. We look forward to meeting with you to discuss this memorandum and addressing any comments you may have.

Sincerely,
AECOM Canada Ltd.

Keith Sears, Ph.D., P.Eng.
Project Manager
Keith.Sears@aecom.com

KS:CU:td
Encl.
cc:

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AECOM Signatures

Report Prepared By:

Charlie Ulloa, E.I.T., M.A.Sc.
Process Engineer in Training

Report Prepared By:

Keith Sears, Ph.D., P.Eng.
Project Manager

Report Reviewed By:

Ray Bilevicius, MSc., P.Eng.
Associate Vice-President

Executive Summary

Drinking water quality in Manitoba is regulated at the provincial level through the *Drinking Water Safety Act*, which is in turn affected by federal and international policy. Manitoba drinking water quality standards are periodically updated to address health risks caused by contaminants in the water supply.

A review of current water quality criteria in relevant worldwide jurisdictions was conducted in order to assess potential changes to drinking water quality criteria used in Manitoba. Of the comparable worldwide regulations, boron, cyanide, *n*-nitrosodimethylamine, nitrite, dichloromethane and vinyl chloride appear to be potential candidates for stricter regulations in Manitoba water supplies. The criteria on dichlormethane is of particular concern given the current water treatment plant's past difficulty with addressing trihalomethane formation. Currently, water quality criteria for vinyl chloride and for waterborne bacterial pathogens are being reviewed by the Federal-Territorial-Provincial Committee of Drinking Water.

Several water quality criteria were addressed in other jurisdictions for which there is no equivalent in the federal *Guidelines for Canadian Drinking Water Quality*. A compound of particular interest is acrylamide, which presents a risk to human health and is present as a by-product of some coagulation processes during water treatment.

Research in other jurisdictions regarding the presence of pharmaceuticals, endocrine-disrupting compounds and perchlorate may also be the subject of research in Canadian water supplies in the future. The presence of pesticides in Manitoba source water may be the target of future regulations, given their presence in surface waters and the absence of any recommended treatment criteria.

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1. Introduction

Drinking water quality in Manitoba is regulated at the provincial level through the *Drinking Water Safety Act*, which is in turn affected by federal and international policy. Manitoba drinking water quality standards are periodically updated to address health risks caused by contaminants in the water supply.

Due to an increasing awareness of water quality issues around the world, Canada and many other countries are reviewing and revising their drinking water standards. As measurement techniques and treatment technologies are advanced and new public health issues are identified, it is anticipated that the number of regulated contaminants will increase and the allowable maximum concentration of contaminant levels in the finished water will decrease. Given the large amount of regulations already in place, regulatory agencies across the world have started to categorize contaminants based on their chemical characteristics to help address target their treatment techniques.

Historically, changes in Canadian drinking water guidelines have followed changes in the drinking water regulations in the United States, which are defined and administered by the United States Environmental Protection Agency (USEPA). Accordingly, many of the anticipated changes in the Canadian guidelines are based on changes in place and predicted for the United States. Additional regulatory agencies, such as the United Kingdom's Drinking Water Directorate, the European Union's Commission and the World Health Organization (WHO), should also be reviewed to determine growing water quality concerns worldwide.

The lifecycle of the City of Brandon's water treatment plant (WTP) upgrade is expected to address water quality concerns for the next twenty years. Therefore, the design criteria for the WTP should be such that future upgrades and modifications of the WTP can be completed efficiently.

In this technical memorandum, we will provide a review of current and possible future water quality regulations and recommend water quality objectives for the basis of WTP upgrades. We will also identify possible approaches towards meeting more stringent goals in the future. This will ensure the WTP upgrades will proceed on the basis of fully supportable and defendable water quality goals.

2. Water Quality Management in Manitoba

2.1 Federal Regulations

The *Canada Water Act* provides a forum between the federal and provincial governments to evaluate the management of water resources. This legislation makes clear that provincial governments have the authority to manage their respective water supplies, including drinking water quality, while the federal government has jurisdiction over boundary waters and international water agreements.

Despite the self-regulation of provincial water supplies, several intergovernmental organizations have developed water quality guidelines that are used as standards throughout Canada.

- The Federal-Provincial-Territorial Committee on Drinking Water (CDW) has created the *Guidelines for Canadian Drinking Water Quality* (GCDWQ). These guidelines are an important document on which most provincial water quality objectives are based.
- The Canadian Council of Ministers of the Environment works together with the CDW to develop policies on drinking water safety and water management.

2.2 Interprovincial Agreements

Interprovincial agreements have been made between the governments of Alberta, Manitoba and Saskatchewan to manage the water resources that extend across the prairies. The Prairie Provinces Water Board regulates these water resources, which includes monitoring the water quality across the region to protect the treatability of potable water. Water quality standards must follow the most conservative standard in cases where there is an overlap in two provincial regulations for the same body of water.

Interprovincial agreements are not expected to influence the water quality criteria of the Brandon WTP, as they would usually apply to discharges to the environment.

2.3 Provincial Regulations

In Manitoba, the water quality standards are dictated by the *Drinking Water Safety Act* and its corresponding regulations.

- The *Drinking Water Safety Act* dictates the construction and licencing procedures for water distribution systems. The Act also allows from the creation of an Office of Drinking Water to regulate the treatment and use of potable water.
- The *Drinking Water Quality Standards Regulation* defines the biological, chemical, physical and radiological standards for potable water based on the GCDWQ.
- The *Drinking Water Safety Regulation* dictates the testing procedures and monitoring requirements for water distribution systems.

Additional Provincial legislation used to protect potable water includes:

- The *Environment Act*, which dictates that development projects must comply with the *Drinking Water Safety Act*.
- The *Water Supplies Regulation* under the *Public Health Act*, which dictates the use of water sources.
- The *Water and Wastewater Facility Operators Regulation* under the provincial *Environment Act*, which dictates the training and duties of water treatment facility operators.

As stated in the *Canada Water Act*, the regulation of potable water in Manitoba is the responsibility of province. The water quality standards of potable water in Manitoba are largely determined by the *Drinking Water Quality Standards Regulation*.

2.4 Water Quality Objectives in Manitoba

Different water quality regulations exist depending on whether the water supply is used for human consumption, recreational use, irrigation, etc. The most stringent criteria tend to apply to water used for human consumption.

Public water suppliers must abide by the criteria given in the provincial *Drinking Water Quality Regulations*, which makes the water quality criteria set out in the GCDWQ as legally enforceable standards. These criteria are separated into the following three categories:

- Maximum Acceptable Concentrations (MAC) are limits to which a contaminant may be present in a water supply before posing a significant risk to human consumption.
- Aesthetic Objectives (AO) are concentration limits on contaminants that do not pose an immediate threat to public health, yet influence the public's perception of their water supply.
- Operation Guidance (OG) targets apply when specific water treatment processes are used which may affect overall water quality, such as the use of aluminum-based coagulants.

Province-specific water quality criteria are also included in the *Drinking Water Quality Regulations*. In instances where a water quality target is stated in both the provincial regulations and the GCDWQ, the provincial regulations will prevail. It should be noted that the water quality targets dictated in the *Drinking Water Quality Standards Regulation* are nearly identical to those stated in the GCDWQ with the exception of the criteria based on bromodichloromethane contamination, which is not directly covered in the GCDWQ.

The provincial regulations make a distinction in water quality criteria for surface water, groundwater and groundwater under the direct influence of surface water (GUDI).

3. Parameters of Concern

Health Canada, which manages the Federal-Territorial-Provincial CDW, periodically reviews water quality guidelines and management principles in consultation with other international organizations such as the USEPA and WHO. Health Canada is also recognized as a WHO/Pan American Health Organization Collaborating Centre for Water Quality, and shares data with the WHO and USEPA regarding water quality research.

The CDW also conducts public consultations in Canada for determining the health effects of various contaminants in drinking water and is currently reviewing health-based measures regarding vinyl chloride and waterborne bacterial pathogens. This report will compare water quality criteria and pending research from the following organizations to determine future water quality regulations:

- The WHO;
- The European Commission (EC);
- The United Kingdom's Drinking Water Inspectorate (UK DWI);
- The USEPA; and
- The pertinent regulatory agencies of Alberta, Saskatchewan and Ontario.

3.1 Physical and Chemical Parameters

As regulations become more stringent worldwide, there has also been a push towards categorizing contaminants into chemical subgroups to aid in future guidance recommendations. Currently, the GCDWQ categorizes water quality criteria into the following subgroups:

- Inorganic parameters;
- Organic parameters;
- Disinfectant parameters;
- Disinfectant by-products parameters;
- Treatment-related parameters; and
- Aesthetic parameters.

Comparison of water quality criteria from various international jurisdictions was based on the grouping detailed above. Most aesthetic objectives were compared alongside the other health-base parameters. While often not presenting an immediate hazard to human health, the odour and taste thresholds for these compounds can be several orders of magnitude smaller than the health-based guidelines. The EC and the UK DWI also use an extensive secondary set of water quality criteria known as “indicator” parameters, which, when exceeded, determine whether further investigation into the quality of a water source is required.

3.2 Microbiological Parameters

Depending on the type of filtration and disinfection that is used in a water treatment system, various microbiological standards will apply to the fully treated water. Based on the type of filtration, turbidity standards will be closely related to the overall microbial standards as this parameter helps infer the effectiveness of various disinfection processes.

3.3 Radiological Parameters

Radiological standards are used to determine whether a water source is emitting an acceptable level of radiation that poses no direct threat to human health. Most radiological standards are based on the total dose of radiation given by water sample, measured in millisieverts per year. By setting a standard to an acceptable level of radiation caused by water consumption, concentration limits on radionuclides can be determined based on radioactive decay.

Some jurisdictions only use radiological parameters as a indicators of overall water quality, whereas others have legally enforceable regulations based on acceptable concentrations.

4. Current Brandon Raw Water Quality

An assessment on the City of Brandon's raw water quality coming into the plant from the Assiniboine River, the Canada Games Park well and the Turtle Crossing Park well was compared to the current GCDWQ. The results from this assessment can be found in **Table 4.1**. Values in bold indicate parameters which exceed the GCDWQ. Average values do not include non-detectable results.

Table 4.1: Main Raw Water Source Characteristics (2006 – 2012)

Parameter	Unit	Assiniboine River			Canada Games Park Well			Turtle Crossing Park Well			GCDWQ
		Min	Max	Ave.	Min	Max	Ave.	Min	Max	Ave.	
Inorganic Parameters											
Aluminum	mg/L	**0.13**	**14.7**	**1.87**	**< 0.0050**	**0.12**	**0.05**	**< 0.005**	**0.20**	**0.08**	O.G. ≤ 0.1
Antimony	mg/L	< 0.00020	0.003	0.001	< 0.00020	0.001	0.001	< 0.001	0.002	0.001	0.006
Arsenic	mg/L	0.0031	**0.0206**	0.0060	0.0245	0.0338	0.0280	0.0228	0.0279	0.0251	0.01
Barium	mg/L	0.0414	0.192	0.074	0.021	0.025	0.023	0.022	0.027	0.024	1
Boron	mg/L	0.08	0.23	0.14	0.09	0.41	0.32	0.11	0.39	0.16	5
Cadmium	mg/L	< 0.00020	0.0011	0.0002	< 0.00001	0.0005	0.0002		< 0.0002		0.005
Chromium	mg/L	< 0.0010	0.019	0.004	< 0.0010	0.006	0.006	< 0.0010			0.05
Copper	mg/L	< 0.001	0.015	0.005	< 0.001	0.016	0.004	< 0.001	0.003	0.002	A.O 1.0
Cyanide	mg/L					< 0.0020		< 0.0020	0.000	0.000	0.2
Fluoride	mg/L	< 0.50	0.4	0.24	< 0.10	0.40	0.25	< 0.50	0.40	0.28	1.5
Iron	mg/L	0.17	**13.4**	**1.90**	**1.72**	**3.24**	**2.17**	**1.77**	**3.39**	**2.72**	A.O. ≤ 0.3
Lead	mg/L	< 0.00050	0.0074	0.0016	< 0.000090	0.0018	0.0009	< 0.0005	0.0006	0.0006	0.01
Manganese	mg/L	0.0308	**0.602**	**0.160**	**0.131**	**0.219**	**0.155**	**0.122**	**0.162**	**0.141**	A.O ≤ 0.05
Nitrate+Nitrite	mg/L	< 0.001	0.51	0.289	< 0.005	0.040	0.020	< 0.005	0.061	0.026	
Selenium	mg/L	< 0.0010	0.004	0.002	< 0.0010	0.007	0.003	< 0.0010	0.003	0.002	0.01
Sodium	mg/L	33.7	123	72.2	70.6	230.0	168.0	61.0	178.0	79.1	A.O. ≤ 200
Sulphate	mg/L	147	360	255	43	233	203	163	198	176	A.O. ≤ 500
Uranium	mg/L	0.00144	0.0076	0.0040	0.0003	0.0018	0.0006	0.0004	0.0023	0.0019	0.02
Zinc	mg/L	< 0.0050	**6**	0.4798	< 0.005	0.0400	0.0198	< 0.01	0.0400	0.0162	A.O. ≤ 5.0
Microbiological Parameters											
Cryptosporidium	oocyst s/L	0	2								
Giardia lamblia	cysts/L	0	102								
Other Treatment-Related, Aesthetic Parameters											
Colour	TCU	0	**174**	**24**	**< 5.0**	**25**	**9**	**5**	**10**	**7**	15
Hardness	mg/L	134	**568**	**383**	**286**	**463**	**355**	**299**	**488**	**427**	A.O. ≤ 200
pH		6.91	**8.73**	8.29	7.65	**8.51**	7.91	7.52	8.47	7.79	6.5 – 8.5
TDS	mg/L	184	**748**	493	9	910	796	650	710	684	500
TOC	mg/L	8	61	16	2	25	9	1	18	7	
Turbidity	NTU	**3.7**	**405**	**41.4**	**< 5.0**	**25**	**9**	**5**	**10**	**7**	0.1

The raw water entering the WTP was found to occasionally have high pH levels as well as high levels of aluminum, arsenic, iron, manganese, colour, hardness, total dissolved solids (TDS) and turbidity. To determine if the WTP was adequately addressing these raw water quality issues, the water quality of the treated water leaving the plant was also evaluated, as seen in **Table 4.2**.

Table 4.2: City of Brandon's Treated Water Characteristics (2006 – 2012)

Parameter	Unit	Treated Water			GCDWQ
		Min	Max	Average	
Inorganic Parameters					
Aluminum	mg/L	0.011	**0.14**	0.053	O.G. ≤ 0.1
Antimony	mg/L	< 0.00020	0.002	0.0008	0.006
Arsenic	mg/L	< 0.0005	0.00782	0.0016	0.01
Barium	mg/L	0.003	0.0568	0.0163	1
Boron	mg/L	0.01	0.189	0.091	5
Cadmium	mg/L	< 0.000010	0.00002	0.00002	0.005
Chromium	mg/L	< 0.0010	0.002	0.0012	0.05
Copper	mg/L	< 0.0010	0.031	0.0034	A.O 1.0
Fluoride	mg/L	0.15	1.2	0.82	1.5
Iron	mg/L	< 0.100	0.09	0.07	A.O. ≤ 0.3
Lead	mg/L	< 0.000090	0.00012	0.00012	0.01
Manganese	mg/L	< 0.0003	0.0026	0.0010	A.O ≤ 0.05
Nitrate+Nitrite	mg/L	0.02	0.957	0.364	
Selenium	mg/L	< 0.0010	0.004	0.002	0.01
Sodium	mg/L	40	152	98.9	A.O. ≤ 200
Sulphate	mg/L	166	389	267	A.O. ≤ 500
Uranium	mg/L	< 0.00010	0.0027	0.0003	0.02
Zinc	mg/L	< 0.0050	0.1	0.0375	A.O. ≤ 5.0
Microbiological Parameters					
Cryptosporidium	oocysts/L	0	0	0	
Giardia lamblia	cysts/L	0	0	0	
Other Treatment-Related, Aesthetic Parameters					
Colour	TCU	0	7	0.2	15
Hardness	mg/L	76	**244**	159	A.O. ≤ 200
pH		6.36	8.09	7.74	6.5 – 8.5
TDS	mg/L	44	**634**	388	500
TOC	mg/L	2	11.6	6.8	
Turbidity	NTU	0	**0.407**	0.069	0.1

From the treated water analysis, the WTP was found to occasionally exceed the past GCDWQ limits for aluminum, TDS, aluminum and pH. The production of trihalomethanes (THMs) in particular was found to be a point of concern, with further analysis showing noncompliance to the provincial limits for bromodichloromethane, as seen in **Table 4.3**.

Table 4.3: City of Brandon Disinfectant By-Product Results (2006 – 2012)

Parameter	Treated Water (mg/L)			GCDWQ	MB
	Min	Max	Average		
Total haloacetic acids	0.014	**0.138**	0.052	0.08	

Bromoacetic acid	< 0.0005	0.0012	0.0010		
Bromochloroacetic acid	0.0036	0.0124	0.0070		
Dibromoacetic acid	< 0.0005	0.005	0.0023		
Dichloroacetic acid	0.005	0.0684	0.0269		
Monochloroacetic acid	< 0.001	0.0314	0.0069		
Trichloroacetic acid	0.003	0.0494	0.0184		
Trihalomethanes	0.024	**0.163**	0.065	0.1	0.1
Bromodichloromethane	0.0034	**0.091**	**0.0173**		0.016
Bromoform	<0.0001	0.0021	0.0007		
Chloroform	0.014	0.123	0.045		
Dibromochloromethane	0.0003	0.0213	0.0055		

THM production is closely related to the total organic carbon (TOC) content of the treated water. The THM levels increase as the contact time between chlorine-based disinfectants and organic matter increases in the distribution system.

Any upgrade to the City of Brandon's WTP must address these water quality concerns. Water quality criteria tend to become stricter over time, possibly creating greater issues with compliance in the future.

5. Canadian Water Quality Objectives

For each water quality criteria that is considered, Health Canada's Water Quality and Health Bureau prepares a guideline document which outlines the latest research into the health effects associated with the contaminant, Canadian exposure to the contaminant, and treatment and analytical considerations. This technical document and a proposed guideline value are peer-reviewed by external experts, reviewed by the Federal-Territorial-Provincial CDW, and undergo a public consultation. The guideline document is revised based on all the feedback received. CDW members provide input on the feasibility of implementing the guideline and discuss any outstanding concerns.

Once all the jurisdictions are satisfied with the guideline and supporting document, the members reach consensus that the guideline is ready to be approved. It is then sent to the CDW's parent committee, the Federal-Provincial-Territorial Committee on Health and the Environment, for final approval. The approved guideline and supporting document are then published.

The GCDWQ are an assembled list of contaminants reviewed by the CDW which may present a concern in Canadian drinking water. Provincial regulatory agencies use the GCDWQ to guide their own drinking water regulations and determine whether stricter criteria are required for their jurisdiction. Given the proximity and shared water resources of Alberta, Saskatchewan and Ontario with Manitoba drinking water supplies, the water quality criteria for these provinces were examined more closely.

5.1 Alberta Environment

Alberta Environment governs Alberta’s water resources through the provincial *Environmental Protection and Enhancement Act* and its accompanying regulations, as well at the *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems.*

The water quality criteria for Alberta are no more strict than those covered in the GCDWQ or Manitoba regulations, with the exception of treated water clarity, which is as follows:

- Particle counts for particles that are larger than 2 microns must be below 50 particles/mL.

5.1.1 Regulations Under Consideration

Alberta Environment determines provincial water quality regulations according to the GCDWQ, with amendments as necessary. As it is the regulatory agency for the province, Alberta Environment is expected to cooperate with the CDW in determining water quality guidelines.

5.2 Saskatchewan Water Security Agency

Established on October 1, 2012, the Saskatchewan Water Security Agency is now responsible for waterworks operations in that province. Formerly the responsibility of the Saskatchewan Ministry of the Environment, the WSA regulates adherence to water quality criteria set out in *The Water Regulations*, under the provincial *Environmental Management Protection Act*. This regulation makes the water quality criteria set out in the GCDWQ legally enforceable.

The water quality criteria for Saskatchewan are no more strict than those covered in the GCDWQ, with the exception of the additional limits of 2,4-dichlorophenol and various radiological parameters; which are as follows:

- A maximum acceptable concentration (MAC) for the organic contaminant 2,4-dichlorophenol at 0.9mg/L; and

- A MAC for gross alpha and gross beta radiation at 0.1 Becquerels per litre (Bq/L) and 0.11 Bq/L respectively.

5.2.1 Regulations Under Consideration

The Saskatchewan Ministry of the Environment has been responsible for consultations with the CDW for the development of previous water quality guidelines and their adoption. The Water Security Agency is now expected to participate in consultation with the CDW to develop future water quality criteria.

5.3 Ontario Ministry of the Environment

The Ontario Ministry of the Environment manages drinking water quality under the provincial *Safe Drinking Water Act* and its relevant regulations, which dictate the construction and licencing procedures for water distribution systems. Additionally, the *Procedure for Disinfection of Drinking Water in Ontario* also dictate required disinfection procedures and turbidity requirements for drinking water before consumption.

Compared to the water quality criteria for Alberta, Saskatchewan and Manitoba, the criteria for Ontario are much more extensive when compared to the GCDWQ. These criteria include:

- A stricter MAC for the disinfectant by-product n-nitrosodimethylamine (NDMA) at 9×10^{-6} mg/L;
- Additional organic contaminant limits for dioxins, furans and polychlorinated biphenyls (PCBs)
  - A MAC for dioxins and furans at 1.5×10^{-8} mg/L; and
  - A MAC for PCBs at 0.003 mg/L;
- 18 additional contaminants limits for pesticide such as Aldicarb, heptachlor and heptachlor epoxide.
- Extensive radionuclide limits, some of which are stricter than those set in place by the WHO, such as the isotopes for radium (^{226}Ra, ^{227}Ra) and plutonium (^{238}P, ^{239}P, ^{240}P).

Both Saskatchewan and Ontario are host to uranium mining projects, which have established the need for additional radiological testing. Ontario is also host to a variety of nuclear facilities that create various radionuclides in their emissions, establishing the need for additional criteria.

5.3.1 Regulations Under Consideration

The Ontario Drinking Water Advisory Council cooperates with the CDW to help develop its national water quality standards and to determine whether the standards in Ontario should be adjusted.

6. International Water Quality Objectives

Since the life cycle of any new facilities would be at least 20 years, it is considered prudent in the identification of these objectives to not only draw upon the present day set of water quality guidelines and regulations in Manitoba, but also to consider the regulatory environment in other jurisdictions. The regulations set by the USEPA are of particular interest, as they have typically predated similar changes in the GCDWQ by several years and have proven to be a valuable "barometer" of the future direction across Canada. A full comparison of water quality guidelines for all jurisdictions mentioned in this report can be found in Appendix A. All water quality guidelines are as current as the time of this report's publication.

6.1 World Health Organization (WHO)

The WHO has developed the *Guidelines for Drinking Water Quality* which outline water management plans for use in a variety of global settings. These guidelines aim to present a framework by which to develop water quality limits for various treatment systems situations across the world.

The WHO document does not contain explicit microbial disinfection criteria except for *Escherichia coli* (*E. coli*). This is due in part to the focus on the performance of overall water treatment techniques that can help address various disinfection targets. The WHO document also cites that water quality targets which require the measurement of pathogens are not as cost-effective or feasible for several jurisdictions as measuring other water quality criteria.

Compared to the GCDWQ, the WHO *Guidelines for Drinking Water Quality* have many additional water quality criteria. These include:

- Additional inorganic contaminant limits for ammonium, molybdenum and nickel, as seen in **Table 6.1**;
- Stricter maximum acceptable concentrations (MACs) for the inorganic contaminants barium, boron, cadmium, cyanide, nitrite, nitrotriacetic acid (NTA), sulphate and uranium;
- Stricter disinfectant limits for chlorite and chlorate, with additional limits on chlorine and chlorine dioxide;
- Additional disinfectant by-products limits in the cases of total haloacetic acids (HAAs) and THMs. Depending on the concentrations of the individual THMs and HAAs, these limits may be more strict than those stated in the GCDWQ;
- Stricter organic contaminant limits on dichloromethane, microcystin-LR and vinyl chloride, with additional contaminant limits for various other organic compounds.
- Stricter pesticide limits for nearly every pesticide compound covered in the GCDWQ, with the exception of Simazine and 2,4,5-trichlorophenoxy propionic acid (also known as Fenoprop and Silvex);
- Additional contaminant limits for various other pesticides, including Alachor, Cyanazine, Lindane and pentachlorophenol; and
- Additional radiological limits for total indicative dose and for a wide range of radionuclides.

Table 6.1: Stricter Water Quality Criteria from the WHO.

Parameter (mg/L)	GCDWQ	MB	WHO
Inorganic Parameters			
Barium	1	**-**	**0.7**
Boron	5	**-**	**0.5**
Cadmium	0.005	**-**	**0.003**
Cyanide	0.2	**-**	**0.07**
Nitrite	3.2	**-**	**0.2**
Nitrilotriacetic acid (NTA)	0.4	**-**	**0.2**
Sulphate	500	**-**	**250**
Uranium	0.02	0.02	**0.015**
Organic Parameters			
Dichloromethane	0.05	**-**	**0.02**
Microcystin-LR	0.0015	**-**	**0.001**
Vinyl chloride	0.002	**-**	**0.0003**
Disinfectant By-product Parameters			
Chlorate	1	**-**	**0.7**
Chlorite	1	**-**	**0.7**
Total haloacetic acids	0.08	**-**	**Varies**
Trihalomethanes	0.1	0.1	**Varies**

6.1.1 Regulations Under Consideration

The WHO currently has various publications regarding emerging issues in the field of water quality, of which the increasing presence of pharmaceuticals in water supplies is a focus. These include:

- Bezafibrate;
- Carbamazepine;
- Diclofenac;
- Ibuprofen;
- Roxithromycin; and
- Sulfamethoxazole.

6.2 European Commission (EC)

The EC *Council Directive 98/83/EC* regulates water quality and management throughout the European Union. This directive adopts some of the policies set in place by the WHO *Guidelines for Drinking Water Quality* as well as standards determined by the EC's Scientific Advisory Committee. This directive requires its member states to develop their own Water Safety Plans to meet the minimum standard dictated in this directive, as well as any additional standards to protect human health.

Compared to the GCDWQ, the EC *Council Directive 98/83/EC* has many additional water quality criteria. These include:

- Additional inorganic contaminant limits for ammonium and nickel, along with stricter limits for antimony, boron, cyanide, iron, nitrite and sulphate, as seen in **Table 6.2**;
- Additional organic contaminant limits for acylamide, epichlorohydrin and polyaromatic hydrocarbon (PAHs), with stricter limits on benzene, 1,2-dichloroethane and vinyl chloride. The limits on

tetrachloroethene and trilchloroethene may be stricter, depending on the relative concentrations of those compounds;

- Additional contaminant limits for various other pesticides with no comparable limits to the GCDWQ, such as Cyanazine, heptachlor and heptachlor epoxide;
- Additional radiological limits for tritium and for total indicative dose; and,
- Additional microbiological limits for *Clostridium perfringens* and *Enterococci* bacteria.

Table 6.2: Stricter Water Quality Criteria from the EC.

Parameter (mg/L)	GCDWQ	MB	EC
Inorganic Parameters			
Antimony	0.006	-	**0.0050**
Boron	5	-	**1.0**
Cyanide	0.2	-	**0.050**
Iron	0.3	-	**0.200**
Nitrite	3.2	-	**0.50**
Sulphate	500	-	**250**
Organic Parameters			
Benzene	0.005	0.005	**0.0010**
Dichloroethane, 1,2-	0.005	-	**0.0030**
Tetrachloroethene	0.03	-	**0.010**[1]
Thrichlrorethene	0.005	-	
Vinyl chloride	0.002	-	**0.00050**

[1] *Based on the sum of the concentrations of tetrachloroethene and trichloroethene.*

6.2.1 Regulations Under Consideration

As outlined in the directive, endocrine-disrupting compounds (EDCs) are a growing concern for the EC. Several compounds are suspected to be EDCs, although there is little data to set a health-based guideline for most of the suspected substances. An investigation into creating a list of priority substances EDCs was implemented, resulting in the identification of 12 candidate compounds in the *State of the Art of the Assessment of Endocrine Disruptors* report published by the EC in January 2012. These compounds include.

- (2,2'-bis(4-(2,3-epoxypropyl)phenyl)propane
- Carbon disulphide,
- 4-Chloro-3-methylphenol,
- 2,4-Dichlorophenol
- 4-Nitrotoluene,
- o-Phenylphenol,
- Resorcinol,
- 4-tert Octylphenol
- 2,2',4,4'-Tetrabrominated diphenyl ether (or tetra-BDE)
- Oestrone
- Oestradiol

- Ethinyloestradiol

These compounds present potential health-based concerns in Europe, although currently do not have an EC policy to regulate their use. 2, 4-Dichlorophenol is currently regulated in Saskatchewan under *The Water Regulations*.

6.3 United Kingdom Drinking Water Inspectorate (UK DWI)

The UK DWI regulates the drinking water quality for England Wales through the *Water Supply (Water Quality) Regulations*. This regulation conforms to many of the requirements dictated in *Council Directive 98/83/EC*, as well as the WHO *Guidelines for Drinking Water Quality*. Research conducted by the Drinking Water Inspectorate is often used to evaluate the potential risks of emerging contaminants, resulting in the Inspectorate becoming a WHO Collaborating Centre for Water Quality in 2010.

Compared to the GCDWQ, the UK DWI standards vary in the following ways:

- Additional inorganic contaminant limits for ammonium and nickel, with stricter limits for antimony, boron, cyanide, iron, nitrite and sulphate, as shown in **Table 6.3**.;
- Additional organic contaminant limits for acylamide, epichlorohydrin and polyaromatic hydrocarbon (PAHs), with stricter limits on benzene, 1,2-dichloroethane and vinyl chloride. The limits on tetrachloroethene and trilchloroethene may be stricter, depending on the relative concentrations of those compounds;
- Additional contaminant limits for various other pesticides with no comparable limits to the GCDWQ, such as heptachlor, heptachlor epoxide and Lindane;
- Additional radiological limits for total indicative dose and tritium; and
- Additional microbiological limits for *Clostridium perfringens* and *Enterococci* protozoa.

Table 6.3: Stricter Water Quality Criteria from the UK DWI.

Parameter (mg/L)	GCDWQ	MB	UK DWI
Inorganic Parameters			
Antimony	0.006	-	**0.0050**
Boron	5	**-**	**1.0**
Cyanide	0.2	**-**	**0.050**
Iron	0.3	-	**0.200**
Nitrite	3.2	**-**	**0.10**
Sulphate	500	**-**	**250**
Organic Parameters			
Benzene	0.005	0.005	**0.0010**
Dichloroethane, 1,2-	0.005	-	**0.0030**
Tetrachloroethene	0.03	-	**0.010**[1]
Thrichlrorethene	0.005	-	
Vinyl chloride	0.002	**-**	**0.00050**

[1] *Based on the sum of the concentrations of tetrachloroethene and trichloroethene.*

6.3.1 Regulations Under Consideration

The DWI conducts much of its research through the UK's Department for Environment Food and Rural Affairs. Like the EC, EDCs were the focus of some research for the DWI, although it was concluded that six of the most likely EDCs were not a significant health concern in the UK drinking water supply. Engineered nanoparticles used in various consumer products are also a growing concern, with significant research into potential health risks to determine what these currently unregulated materials have on drinking water supply. Perchlorate and nitrosoamines such as NDMA are currently being monitored in the water supply to determine the scope and need for future regulations, as both have been detected in significant levels throughout the UK. These same compounds either already have a guideline or are currently under review USEPA as well.

6.4 United States Environmental Protection Agency (USEPA)

The USEPA is a national organization that regulates and enforces various environmental laws in the United States. The USEPA is in charge of managing water quality under the authority of the United States *Safe Drinking Water Act*. Several regulations under this Act serve to manage overall water quality, including the following:

- *The National Primary and Secondary Drinking Water Standards*
  - *The Primary Drinking Water Standards* set guidelines by which the water management is regulated and enforced. These standards contain reference to Maximum Contaminant Levels (MCL), similar to MACs, for water-based contaminants. When no practically reliable method for measuring a given contaminant is available, a Maximum Contaminant Level Goal (MCLG) dictates ideal levels of treatment. MCLG are not practically enforceable.
  - *The Secondary Drinking Water Standards* set non-enforceable guidelines which regulate contaminants that may cause aesthetic concerns in drinking water.
- *The Groundwater Rule* dictates treatment measured for water supplies taken from groundwater sources, specifically referencing measures to address fecal contamination.
- *The Surface Water Treatment Rule* dictates treatment measures to be taken to reduce the incidence of pathogens in the distribution system, with emphasis on *Giardia lamblia* and *Legionella*. This rule applies to all public water systems in the United States using both surface water and GUDI.
- *The Long Term 1 Enhanced Surface Water Treatment Rule* specifies additional measures to be taken to reduce the incidence of pathogens in the distribution system, with emphasis on *Cryptosporidium*. This rule applies to all public water systems in the United States using both surface water and GUDI.
- *The Stage 1&2 Disinfectants/Disinfection By-Product Rules* dictate measures to manage the production of various contaminants during chemical disinfection, specifically the production of THMs when chlorine-based chemicals are used.
- The *Total Coliform Rule* proposes methods by which a water distributor can mitigate hazards when coliform contamination is present.

Compared to the GCDWQ, the USEPA standards vary in the following ways:

- Additional inorganic contaminant limits for asbestos and thallium, with a stricter limit for sulphate, as seen in **Table 6.4**;
- Additional disinfectant limits for chlorine and chlorine dioxide;
- Stricter disinfectant by-products limits in the cases of haloacetic acids (HAAs) and THMs;
- Stricter limits on 1,1-dichloroethene, dichloromethane and tetrachloroethene, with additional limits on a wide range of organic compounds such as acrylamide, styrene and various trichlorobenzenes;
- Stricter pesticides limits for nearly every pesticide compound covered in the GCDWQ, with additional contaminant limits for various other pesticides such as heptachlor, heptachlor epoxide and Lindane;
- Additional radiological limits for gross alpha and beta particles, which are indicative of radionuclides, as well as for two radium isotopes; and,

- Additional non-enforceable microbiological guidelines for *Legionella*.

Table 6.4: Stricter Water Quality Criteria from the USEPA.

Parameter (mg/L)	GCDWQ	MB	USEPA
Inorganic Parameters			
Sulphate	500	**-**	**250**
Organic Parameters			
Dichloroethene, 1.1-	0.014	**-**	**0.007**
Dichloromethane	0.05	**-**	**0.005**
Tetrachloroethene	0.03	**-**	**0.005**
Disinfectant By-Product Parameters			
Total haloacetic acids	0.08		**0.060**
Trihalomethanes	0.1	0.1	**0.080**

6.4.1 Regulations Under Consideration

The USEPA tracks contaminants for which additional research is required to determine a threat to public health on a Contaminant Candidate List (CCL). These contaminants are tracked through the Unregulated Contaminant Monitoring Program to determine at which concentrations, if any, that start to present a risk to public health. The CCL is usually filtered down further to at least 5 contaminants to determine required research efforts.

Of particular interest is the investigation of the effects of Radon on water quality, which is currently not identified as a significant risk by the CDW. Other regulations on perchlorate, methyl tert-butyl ether (MTBE) and total coliforms are also growing concerns. The USEPA is required to conduct a six year review of its drinking water standards as dictated by the *Safe Drinking Water Act*.

7. Comparison of Water Quality Criteria

7.1 General

A comparison of all water quality criteria investigated can be found in **Appendix A**. Water quality criteria that are more stringent than those set in place by the current GCDWQ and Manitoban regulation can be found in **Table 7.1**.

Table 7.1: Water Quality Criteria Which Exceed Manitoban Regulations

Parameter	GCDWQ	MB	WHO	EC	UK DWI	USEPA	ON
Inorganic Parameters							
Antimony	0.006	-	0.02	**0.0050**	**0.0050**	0.006	0.006
Barium	1	-	**0.7**	-	-	2	1
Boron	5	-	**0.5**	**1.0**	**1.0**	-	5
Cadmium	0.005	-	**0.003**	0.0050	0.0050	0.005	0.005
Cyanide	0.2	-	**0.07**	**0.050**	**0.050**	0.2	0.2
Iron	0.3	-	0.3	**0.200**	**0.200**	0.3	-
Nitrite	3.2	-	**0.2**	**0.50**	**0.10**	3	3
Nitrilotriacetic acid (NTA)	0.4	-	**0.2**	-	-	-	0.4
Sulphate	500	-	**250**	**250**	**250**	**250**	-
Uranium	0.02	-	**0.015**	-	-	0.03	0.02
Organic Parameters							
Benzene	0.005	-	0.01	**0.0010**	**0.0010**	0.005	0.005
Dichloroethane, 1,2-	0.005	-	0.03	**0.0030**	**0.0030**	0.005	0.005
Dichloroethene, 1,1-	0.014	-	-	-	-	**0.007**	0.014
Dichloromethane	0.05	-	**0.02**	-	-	**0.005**	**0.05**
Microcystin-LR	0.0015	-	**0.001**	-	-	-	0.0015
Tetrachloroethene	0.03	-	0.04	**0.010[1]**	**0.010[1]**	**0.005**	0.03
Thrichlrorethene	0.005	-	0.02			0.005	0.005
Vinyl chloride	0.002	-	**0.0003**	**0.00050**	**0.00050**	0.002	0.002
Disinfectant By-Product Parameters							
Chlorate	1	-	**0.7**	-	-	-	-
Chlorite	1	-	**0.7**	-	-	1	-
NDMA	0.00004	-	0.1	-	-	-	**0.000009**
Total haloacetic acids	0.08	-	**Varies**	-	-	**0.060**	-
Trihalomethanes	0.1	-	**Varies**	0.100	0.100	**0.080**	0.1

All values in mg/L unless stated otherwise. Values in bold exceed GCDWQ limits.
[1] Based on the sum of the concentrations of tetrachloroethene and trichloroethene.

From the table above:, it can be seen that a greater than 50% difference in the GCDWQ limits and other jurisdictional limits occur for boron, cyanide, NDMA, nitrite, sulphate, dichloromethane and vinyl chloride.

- The GCDWQ limit for vinyl chloride is currently under review subject of review by the Federal-Territorial-Provincial CDW.
- The parameters for iron and sulphate are mainly aesthetic objectives and are unlikely to change.

Based on the assessment of the Brandon WTP by AECOM in 2008, THMs appear to be one the parameters of greater concern. The USEPA currently has the strictest guidelines for THMs, with both the USEPA and the WHO defining further limits on specific THMs.

7.2 Additional Parameters

7.2.1 General

Several jurisdictional criteria for which there was no equivalent Manitoba or GCDWQ limit. This may be due to several reasons:

- There is insufficient data to support a guideline for drinking water quality.
- There is evidence to support a low health-based risk or aesthetic issue;
- The compound is not present is significant amounts in drinking water around Manitoba to present a health-based risk;
- The compound is restricted from use within Canada; and
- The parameter is interpreted by the various regulatory agencies in different manner, such as a parameter which measures the sum of various compounds which could be measured individually.

Through the CDW, the GCDWQ is periodically developed with input from provincial bodies to determine which parameters must be reviewed and which should be archived. Compounds that are considered to be of significant concern are added the GCDWQ after a public consultation.

In addition, the safety of drinking water is also affected by the *Canadian Environment Protection Act,* which defines a “priority substances list” involving compounds that are suspected to present health-based risks to Canadian. Compounds on this list are periodically reviewed for safety and a *Priority Substances List Assessment Report* is published determining whether or not a compound presents a toxic threat to the public at concentrations found in the Canadian environment.

7.2.2 Inorganic Parameters

According to the CDW Technical Documents for ammonia, asbestos, and silver, these compounds are not present in Canadian waters at concentrations that could present a hazard to human health. Therefore, regulatory guidelines have not been established. The Technical Document for asbestos states that no conclusive evidence has be found that ingested asbestos is carcinogenic, therefore a regulatory guideline has not been established.

There does not seems to be significant literature from Health Canada regarding the presence of beryllium, molybdenum and thallium in drinking water. The USEPA has standards for beryllium and thallium mainly to address chemical runoff from industrial sites that might affect drinking water. Only the WHO has regulatory standards for molybdenum, which is based on a 2-year study of human consumption of molybdenum in drinking water.

7.2.3 Disinfectant and Disinfectant By-product Parameters

According to the CDW Technical Document for chlorine, chlorine is not considered to present a health-risk at the levels found in drinking water after chlorination, therefore a regulatory guideline has not been established. According to the Technical Document for chlorite and chlorate, a regulatory guideline has not been established for chlorine dioxide because of its rapid decomposition to both chlorite and chlorate, both of which have MAC guidelines.

The GCDWQ presents a combined value for chloramines, which include mono-, di- and trichloramine. Monochloramine is main form of chloramine present at pH levels in the range of 7.5 to 9, which is the usual range for receiving water streams. It is considered that the chloramine-related guidelines between the WHO and the GCDWQ are similarly based.

Only the WHO has regulatory standards for sodium dichloroisocyanurate, which is not considered to be of significant concern due to its low toxicity and lack or carcinogenic and teratogenic effects. The WHO regulation for cyanogen chloride is based on cyanide, as there are few data to support a guideline on the health effects of cyanogen chloride itself.

7.2.4 Organic Parameters

According to Health Canada's Priority Substances List Assessment for chlorbenzene, polychlorinated dibenzodioxins (dioxins), polychlorinated dibenzofurans (furans), styrene and hexachlorobutadiene, the current levels of these compounds in the Canadian environment do not pose a threat to human health. The assessments for trichlorobenzene and hexachlorbenzene have found very little or inconclusive data on the presence of these compounds Canadian drinking water supplies.

The GCDWQ regulations for phlthalic acid esters (which includes di(2-ethylhexyl)phthalate), polyaromatic hydrocarbons (with the exception of benzo[a]pyrene) and polychlorinated biphenyls have been archived due to low levels of these contaminants in Canadian drinking water.

The regulations for acrylamide in drinking water from the WHO, USEPA, EC and UK DWI refer to the acrylamide residual left over from certain coagulation processes during drinking water treatment. Growing evidence of an increased risk to breast and ovarian cancer has resulted in a review of acrylamide by Health Canada under its Chemicals Management Plan, for which a draft report was released in 2009.

Only the WHO has regulatory standards for hydrogen sulphide and epichlorohydrin, and are not considered to be of significant concern for drinking water supplies.

Amongst all of the jurisdictional water quality criteria, there were several organic compounds for which Canadian health and environmental regulations did not specifically address. It is unknown whether or not these compounds present a current risk to drinking water quality. These compounds include:

- Dibromoacetonitrile, (WHO);
- Dichloroacetonitrile (WHO);
- Di(2-ethylhexyl) adipate (USEPA);
- *cis*-1,2-Dichloroethene (USEPA, WHO);
- *trans*-1,2-Dichloroethene (USEPA, WHO);
- Dioxane, 1,4- (WHO);
- Edetic acid (WHO);
- Ethylene dibromide (USEPA);
- Hexachlorocyclopentadiene (USEPA);
- Trichloroethane, 1,1,1- (USEPA); and,
- Trichloroethane, 1,1,2- (USEPA).

7.2.5 Pesticide Parameters

Under the federal *Pest Control Products Act*, all pesticides must be included in the Pesticide Public Registry before use in Canada. The Registry serves to track applications of new products into Canada, and allow Health Canada to regulate approved pesticides.

Of the 68 different pesticide-related water quality criteria covered in the jurisdictional comparison, only 27 of those criteria are included in the GCDWQ. This is, in part, due to the fact that a large variety of pesticide-related products are used across the world. Many of these pesticides are no longer registered for use within Canada or have corresponding Technical Documents for the GCDWQ which have been archived due to low concentrations found in the environment. Such pesticides include:

- Aldicoarb
- Aldrin
- Bendiocarb
- Cyanazine
- Dinoseb
- Methoxychlor

By only comparing provincial water quality criteria, it can be noted that Ontario has some of the most comprehensive guidelines regarding pesticide use, with 17 additional pesticide-related water quality criteria than the GCDWQ. Many of these pesticides are no longer registered for use within Canada, indicating the need to retain water quality guidelines until such a time that the hazard is no longer significant.

Because of the location-specific nature of pesticide use, adopting water criteria from jurisdictions may not be appropriate. Without past and current data on pesticide use in Manitoba, appropriate pesticide guidelines cannot be chosen. In 2011, Environment Canada's first National Water Quality Surveillance Program published a study entitled *Presence and Levels of Priority Pesticides in Selected Canadian Aquatic Ecosystems*, which detailed current-use pesticides around aquatic ecosystems from 2003-2005. Previous to this study, no systematic wide-scale study was conducted on pesticide use. In addition, while pesticide approvals were tracked through the *Pest Control Products Act*, overall sales and use data of pesticides have never been systematically recorded, except in certain areas of Canada.

The study was able to find the presence of 33 different pesticide compounds in source water (rivers, surface water and groundwater) in the prairies. Of these compounds, only 12 are addressed in the GCDWQ. An additional 4 pesticides have been addressed in other jurisdictional criteria covered in this report. Due to the large amount of unregulated pesticide compounds and a recent push by Environment Canada to assess their presence in source water, it is expected that action towards greater pesticide removal may be made in the future.

7.2.6 Microbiological Parameters

Disinfection and turbidity parameters are nearly uniform for all jurisdictions, as seen in Table A.7 and A.8. The main difference between jurisdictions was the type of microbiological monitoring conducted. Test parameters that are not currently used in Manitoba include:

- *Clostridium perfringens* (including spores);
- Enterococci; and
- Fecal coliforms (also known as thermotolerant coliforms).

This additional testing does not change the overall 4-log reduction in viruses for a WTP, but simply make it easier to determine the efficacy of viral reduction after water treatment. Since viruses tend to be difficult to sample directly, *Clostridium perfringens* (*C.perfringens*) and *Enterococci* can be used as indicators to infer viral presence.

- *C.perfringens* tends to have the same resistance to water treatment as enteric viruses. The presence of *C.perfringens* implies the possibility of viral contamination in a water body and vice versa.
- Enterococci are found in fecal matter and tend to be more resistant to water treatment than coliform bacteria. Their presence generally implies fecal contamination, and can indirectly infer the presence of viruses due to their enhanced treatment resistance.

Fecal coliforms are sampled to detect the presence of fecal contamination, although such tests have been known to show false positives in organically rich waters lacking fecal matter. Testing for *E.coli* is usually preferred in this case as it is a true indicator of fecal contamination. It is likely *E.coli* testing will continue in Manitoba.

7.2.7 Radiological Parameters

The radiological parameters used in the GCDWQ are used to assess the presence of radionuclides most likely to be found in Canadian water supplies. The radiological water quality criteria used in Manitoba are entirely derived from the GCDWQ.

The additional radiological criteria used in Saskatchewan and Ontario can be attributed to the development of uranium mines and other man-made nuclear activities in those provinces. While there may be a potential for exploratory uranium mines in Manitoba, it is unlikely that radiological water quality guidelines will change significantly for the province.

8. Conclusion

The compounds in **Table 7.1** may be subject to increased regulation in the future due to more stringent requirements found in other jurisdictions. Contaminants of note are those limits that vary by more than 50% of the total concentration, including boron, cyanide, NDMA, nitrite, sulphate, dichloromethane and vinyl chloride. Currently, water quality criteria for vinyl chloride and for waterborne bacterial pathogens are being reviewed by the Federal-Territorial-Provincial CDW. The water quality criterion for NDMA is currently under review by the UK DWI.

Several water quality criteria were addressed in other jurisdictions for which there is no equivalent in the GCDWQ. A compound of particular interest is acrylamide, which presents a risk to human health and is present as a by-product of some coagulation processes during water treatment. Overall, a greater number of compounds present in the environment are being regulated worldwide as health concerns grow over previously unregulated compounds. This is leading to the categorization of contaminants based on their chemical characteristics to aid in treatment evaluations.

Research in other jurisdictions regarding the presence of pharmaceuticals, endocrine-disrupting compounds and perchlorate may also be the subject of research in Canadian water supplies in the future. The presence of pesticides in Manitoba source water may also be the target of future regulations, given their possible presence in the water supply and the absence of any recommended treatment criteria.

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Appendix A – Water Quality Parameter Summary Tables

Appendix Table 1: Inorganic Parameters

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Aluminum		OG: 0.1/0.2[1]				0.1		0.200		0.200			0.05 – 2			
Ammonium						**1.5**		**0.50**		**0.50**						
Antimony	0.006				0.02		**0.0050**		**0.0050**		0.006	0.006				0.006
Arsenic	0.010 [2]			0.01	0.01 [3]		0.010		0.010		0	0.010		0.025 [4]		0.025
Asbestos (fibres >10μm)											**7 MFL**[5]	**7 MFL**[5]				
Barium	1.0				**0.7**						2	2		1		1.0
Beryllium											**0.004**	**0.004**				
Boron	5				**0.5** [6]		**1.0**		**1.0**					5.0 [4]		5.0
Cadmium	0.005				**0.003**		0.0050		0.0050		0.005	0.005		0.005		0.005
Chloride		250				200-300		250		250			250			
Chromium	0.05				0.05 [3]		0.050		0.050		0.1	0.1		0.05		0.05
Copper		1.0			2	1	2.0 [7]		2.0		1.3	1.3 [8]	1.0			
Cyanide	0.2				**0.07**		**0.050**		**0.050**		0.2	0.2		0.2		0.2
Fluoride	1.5			1.5	1.5		1.5 [7]		1.5		4.0	4.0		1.5 [8]		1.5
Hydrogen sulphide						**0.05-0.1**										
Iron		0.3				0.3		**0.200**	**0.200**				0.3		0.3 [10]	
Lead	0.010		0.01	0.01	0.01		0.010		0.025 [11]		0	0.015 [9]		0.01		0.010
Manganese		0.05			0.4 [14]	0.1		0.050	0.050				0.05		0.08 [10]	
Mercury	0.001				0.006		0.0010		0.0010		0.002	0.002		0.001		0.001
Molybdenum					**0.07**											
Nickel					**0.07**		**0.020**		**0.020**							
Nitrate (as NO_3^-) [12]	45			45	50		50		50		44	44		45		44
Nitrite (as NO_2^-) [13]	3.2				**3/0.2** [15]		**0.50**		**0.5/0.1** [16]		3	3				3
Nitrate + Nitrite (as N)							See note 17									**10.0**
Nitrilotriacetic acid (NTA)	0.4				**0.2**											0.4
Selenium	0.01				0.01		0.010		0.010		0.05	0.05		0.01		0.01
Silver													0.10			
Sodium		200				200		200	200							
Sulphate		500				**250**		**250**		250			**250**			
Sulphide		0.05														
Thallium											**0.0005**	**0.002**				
Uranium	0.02			0.02	**0.015** [3,6,18]									0.02		0.02
Zinc		5.0											5			

Comments:

1 <0.1mg/L for conventional treatment, <0.2 mg/L for other treatment types. Based on the use of aluminum salts used as coagulants in drinking water.
2 As low as reasonably possible.
3 Provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited.
4 Interim guidelines.
5 MFL: million fibres per litre.
6 Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.
7 The value applies to a sample taken from a tap so as to be a representative of a weekly average value ingested by consumers.
8 MAC of naturally occurring fluoride in treated drinking water.
9 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.
10 Where iron and manganese removal are practiced.
11 To be 0.010 mg/L after December 2013.
12 In cases where a guideline was stated in terms of N, the guideline was multiplied by a factor of 4.4 and rounded down.
13 In cases where a guideline was stated in terms of N, the guideline was multiplied by a factor of 3.3 and rounded down.
14 Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, leading to consumer complaints.
15 Short-term exposure/long term exposure.
16 Consumers' taps/treatment works.
17 Limit is the concentration for both nitrate and nitrate satisfying the equation [nitrate]/50 + [nitrite]/3 ≤ 1, and that the value of 0.10 mg/L for nitrates is complied with exiting the water treatment works.
18 Only chemical aspects of uranium addressed.

All values in mg/L unless stated otherwise.
Values in bold exceed GCDWQ limits.

Appendix Table 2: Organic Parameters

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Acrylamide					**0.0005**		**0.00010** [1]		**0.00010** [1]		0	**See note 2**				
Benzene	0.005			0.005	0.01		**0.0010**		**0.0010**		0	0.005		0.005		0.005
Carbon tetrachloride	0.002				0.004					0.003	0	0.005		0.005		0.005
Chlorobenzene						**0.01-0.02**					0.1	**0.1**				
Chlorophenol, 2-						**0.0001**										
Di(2-ethylhexyl) adipate											0.4	**0.4**				
Di(2-ethylhexyl)phthalate					**0.008**						0	**0.006**				
Dibromoacetonitrile					**0.07**											
Dichlorobenzene, 1,2-	0.2 [3]	0.003			1 [4]	0.002					0.6	0.6		0.2		0.2
Dichlorobenzene, 1,4-	0.005 [3]	0.001			0.3 [4]	0.0003					0.075	0.075		0.005		0.005
Dichloroethane, 1,2-	0.005				0.03		**0.0030**		**0.0030**		0	0.005		0.005 [5]		0.005
Dichloroethene, 1,1-	0.014										0.007	**0.007**		0.014		0.014
Dichloroethene, *cis*-1,2-					**0.05** [6]						0.07	**0.07**				
Dichloroethene, *trans*-1,2-											0.1	**0.1**				
Dichloromethane	0.05				**0.02**						0	**0.005**		0.05		0.05
Dichlorophenol, 2,4-														**0.9**		
Dioxane, 1,4-					**0.05**											
Dioxin (2,3,7,8-TCDD)											0	**$3x10^{-8}$**				
Dioxin and Furan																**1.5 x10^{-8}** [7]
Edetic acid (EDTA)					**0.6** [8]											
Epichlorohydrin					**0.0004** [9]		**0.00010** [1]		**0.00010** [1]		0	**See note 2**				
Ethylbenzene		0.0024			0.3 [4]	0.002 - 0.0130					0.7	0.7				
Ethylene dibromide											0	**0.00005**				
Hexachlorobenzene											0	**0.001**				
Hexachlorobutadiene					**0.0006**											
Hexachlorocyclopentadiene											0.05	**0.05**				
Methyl tertiary-butyl ether (MTBE)		0.015														
Microcystin-LR	0.0015				**0.001** [9, 10]											0.0015
Monochlorobenzene	0.08	0.03												0.08		0.08
Polychlorinated biphenyls (PCBs)											0	0.0005				**0.003**
Polycyclic aromatics hydrocarbons							**0.00010** [11]		**0.00010** [11]							
Benzo[a]pyrene	0.00001				0.0007		0.000010		0.000010		0	0.0002		0.00001		0.00001
Styrene					**0.02** [4]	**0.004-2.6**					0.1	0.1				
Tetrachloroethene	0.03			0.03	0.04		**0.010** [12]		**0.010** [12]		0	**0.005**				0.03
Trichloroethene	0.005			0.005	0.02 [9]						0	0.005		0.05		0.005
Tetrachlorophenol, 2,3,4,6-	0.1	0.001												0.1		0.1

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Toluene		0.024			0.7 [4]	0.024-0.17					1	1				
Trichlorobenzene, 1,2,4-						**0.005-0.03**					0.07	**0.07**				
Trichlorobenzene, 1,2,3-						**0.01**										
Trichlorobenzene, 1,3,5-						**0.05**										
Trichloroethane, 1,1,1-											0.2	**0.2**				
Trichloroethane, 1,1,2-											0.003	**0.005**				
Vinyl chloride	0.002				**0.0003**		**0.00050** [1]		**0.00050** [1]		0	0.002		0.002		0.002
Xylenes		0.3			0.5 [4]						10	10				

Comments:

1 The parametric value refers to the residual monomer concentration in the water as calculated according to specifications of the maximum release from the corresponding polymer in contact with the water.
2 When acrylamide and epichlorohydrin are used to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:
Acrylamide = 0.05% dosed at 1 mg/L (or equivalent)
Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent)
3 In cases where total dichlorobenzenes are measured and concentrations exceed the most stringent value (0.005 mg/L), the concentrations of the individual isomers should be established.
4 Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, causing consumer complaints.
5 Interim guideline.
6 The sum of both the *cis* and *trans* forms of dichloroethene.
7 Total toxic equivalents when compared with 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin).
8 Applies to the free acid.
9 Provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited.
10 For total microcystin-LR (free plus cell-bound).
11 The sum of the following compounds: benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene.
12 The sum of both tetrachloroethene and trichloroethene.

All values in mg/L unless stated otherwise.
Values in bold exceed GCDWQ limits.

Appendix Table 3: Pesticide Parameters

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater , GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Alachlor					**0.02**						0	**0.002**				**0.005**
Aldicarb					**0.01**[1]											**0.009**
Aldrin					**0.00003**[2]		**0.000030**		**0.000030**							**0.0007**
Dieldrin							**0.000030**		**0.000030**							
Atrazine*	0.005				**0.002**						0.003	**0.003**		0.005[3]		
Atrazine + N-dealkylated metabolites																**0.005**
Azinphos-methyl	0.02															0.02
Bendiocarb																**0.04**
Bromoxynil*	0.005													0.005[3]		0.005
Carbaryl	0.09															0.09
Carbofuran	0.09				**0.007**						0.04	**0.04**		0.09		0.09
Chlorotoluron					**0.03**											
Chlorpyrifos (Dursban)*	0.09				**0.03**									0.09		0.09
Cyanazine					**0.0006**											**0.01**
Dalapon											0.2	**0.2**				
Dichlorodiphenyltrichloroethane (DDT) and metabolites					**0.001**											**0.03**
Diazinon	0.02															0.02
Dibromo-3-chloropropane, 1,2- (DBCP)					**0.001**						0	**0.0002**				
Dibromoethane, 1,2-					**0.0004**[4]											
Dicamba*	0.12													0.12		0.12
Dichlorophenol, 2,4- (2,4-DCP)	0.9	0.0003				0.0003										0.9
Dichlorophenoxyacetic acid, 2,4- (2,4-D)*	0.1				**0.03**[5]						0.07	**0.07**		0.1[3]		0.1
4-(2,4-dichlorophenoxy)butyric acid (2,4-DB)					**0.09**											
Dichloropropane, 1,2- (1,2-DCP)					**0.04**[4]						0	**0.005**				
Dichloropropene, 1,3-					**0.02**											
Dichlorprop (2,4-DP)*					**0.1**											
Diclofop-methyl*	0.009													0.009		0.009
Dimethoate (Cygon)*	0.02				**0.006**									0.02[3]		0.02
Dinoseb											0.007	**0.007**				**0.01**
Diquat	0.07										0.02	**0.02**				0.07
Diuron	0.15															0.15
Endothall											0.1	**0.1**				
Endrin					**0.0006**						0.002	**0.002**				
Glyphosate	0.28										0.7	0.7				0.28
Heptachlor							**0.000030**		**0.000030**		0	**0.0004**				**0.003**[6]
Heptachlor epoxide							**0.000030**		**0.000030**		0	**0.0002**				

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Isoproturon					**0.009**											
Lindane					**0.002**						0.0002	**0.0002**				**0.004**
Malathion	0.19													0.19		0.19
Mecoprop*					**0.01**											
Methoxychlor					**0.02**						**0.04**	**0.04**				**0.9**
2-methyl-4-chlorophenoxyacetic acid (MCPA)*	0.1				**0.002**											
Metolachlor*	0.05				**0.01**											0.05
Metribuzin*	0.08															0.08
Molinate					**0.006**											
Oxamyl (Vydate)											0.2	**0.2**				
Paraquat	0.01/0.007 [7]															0.01
Parathion																**0.05**
Pendimethalin					**0.02**											
Pentachlorophenol	0.06	0.03			**0.009** [4]						0	**0.001**		0.06		0.06
Permethrin					**0.3** [8]											
Phorate	0.002															0.002
Picloram*	0.19										0.5	0.5		0.19 [3]		0.19
Prometryne																**0.001**
Pyriproxyfen					**0.3** [9]											
Simazine*	0.01				0.002						0.004	**0.004**				0.01
Temephos																**0.28**
Terbufos	0.001															0.001
Terbuthylazine					**0.007**											
Toxaphene											0	**0.003**				
Triallate*																**0.23**
Trichlorophenol, 2,4,6-						**0.002**										
Trichlorophenoxy propionic acid, 2,4,5- (2,4,5-TP, Silvex, Fenoprop)*					0.009						0.05	**0.05**				
Trichlorophenoxyacetic acid, 2,4,5- (2,4,5-T)*					**0.009**											**0.28**
Trifluralin	0.045				**0.02**									0.045 [3]		0.045
Other Pesticides							**0.00010** [10,11]		**0.00010** [11]							
Pesticides—Total							**0.00050** [10,12]		**0.00050** [12]							

Comments:

1 Applies to aldicarb sulfoxide and aldicarb sulfone.
2 For combined aldrin plus dieldrin.
3 Interim guideline.

4 Provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited.
5 Applies to free acid.
6 For both heptachlor and heptachlor epoxide.
7 0.01 as paraquate dichloride, 0.007 as paraquat ion.
8 Only when used as a larvicide for public health purposes.
9 This is not to be used as a guideline value where pyriproxyfen is added to water for public health purposes.
10 "Pesticides" includes organic insecticides, organic herbicides, organic fungicides, organic nematocides, organic acaricides, organic algicides, organic rodenticides, organic slimicides, related products (inter alia, growth regulators) and their relevant metabolites, degradation and reaction products.
11 The parametric value applies to each individual pesticide except in the case of aldrin, dieldrin, heptachlor and heptachlor epoxide.
12 The sum of all individual pesticides detected and quantified in the monitoring procedure.

*Detected in *Presence and Levels of Priority Pesticides in Selected Canadian Aquatic Ecosystems*, Environment Canada, 2011.
All values in mg/L unless stated otherwise.
Values in bold exceed GCDWQ limits.

Appendix Table 4: Disinfectant Parameters

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Chloramines	3.0 [1]										4 [2]	4.0 [2]				3.0
Monochloramine					3	0.3-5										
Chlorine					**5**	0.3-5					4	**4.0**				
Chlorine dioxide											0.8	**0.8**				
Sodium dichloroisocyanurate					**50/40** [3]											

Comments:

1 Mainly based on healthaffects of monochloramine.
2 Chloramines measured as Cl_2.
3 As sodium dichloroisocyanurate/as cyanuric acid.

All values in mg/L unless stated otherwise.
Values in bold exceed GCDWQ limits.

Appendix Table 5: Disinfectant By-product Parameters

Parameter	GCDWQ		MB		WHO		EC		UK DWI		USEPA			SK	AB	ON
	MAC	AO	MAC : Surface Water	MAC : Groundwater, GUDI	Guideline	Acceptability Aspect	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	Secondary Guidelines	MAC	MAC	MAC
Bromate	0.01				0.01 [1,2]		0.010 [3]		0.010		0	0.010				0.01
Chlorate	1				**0.7** [4]											
Chlorite	1				**0.7** [4]						0.8	1.0				
Cyanogen chloride					**0.07** [5]											
Dichloroacetonitrile					**0.02** [1]											
N-Nitrosodimethylamine	0.00004				0.1											**0.000009**
Total haloacetic acids (HAAs)	0.08 [6, 7, 8]											**0.060** [7]				
Bromoacetic acid											See note 9					
Dibromoacetic acid											See note 9					
Dichloroacetatic acid					**0.05** [4, 10]						**0**					
Monochloroacetatic acid					**0.02**						**0.07**					
Trichloroacetatic acid					**0.2**						**0.02**					
Trichlorophenol,2,4,6-	0.005	0.002			0.2 [11]									0.005		0.005
Trihalomethanes (THMs)	0.1 [6]		0.1 [6]	For GUDI: 0.1 [6]	See note 12		0.100 [13]		0.100 [13]			**0.080**		0.1 [6, 14]	0.100 [6, 15]	0.100
Bromodichloromethane			0.01 [6]	For GUDI: 0.016 [6]	**0.06**						**0**				0.016 [6, 15]	
Bromoform					**0.1**						**0**					
Chloroform					**0.3**						**0.07**					
Dibromochloromethane					**0.1**						**0.06**					

Comments:

1 Provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited.
2 Provisional guideline value because calculated guideline value is below the practical quantification level.
3 Lower values are recommended where possible, without compromising disinfection.
4 Provisional guideline value because disinfection is likely to result in the guideline value being exceeded.
5 For cyanide as total cyanogenic compounds (repeated cyanide standard).
6 Based on a running annual average of quarterly samples.
7 Sum of the concentrations of the HAAs specified in this list.
8 As low as reasonably possible.
9 Bromoacetic acid and dibromoacetic acid are regulated with this group but have no MCLGs.
10 Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source control, etc.
11 Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, causing consumer complaints.
12 The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1.
13 Sum of the concentrations of the THMs specified in this list.
14 Interim guideline.
15 Measured at the furthest point of the distribution system.

All values in mg/L unless stated otherwise.
Values in bold exceed GCDWQ limits.

Appendix Table 6: Other Treatment-Related, Aesthetic Parameters

Parameter	GCDWQ	WHO	EC	UK DWI		USEPA
	AO	Guideline	Indicator Parameters	Chemical Parameters	Indicator Parameters	Secondary Guidelines
Colour (TCU)	15	15	Acceptable to consumers and no abnormal change	20		15
Conductivity (µS/cm at 20°C)			2500		2500	
Corrosivity						Non-corrosive
Foaming Agents (mg/L)						0.5
Hardness (mg/L as $CaCO_3$)	<200 [1]	<200 [1]				
Odour (TON)	Inoffensive			Acceptable to consumers and no abnormal change		3
Oxdizability (mg/l O_2)			5.0 [2]			
Particle Count (greater than 2µm)						
pH [3]	6.5-8.5	6.5-8	6.5 -9.5 [4]		6.5-9.5	6.5-8.5
Taste	Inoffensive		Acceptable to consumers and no abnormal change		Acceptable to consumers and no abnormal change	
Temperature (°C)	15	Generally cold				
Total Dissolved Solids (mg/L)	500	600				500
Total Organic Carbon (mg/L)			No abnormal change [5]		No abnormal change	

Comments:

1 Hardness levels in excess of 500 mg/L have been found suitable by some consumers. Generally, hardness levels should be kept below 200mg/L in order to prevent scaling in the treatment works.
2 This parameter need not be measured if the parameter TOC is analysed.
3 pH should remain within this range.
4 For still water put into bottles or containers, the minimum value may be reduced to 4,5 pH units. For water put into bottles or containers which is naturally rich in or artificially enriched with carbon dioxide, the minimum value may be lower.
5 The parameter need not be analysed for supplies less than 10000 m^3 a day.

Values in bold exceed GCDWQ limits.

Appendix Table 7: Microbiological Parameters

Parameter		GCDWQ	MB	WHO	EC		UK DWI		USEPA		SK	AB	ON	
	Units	Guideline	MAC : Surface Water, GUDI	Guideline	Chemical Parameters	Indicator Parameters	Chemical Parameters	Indicator Parameters	MCLG	MCL	MAC	MAC	MAC: Surface water	MAC: Groundwater
Background bacteria														
***Clostridium perfringens* (including spores)**	number/100mL					**0** [1]		**0**						
Enterococci	number/100mL				**0**		**0**							
Legionella	number/100mL								0					
Heterotrophic plate count	colonies/1 mL		**500** [2]			No abnormal change		No abnormal change		**500**				
Protozoa														
Cryptosporidium	log reduction	3	3 [3]						Complete removal	2 [4]	3	3	2	
Giardia lamblia	log reduction	3	3 [3]						Complete removal	3 [4]	3	3	3	
Total Coliforms	number/100mL	0 [5]	0, 200 [2]			0	0			See note 6	0, 200 [2]		0	0
Fecal coliform	number/100mL										0, 200 [2]			
Escherichia coli	number/100mL	0	0	0	0		0	0					0	0
Viruses (enteric)	log reduction	4	4						Complete removal	4	4	4	4	2

Comments:

1 Applies to surface water.
2 Where membrane filtration analysis is used.
3 This standard can be changed depending on the quality of the source water.
4 Applies to surface water, GUDI.
5 At the exit of municipal treatment plant or throughout semi-public systems. In municipal distribution systems, no consecutive samples or no more than 10% of samples should contain total coliforms.
6 <5.0% of samples coliform-positve samples/month. <1 sample/month if less than 40 monthly sample taken.

Values in bold exceed GCDWQ limits.

Appendix Table 8: Turbidity Parameters

Parameter		GCDWQ	MB	WHO	EC	UK DWI		USEPA	SK	AB	ON
	Units	Guideline	MAC : Surface, GUDI	Guideline	Indicator Parameters	Chemical Parameters	Indicator Parameters	Treatment Technique	MAC	MAC	MAC
Acceptability	NTU			5	Acceptable to consumers and no abnormal change.	At the WTP: 4	At consumers' taps: 1				
General Target	NTU	0.1		0.1	For surface water: 1.0 NTU				For source water ≥ 1.5 NTU: 0.3[1,2] For source water < 1.5 NTU: 0.2[1,3] Groundwater: 1.0 A		0.1
Slow Sand, Diatomaceous Earth Filtration	NTU	1[4]	1[4,5]					1[6]	1[1,5]	1[7]	1[8]
Chemically Assisted filtration	NTU	0.3[1]	0.3[1,2]					0.3[9]			0.3[8]
Membrane Filtration	NTU	0.1[10]	0.1[10]					Regulated by state[6]	0.1[10]	0.1[11]	0.1[12]
Particle Count	< 2µm/mL									20[11]	
Cartridge Filtration	NTU							Regulated by state[6]		0.3[13]	0.2[8]
Particle Count	< 2µm/mL									50[13]	
Rapid Sand Filtration	NTU							Regulated by state[6]		0.3[13]	
Particle Count	< 2µm/mL									50[13]	

1 To meet this turbidity in at least 95% of a) measurements made or b) the time each calendar month; never to exceed 1.0 NTU.
2 Does not exceed 0.3 NTU for more than 12 consecutive hours.
3 Does not exceed 0.2 NTU for more than 12 consecutive hours.
4 To meet this turbidity in at least 95% of a) measurements made or b) the time each calendar month; never to exceed 3.0 NTU.
5 Does not exceed 1.0 NTU for more than 12 consecutive hours.
6 To meet this turbidity in 95% of the measurements made per month; never to exceed 5.0 NTU.
7 Exceedance of up to 3 NTU for 3 h/day/filter allowed.
8 To meet this turbidity in 95% of the measurements made per month.
9 To meet this turbidity in 95% of the measurements made per month; never to exceed 1.0 NTU.
10 To meet this turbidity in at least 99% of a) measurements made or b) the time each calendar month; never to exceed 0.3 NTU.
11 Exceedance of up to 0.3 NTU and 50 particles/mL for 15 min/day/filter allowed.
12 To meet this turbidity in 99% of the measurements made per month.
13 Exceedance of up to 1 NTU and 200 particles/mL for 15 min/day/filter allowed.

Appendix Table 9: Radiological Parameters

Parameter		GCDWQ	WHO	EC	UK DWI	USEPA		SK	ON
	Unit	MAC	Guideline	Indicator Parameter	Indicator Parameter	MCLG	MCL	MAC	MAC
Total indicative dose	mSv/year		**0.1**	**0.10**[1]	**0.1**				
Gross alpha	Bq/litre		**0.5**			**0**	**0.56**	**0.1**	
Gross beta	Bq/litre		**1**			**0**	**0.04 mSv/year**[2]	**0.11**	
^{226}Ra, ^{228}Ra	mSv/year					**0**	**0.185**		
^{3}H	Bq/litre	7000	10000	**100**	**100**				7000
Uranium	mg/L					**0**	**0.03**		

Comments:

1 Excluding ^{3}H, ^{40}K, radon and radon decay products.
2 Includes both beta particles and beta emitters.

Values in bold exceed GCDWQ limits.

Appendix Table 10: Additional Radiological Parameters

Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON	Parameter	GCDWQ	WHO	ON
^{7}Be		10000	4000	^{73}As		1000		^{106}Ru		10	10	^{131}I	6	10	6	^{169}Yb			100	^{224}Ra		1	2	^{239}Pu		1	0.2
^{14}C		100	200	^{74}As		100		^{105}Rh		1000	300	^{129}Cs		1000		^{175}Yb		1000		^{225}Ra		1		^{240}Pu		1	0.2
^{22}Na		100	50	^{76}As		100		^{103}Pd		1000		^{131}Cs		1000	2000	^{182}Ta		100		^{226}Ra	0.5	1	0.6	^{241}Pu		10	10
^{32}P		100	50	^{77}As		1000		^{105}Ag		100		^{132}Cs		100		^{181}W		1000		^{227}Ra		0.1	0.5	^{242}Pu		1	
^{33}P		1000		^{75}Se		100	70	^{108m}Ag			70	^{134}Cs		10	7	^{185}W		1000		^{227}Th		10		^{244}Pu		1	
^{35}S		100	500	^{82}Br		100	300	^{110m}Ag		100	50	^{135}Cs		100		^{186}Re		100		^{228}Th		1	2	^{241}Am		1	0.2
^{36}Cl		100		^{81}Rb			3000	^{111}Ag		100	70	^{136}Cs		100	50	^{185}Os		100		^{229}Th		0.1		^{242}Am		1000	
^{45}Ca		100	200	^{86}Rb		100	50	^{109}Cd		100		^{137}Cs	10	10	10	^{191}Os		100		^{230}Th		1	0.4	^{242m}Am		1	
^{47}Ca		100	60	^{85}Sr		100	300	^{115}Cd		100		^{131}Ba		1000		^{193}Os		100		^{231}Th		1000		^{243}Am		1	
^{46}Sc		100		^{89}Sr		100	40	^{115m}Cd		100		^{140}Ba		100	40	^{190}Ir		100		^{232}Th		1	0.1	^{242}Cm		10	
^{47}Sc		100		^{90}Sr	5	10	5	^{111}In		1000	400	^{140}La		100		^{192}Ir		100		^{234}Th		100	20	^{243}Cm		1	
^{48}Sc		100		^{90}Y		100	30	^{114m}In		100		^{139}Ce		1000		^{191}Pt		1000		^{230}Pa		100		^{244}Cm		1	
^{48}V		100		^{91}Y		100	30	^{113}Sn		100		^{141}Ce		100	100	^{193m}Pt		1000		^{231}Pa		0.1		^{245}Cm		1	
^{51}Cr		10000	3000	^{93}Zr		100		^{125}Sn		100		^{143}Ce		100		^{198}Au		100	90	^{233}Pa		100		^{246}Cm		1	
^{52}Mn		100		^{95}Zr		100		^{122}Sb		100	50	^{144}Ce		10	20	^{199}Au		1000		^{230}U		1		Cm		1	
^{53}Mn		10000		^{93m}Nb		1000		^{124}Sb		100	40	^{143}Pr		100		^{197}Hg		1000	400	^{231}U		1000		^{248}Cm		0.1	
^{54}Mn		100	200	^{94}Nb		100		^{125}Sb		100	100	^{147}Nd		100		^{203}Hg		100	80	^{232}U		1		^{249}Bk		100	
^{55}Fe		1000	300	^{95}Nb		100	200	^{123m}Te		100		^{147}Pm		1000		^{200}Tl		1000		^{233}U		1		^{246}Cf		100	
^{59}Fe		100	40	^{95}Zr			100	^{127}Te		1000		^{149}Pm		100		^{201}Tl		1000	2000	^{234}U		1	4	^{248}Cf		10	
^{56}Co		100		^{93}Mo		100		^{127m}Te		100		^{151}Sm		1000		^{202}Tl		1000		^{235}U		1	4	^{249}Cf		1	
^{57}Co		1000	40	^{99}Mo		100	70	^{129}Te		1000		^{153}Sm		100		^{204}Tl		100		^{236}U		1		^{250}Cf		1	
^{58}Co		100	20	^{96}Tc		100		^{129m}Te		100	40	^{152}Eu		100		^{203}Pb		1000		^{237}U		100		^{251}Cf		1	
^{60}Co		100	2	^{97}Tc		1000		^{131m}Te		1000		^{154}Eu		100		^{210}Pb	0.2	0.1	0.1	^{238}U		10	4	^{252}Cf		1	
^{59}Ni		1000		^{97m}Tc		100		^{131m}Te		100	40	^{155}Eu		1000		^{206}Bi		100		^{237}Np		1		^{253}Cf		100	
^{63}Ni		1000		^{99}Tc		100	200	^{132}Te		100	40	^{153}Gd		1000		^{207}Bi		100		^{239}Np		100	100	^{254}Cf		1	
^{65}Zn		100	40	^{99m}Tc			7000	^{125}I		10	10	^{160}Tb		100		^{210}Bi		100	70	^{236}Pu		1		^{253}Es		10	
^{67}Ga			500	^{97}Ru		1000		^{126}I		10		^{169}Er		1000		^{210}Po		0.1	0.2	^{237}Pu		1000		^{254}Es		10	
^{71}Ge		10000		^{103}Ru		100	100	^{129}I		1	1	^{171}Tm		1000		^{223}Ra		1		^{238}Pu		1	0.3	^{254m}Es		100	

All values in Bq/L unless stated otherwise.

Appendix F.

- **City of Brandon Water Utility Master Plan Potential Groundwater Supply Option Review**

City of Brandon
Water Utility Master Plan
Potential Groundwater Supply Option Review
Draft Report

Prepared by: W.L. Gibbons & Associates Inc.
64 St. Andrew Road
Winnipeg, MB R2M 3H6

February, 2013

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1.0 Introduction

W.L. Gibbons & Associates Inc. (WLG) was retained by AECOM to provide hydrogeologic services in association with the assessment of the potential options for the City of Brandon to obtain part or all of its water supply from groundwater sources. The assessment of the groundwater source options is part of an overall Master Plan study being completed by AECOM for the City of Brandon. The purpose of the Master Plan is to assess the current state of the City of Brandon water supply system and provide guidance on the steps that should be taken over the next 10 to 20 years to maintain and improve the water supply system.

It is understood based on information provided by AECOM that the City of Brandons future average day water demand will be 289 Lps. The average day demand is the pumping rate required to meet the cities needs based on the assumption that the water is pumped at a continuous rate for 24 hours per day. This is the equivalent of an annual withdrawal of approximately 9,100 dam^3 per annum. The following assessment of the potential groundwater supply options has been done from the perspective of meeting the average day demand of 289 Lps. If the average day demand can be met, future studies would be required to determine if the peak day demand can be met using groundwater, or if it will be necessary to maintain a blended groundwater/surface water supply system.

The following review of the potential groundwater supply options has been completed in consideration of the fact that this is a Master Planning study. As such, the review of the groundwater supply options has been done on a broad overview basis. The detailed assessment of the available information has not been completed, nor was it required for this study. The detailed assessment of the available information for specific options would be part of future studies implemented as part of the overall Master Plan.

1.1 Background

The City of Brandon has historically obtained its water supply from the Assiniboine River. In addition to this existing surface water supply, since the mid 1990's, the City of Brandon has maintained two groundwater supply wells as an emergency back-up in the event of a problem with the surface water supply. Until recently, the operation of these wells has been limited primarily to annual short term, routine maintenance pumping events to verify the wells still function as intended. In the last few years, longer term pumping (weeks to months) has been done as part of studies to assess the potential to supplement the surface water supply during specific times of the year when surface water quality is poor. It is understood that the results of these longer term tests have been favourable, and that the City of Brandon would like to further pursue developing groundwater as a potential supply.

The operation of these wells has always been done under either short term approvals issued under the Water Rights Act, or more recently under longer term approvals which set specific limits as to the duration and amounts of water that can be pumped. A formal Water Rights License authorizing the long term operation of these wells has never been issued. A primary reason for this is ongoing concerns about the sustainability of any long term withdrawals and potential impacts to existing Third Party groundwater users on the aquifer and associated aquifers. As is outlined in more detail in the following sections, the hydrogeology of the Brandon area is very complex and the recharge/discharge mechanisms active in this aquifer system are not well understood. As such, estimating the long term sustainable yield with a reasonable level of confidence is difficult. Past experience from work on similar complex aquifer systems has shown that it is necessary to conduct long term pumping (years), coupled with a comprehensive monitoring program, to determine the long term sustainable yield (Maathuis and van der Kamp, 2003).

1.2 Information Sources

The sources of information reviewed as part of this assessment include, but are not limited to:

Alley, W., Reilly, T., and Franke, O., 1999. Sustainability of Groundwater Resources. United States Geologic Survey Circular 1186.

Assiniboine Delta Aquifer Management Board, 2005. Assiniboine Delta Aquifer Management Plan.

Bell, Jeff, 2011. Hydrogeology of the Brandon Channel Aquifer as Related to Water Supply, Brandon, Manitoba. Prepared for the GEOHYDRO 2011 conference.

Betcher, R., Grove, G., and Pupp, C., 1995. Groundwater in Manitoba, Hydrogeology, Quality Concerns, Management. National Hydrology Research Institute NHRI Contribution No. CS-93017, March, 1995.

Betcher, R., Matile, G., and Keller, G., 2007. Yes Virginia, There are Buried Valley Aquifers in Manitoba.

KGS Group, 2010. City of Brandon, Integrated Water Sourcing Plan, Final Report, December 2010. Prepared for the City of Brandon.

KGS Group, 2011. City of Brandon, Water Source Review, Final Report, March 2011. Prepared for the City of Brandon.

KGS Group, 2012. City of Brandon Supplemental Groundwater Supply Study East of First Street North – Results of September 2011 Exploration Test Drilling. Prepared for the City of Brandon.

Maathuis, H., van der Kamp, G., 2003. Groundwater Resource Evaluations of the Estevan Valley Aquifer in Southeastern Saskatchewan: A 40 Year Historical Perspective. Prepared for the 56th Canadian Geotechnical Conference.

Oldenborger, G., Pugin, A., Hinto, M., Pullan, S., Russell, H., and Sharpe, D., 2010. Airborne Time Domain Electromagnetic Data For Mapping And Characterization Of The Spiritwood Valley Aquifer, Manitoba, Canada. Geologic Survey of Canada Current Research 2010-2011.

Theis, C., 1935, The relation between lowering the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., Vol. 16, pp. 519-524.

UMA Engineering Ltd., 1997. Simplot Groundwater Study, Brandon, MB. Prepared for Simplot/Kilborn Western Inc.

UMA Engineering Ltd., 2005. Canexus Chemicals Limited, Brandon Chlorate Plant, Freshwater Well System, 2005 Licensing Expansion Assessment Report. Prepared for Canexus Chemicals Ltd.

Wang, J, and Betcher, R., 2011. Groundwater, Drought/Wet Cycle and Climate Change, Southern Manitoba, Canada. Prepared for the GEOHYDRO 2011 conference.

Wardrop Engineering Inc., 1997. Hydrogeological Assessment of Westbran Park and Curran Park Production Wells. Prepared for the City of Brandon.

2.0 Water Rights Licensing Process

The legal instrument to regulate water use and water control in Manitoba is the MB Water Rights Act and Regulations. The water use licensing program is administered by the Water Rights Licensing Branch of MB Conservation and Water Stewardship. Their role is to ensure the optimum development and use of the province's water resources while sustaining the resource base and maintaining environmental quality. Water rights licenses for individual water development projects are issued using administrative rules and procedures provided for by the Act. In general, the construction of works or the use or diversion of water without a license is prohibited. The exception is the use of water for domestic purposes at a rate of less than 25,000 litres per day.

In order to obtain a Water Rights License, the proponent is required to demonstrate that:

a) a well(s) of sufficient capacity for the project can be developed,

b) that the withdrawal is sustainable at the proposed rate, and

c) that the withdrawal will not adversely affect existing groundwater users or the environment.

With regards to the two City of Brandon groundwater supply wells, the full licensing of the wells as a primary source of water has not been possible due to concerns associated with the sustainability of any long term withdrawals, and the potential adverse effects this may have on existing groundwater users.

2.1 Definition of Sustainable Yield

A key component of the Water Rights Licensing process is the need to demonstrate that the proposed withdrawal is sustainable over the long term. This requires an estimate of the sustainable yield of the aquifer(s) being utilized. Given that there is ***no unique, universally accepted definition of the term sustainable yield***, or the associated terms "safe yield" or "groundwater sustainability", some discussion is provided below to define "sustainable yield" as the term is used in this report, and also to clarify the limitations of estimates of sustainable yield.

Alley et al (1999) have defined groundwater sustainability as "development and use of groundwater in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences". They further clarify that "unacceptable consequences" may involve a large number of unquantifiable criteria for which the assessment is largely subjective and therefore will vary from person to person.

Any aquifer system under natural conditions is in a state of approximate dynamic equilibrium. Withdrawals by wells must be balanced by increases in recharge, decreases in discharge, a change in storage, or by a combination of these (Theis, 1935). As such, any groundwater withdrawal will have an effect. However, the degree of the effect may be minimal and/or unmeasureable with respect to the full water balance of the system and therefore of no significant consequence.

Examples of quantifiable criteria that can be objectively assessed include: unacceptable lowering of groundwater levels (ie: such that third party wells are affected); unacceptable water quality changes (ie: saltwater intrusion); or, significant impact on surface water bodies (ie: reduction of base flow).

It is important to note that the estimates of sustainable yield are based primarily on estimates of the rate of recharge or discharge (sustainable systems by definition will have no net changes in long term storage). Recharge and discharge processes are highly variable in time and space and therefore have a high level of uncertainty associated with them. The accurate determination of the yield of an aquifer can only be determined through the long term monitoring of the dynamic response of the aquifer system to the stress of pumping. This monitoring would include water level and water quality monitoring, coupled with regular evaluations to confirm the validity of the initial estimates, and the need to re-evaluate the initial estimate based on the new information. Such an evaluation may include the need to reduce the rate of groundwater withdrawal if long term monitoring results indicates that unacceptable consequences are or may be occurring.

Any decision to develop a water supply from groundwater requires the outlay of capital to construct the infrastructure necessary to extract the water. In addition, once constructed, the community using the water becomes reliant on the water supply being available on an at-demand basis. As such, the consequences of a sustainable yield estimate that is subsequently found to be too high are very significant. The safe approach is to use conservative safe yield estimates in the initial decision making process, with the understanding that the estimate could increase over time as new information on the dynamic response of an aquifer system to pumping is obtained.

3.0 Existing City Supply Wells

The City of Brandon currently has two groundwater supply wells which are connected to the existing water treatment system. The wells are designated as the Canada Games Park well and the Turtle Crossing Park well. The locations of the two wells are shown on Figure 01.

The two wells were established in 1996 as part of a work program to establish an emergency back-up water supply for the City's existing surface water supply. The assessment report (Wardrop Engineering, 1997) associated with these well installations found that they were suitable for use as back-up water supplies in an emergency, with some limitations. Until 2009, the use of the wells has primarily been limited to routine annual short term pumping to confirm the wells are capable of being operated, if required.

3.1 Assiniboine River Valley Aquifer (ARVA)

The existing City of Brandon wells withdraw water from an aquifer designated as the Assiniboine River Valley Aquifer (ARVA, Figure 01). The aquifer consists of fine to very coarse sand and gravel deposits that are fully contained within the Assiniboine River Valley. The aquifer is generally found directly overlying the shale bedrock and is confined by the north and south slopes of the Assiniboine River Valley walls, and an overlying clay layer 10 to 15 meters thick. The aquifer extends from the Little Saskatchewan River to the west to at least as far east as the MB Hydro generating station, east of 17th Street East. The available evidence (KGS, 2011) suggests that the aquifer does not exist further west of the Little Saskatchewan River. The eastern limit of the ARVA has never been fully defined.

Groundwater flow in the ARVA, based on monitoring data from this aquifer, is from west to east. The recharge/discharge mechanisms active in this aquifer have never been fully defined (nor documented). It is generally accepted that recharge is by infiltration of precipitation (and river water) through the confining overburden with higher rates of recharge occurring where the confining overburden is thin such as in locations where "windows" through the confining overburden exist (ie: areas where the sand and gravel is continuous to surface). As is discussed in more detail below, recharge to the ARVA is highly variable on an annual basis, and is very strongly dependant on the precipitation and river level conditions prevailing at the time.

Evidence exists from past work on this aquifer system that a portion of the groundwater within the ARVA discharges downwards into the Brandon Channel Aquifer (BCA) near the MB Hydro generating station. This evidence includes the fact that Koch Chemicals has been pumping from the BCA since the early 1960's and that the chemistry of the groundwater in the BCA has changed in a manner that is indicative of the influx of fresher water from surface or from near surface. Further evidence of an interconnection between the ARVA and the BCA includes the results of a major pumping test conducted in 1996 where a response to pumping from each aquifer was measured in the other aquifer (Wardrop 1997, UMA 1997, UMA 2005). The magnitude of this recharge to the BCA has never been quantified, nor has it been determined how much of it is discharge from the ARVA, and how much is river water, or water from other sources.

More recently (KGS, 2012), investigations in the area west of 1st Street North have been successful in obtaining the significant information on how precipitation and surface water may be recharging to the ARVA and subsequently to the BCA. The information (Figure 02) suggests that a substantial component of the recharge may be due to the recharge of precipitation into the surficial “outwash” sands and gravels that mantle the area and then flow into the ARVA and subsequently the BCA. The results suggest that the direct influx of of water from the Assiniboine River may not be as significant as initially assumed, except when the river is in flood stage and comes into contact with the surficial sands and gravels. If a similar recharge mechanism can be demonstrated elsewhere in the ARVA, and in particular in the area of the existing city wells, substantive progress would be made towards understanding how the aquifer is recharged, the conditions which control the rate of recharge, and the long term sustainable yield.

It is unclear from the available information as to whether any discharge points from the ARVA, other than the infiltration of water downward into the BCA, exist. Typically, in long linear aquifers such as this with recharge at the west end, and a flow direction to the east, it is reasonable to expect that at some point to the east the groundwater pressures would be above grade and water would discharge to surface via springs either to the valley floor or the river itself. There is no known evidence of any springs or discharges to the valley or the river east of Brandon.

As is discussed in Section 2.1, determining the sustainable yield of an aquifer requires a sound understanding of the recharge and discharges mechanisms that are active in the aquifer. Studies to date have been unsuccessful in defining these recharge and discharge mechanisms in a quantifiable manner. In situations such as this, the only means of determining the average annual recharge to the aquifer, and hence the sustainable yield, is to conduct long term pumping tests such as those conducted in 2009 and 2010 (see below) so that the dynamic response of the aquifer to pumping can be measured and the sustainable yield determined.

3.2 Brandon Channel Aquifer

A second major aquifer is present on the east side of the City of Brandon that is designated as the Brandon Channel Aquifer (Figure 01 and 02). The aquifer is comprised of a thick sequence of coarse sands and gravels that overlie the shale bedrock, similar to the ARVA but at depths ranging from 45 to 65 meters. The aquifer is overlain by a thick sequence of clay tills with small interbeds of sand and gravel. The aquifer extends from the Koch Chemical plant/MB Hydro generating station area eastwards past the Canexus plant. Recent investigations (Bell, 2011) indicate that a channel may extend to the southwest. Investigations (KGS 2012, Figure 02) also indicate that the north/northwest limit of the aquifer is beneath or near the Assiniboine River Valley. The eastern and southwestern limits of this aquifer have never been fully defined.

There are currently two major users of the water from this aquifer, Koch Chemicals and Canexus, both of which developed their water supplies in the 1960’s. Maple Leaf Foods has recently initiated the process of investigations and regulatory approvals to develop their own water supply from this aquifer. The Koch Chemicals Water Rights License (expiry date 2018) authorizes the withdrawal of 8,012 dam^3 per annum. The Canexus Water Rights License (expiry date 2016) authorizes the withdrawal of 1,950 dam^3 per annum. It is understood that their current water use rates are at approximately 60% of the full authorized annual limit (Bell, 2011).

The available evidence supports the interpretation that the primary source of recharge, at least in the western and central portions of the aquifer, is the infiltration of surficial and near surface water in the area north of the Koch Chemical Plant (Figure 02). This evidence includes the changes in water quality that have occurred at the Koch plant where the water quality has improved as a result of an influx of fresher water since pumping started in the 1960's. The changes in water quality have not been detected at the Canexus plant, although recent sampling indicates that fresher water may be approaching that area as well (Bell, 2011). At this time, the only known discharge from this aquifer is to the pumping systems operating at the Koch and Canexus plants.

The source of the water at the northern recharge area of the BCA is some combination of water discharging from the ARVA, surface (possibly river) water, and potentially the infiltration of water from the surficial sand and gravel deposits which are present throughout the area east of Brandon. The interconnection between the ARVA and the BCA was demonstrated during the 8 day, large scale pumping tests conducted in 1996 where a response to pumping from each aquifer was measured in the other aquifer (Wardrop 1997, UMA 1997, UMA 2005). As such, any proposed development of the ARVA would have to consider the effects on the BCA and vice versa.

Similar to the ARVA, it has never been possible to estimate the sustainable yield of the BCA due to its complexity and the uncertainties associated with the sources and rates of recharge. Development of this aquifer has proceeded on an incremental basis with smaller scale withdrawals initially authorized, the effects on the aquifer monitored, and additional withdrawals approved once the monitoring data has demonstrated that the prior approved withdrawal rate is sustainable and the potential exists for further increased withdrawals. A similar incremental approach will need to be taken to the development of the ARVA by the City of Brandon.

3.3 Current Hydrogeologic Investigations

In 2009, the City of Brandon retained KGS Group to undertake a hydrogeologic water source review to determine if sufficient groundwater would be available from the existing two city wells to blend with river water to improve the water quality from the City's water treatment plant. This work included long term pumping tests of the city's wells in 2009 and 2010, as well as ancillary hydrogeologic investigations. The results of this work are documented in the KGS Group report entitled "City of Brandon, Water Source Review, Final Report", dated March 2011. Significant findings of this study include:

- The recharge rate of the aquifer was found to be highly variable with an estimated recharge rate of approximately 36.6 Lps obtained from the 2009/10 testing data, and an estimated recharge rate of 95.7 Lps obtained from the 2010/11 testing data. The increase in recharge rates in 2010/11 was attributed to the higher precipitation during the summer of 2010, and the associated increase in river levels.

- Analysis of the pumping tests indicated that a combined continuous pumping rate of 190 Lps could be sustained for in excess of 20 years (ie: linearly extrapolating the rate of observed drawdown forward in time indicates that while water levels would continue to fall during this extended pumping, drawdowns would remain well above the cities pump intakes for at least 20 years). The analysis only considers the rate of withdrawal of water from storage, and does not consider the effects of recharge. As such, the withdrawal is not considered sustainable but the analysis does provide useful information on the potential sustainable yield of the wells.

- If the combined pumping rate is increased to 253 Lps, the water levels decline to the top of the pump intake in 7 months to 2 years. This information suggests that there is an upper bound to the pumping rate at which the wells can be pumped where the effects become significant in the short term.

- Drawdown effects from the cities pumping in 2009 and 2010 were found to not extend east to the Koch and Canexus chemical plant area. It is noted that drawdown effects during the 1996 tests were detectable in the adjoining aquifer. The lack of an observed drawdown effect in 2009 and 2010 is most likely attributable to the fact that the pumping rates in 1996 were substantially higher (596 Lps combined city and Koch pumping versus a current estimated 374 Lps combined pumping rate). These results further indicate that there is an upper limit at which the effects of pumping become significant in the short term.

- The pumping of the city wells has some potential to adversely affect existing groundwater users, most significantly five existing domestic wells to the west of the Turtle Crossing Park Well. Mitigation of these effects will be required if monitoring of groundwater levels finds that an adverse effect has or may occur.

- The study identified a number of potential options to increase the supply capacity of the ARVA, including:

    - Utilizing an aquifer storage and recovery system to supplement the shortfall in average annual recharge by artificially recharging treated river water to the aquifer.

    - Potential additional supply capacity may be available from the ARVA to the east between 1st Street North and the City Bypass Route (PTH 110).

    - Potential additional supply capacity may be available from the ARVA to the west near the area where the Trans-Canada Highway crosses the Assiniboine River Valley. Note: The assessment concluded that wells at this location would likely capture water that normally flows to the existing wells and as such, no "new" water would be available. However wells at this location would reduce the size and depth of the drawdown cone from the existing wells and would therefore reduce the adverse effects.

In 2011, an exploration testing program was conducted in the area between 1st Street North and PTH 110. The results of this investigation are summarized in the KGS Group report entitled "City of Brandon, Supplemental Groundwater Supply Study East of First Street North, Results of September 2011 Exploration Test Drilling" dated January 18, 2012. The results of that study found that an interconnection between the BCA and the ARVA does exist in that area and that there is or likely is a hydraulic interaction between the aquifers, and the groundwater within the shallow sand and gravel deposits in the area. As has been found elsewhere in the ARVA, the river is underlain by clays which would limit the potential direct recharge of river water to the aquifer. In addition, the study found that the potential existed to establish a well in this area with a capacity of 75 Lps or more. However, the sustainability of groundwater withdrawals at that rate, and the potential drawdown/third party well interference effects could not be determined without the installation of a test well and completion of long term pumping coupled with monitoring of groundwater levels and quality.

3.4 Assessment

3.1.1 Existing City Groundwater Supply Wells

It has long been recognized that the Assiniboine River Valley Aquifer is a significant source of groundwater with the capability to be pumped at high rates. However, the complexity of the aquifer has precluded the determination of the sustainable yield of the aquifer and the long term sustainable pumping rate. While the province has maintained a water level monitoring program within the aquifer, the information obtained has been of limited value in advancing the knowledge of the recharge and discharge mechanisms active in this aquifer. This is primarily due to the fact that, in the absence of significant pumping, the aquifer is in a relatively steady state condition and it has not been possible to observe the aquifers response to either changes in the discharge rate (ie: pumping) or changes in the recharge rate due to changing surface conditions (ie: flooding or high precipitation years). It has only been since the implementation of the cities long term pumping tests in 2009 to supplement their surface water supply with groundwater that the actual dynamic response can be measured, and progress made towards determining the sustainable yield of the aquifer. As such it is highly recommended that the city continue with its current program of long term pumping and that this be coupled with a comprehensive monitoring program and annual evaluations to assess the data from the previous year and develop a plan for the following year. Key components of this ongoing work program would include:

- **Annual Pumping Program** – At the start of each year, the information from the previous years pumping should be evaluated in conjunction with the current information of the status of the aquifer, and a plan developed for the coming years pumping program. The target would be to maximize the volume and duration of pumping without causing short term transient effects (ie: adversely affecting existing third party groundwater users) or long term effects (ie: lowering the aquifer to the point that full recovery would take years and therefore future pumping events would be compromised). In addition, once the annual plan is developed, all efforts should be made to operate the wells in accordance with the plan so that the maximum amount of information on the response of the aquifer can be obtained. Any significant changes to the pumping rates during the year could make the assessment of the data accumulated more difficult and therefore could compromise the value of the pumping program. Finally, a comprehensive database of the pumping should be maintained with daily details of which wells are being operated, and the corresponding flow rates.

- **Annual Groundwater Monitoring Program** – The adequacy of the groundwater monitoring program should be reviewed on an annual basis to determine if changes should be made on the basis of the information collected during the previous year. This would include the review of the network of monitoring locations to ensure that they are capturing the required information on groundwater levels, temperature, and water quality changes. Where justified by the information being collected, changes to the monitoring program should be made, including the installation of additional monitoring locations, and changes to the parameters being monitored. All information collected should be compiled in a comprehensive database.

- **Annual Surface Water Monitoring Program** – The information collected to date has shown that the recharge rate to the aquifer is highly variable on a year to year basis, and that it appears to be related to the surface water conditions prevailing in any particular year. A comprehensive surface water monitoring program should be developed and maintained so that the mechanisms that control the rate of recharge can be better understood. This program would include but not be limited to: monitoring of the Assiniboine River levels and water quality; monitoring of the precipitation; monitoring of the shallow groundwater levels in the surficial sand and gravel deposits that may be a source of recharge to the deeper ARVA aquifer. All information collected should be compiled in a comprehensive database.

- **Ongoing Investigation Program** – Where warranted by the results of the monitoring program, follow-up investigations such as test hole drilling programs may be required and an allowance for this should be carried in the annual budget for these activities. A particular focus of these follow-up investigations should be in developing a better understanding of the recharge mechanisms active in this aquifer. For example, if the surface water monitoring program identifies that recharge increases dramatically when a portion of the valley floor is flooded, investigations should be conducted in that area to confirm the means by which this increased recharge occurs.

- **Annual Reporting** – The results of each years pumping and monitoring program should be compiled into a comprehensive annual report complete with a detailed description of the activities undertaken, the results obtained, the assessment of the results particularly with respect to recharge rates, and recommendations for the following years pumping and monitoring program.

All of the above activities should be considered to be a research program designed to obtain the required information on the response of the aquifer to pumping, with the ultimate goal of determining the rate at which the aquifer can be pumped on a long term sustainable basis. As the work is of a research nature, it is imperative that a qualified person be retained to complete the ongoing assessments and help guide the work program to a successful conclusion.

3.4.2 Other ARVA Groundwater Sources

The work to date has identified that it may be possible to develop additional groundwater supply wells within the ARVA to supplement the existing supply. As outlined in Section 3.3, this includes the ARVA between 1st Street North and PTH 110, and the west portion of the ARVA near the Trans-Canada Highway Crossing. Of these options, the site to the east of 1st Street North has the greatest potential as a source of additional water. The installation of a test well and the completion of a long term (multi-year) pumping test complete with a comprehensive monitoring program would be required to determine the sustainable yield and long term sustainable pumping rate from this site.

4.0 Groundwater Supply Options

The following provides an overview of the hydrogeology of Southwest Manitoba and the potential sources of groundwater within the area. The information provided is general in nature and if any options are to be pursued further, a more detailed assessment would need to be done.

4.1 Bedrock Aquifers

Southwestern Manitoba from the Portage La Prairie area to the Saskatchewan border is underlain by a thick sequence of shales that, with the exceptions noted below, has limited permeability and therefore limited potential to contain groundwater resources that can be extracted in useful quantities. Permeable sandstone aquifers, such as the Swan River Formation and the Winnipeg Formation, do exist at depth beneath the shales. However, they contain saline groundwater which cannot be used without extensive treatment. As such, the top of the bedrock sequence is generally considered the base of exploration for potable groundwater supplies. The exception to this includes the following:

- **Odanah Shale Aquifer** – Within the shale sequence are hard brittle, siliceous shales which can be heavily fractured and contain open joints and bedding planes that are transmissive to water. The Odanah Shales (Figure 3) are present both to the north and south of the City of Brandon but not directly beneath it. Well yields in this aquifer are generally low and suitable primarily for domestic wells. Total dissolved solids concentrations vary from 500 to 9,000 mg/l ((Betcher, Grove and Pupp, 1995) with the better quality water obtained in areas were the overburden cover is thin and local recharge can occur. It is considered very unlikely that a groundwater supply system of a capacity suitable for the City of Brandons water supply requirements could be developed in the Odanah Shale Aquifer, due primarily to the difficulty in establishing wells of significant capacity, and concerns about sustainability of any withdrawal.

- **Boissevain and Turtle Mountain Formation Aquifers** – The Boissevain and Turtle Mountain Formation Aquifers (Figure 3) are found in the Turtle Mountain Uplands. The formations consist of sand with varying amounts of silt and clay. The yields of wells established within these formations is generally low with a maximum reported well yield of 5.5 Lps (Betcher, Grove and Pupp, 1995). The potential well yields are considered to be too low to be suitable for use as part of the City of Brandon water supply.

4.2 Sand and Gravel Aquifers

Groundwater is available from sand and gravel deposits found within the overburden profile throughout Southwestern Manitoba. These deposits are found both at surface and at depth. The major sand and gravel aquifers are as follows:

4.2.1 Assiniboine Delta Aquifer

The single largest source of groundwater in the City of Brandon Area is the Assiniboine Delta Aquifer (ADA, Figure 4). The ADA is a extensive sand and gravel deposit deposited by the Assiniboine River into glacial Lake Agassiz. The deposits extend over an area of 3,800 km^2 from just east of the Brandon city limits to near MacGregor, MB. The aquifer has approximately 15,000,000 dam^3 of groundwater in storage at any time (Assiniboine Delta Aquifer Management Plan, May 2005). Recharge is by infiltration of precipitation onto the aquifer. Discharge is to the numerous waterways that drain the area.

The aquifer has been sub-divided into 13 sub-basins based on the interpreted groundwater flow directions in each sub-basin. On the basis of studies completed in the 1980's, allocation limits were established for each sub-basin. These allocation limits are based primarily on detailed studies of the Pine Creek area, with the estimated average annual recharge rate from that study applied to all sub-basins on the basis of the surface area of the sub-basin.

The closest sub-basin to the City of Brandon, and the most readily accessible is the Assiniboine West Sub-basin which includes the Shilo area as well as a significant portion of the Spruce Woods Provincial Forest. At the time the allocation limits were set, the Spruce Woods Provincial Forest and CFB Shilo areas were considered unavailable for development. Therefore any recharge that may occur in these areas was neglected in the calculation of the allocation limit for the Assiniboine West Sub-basin. The current allocation limit for the Assiniboine West Sub-basin is 5,092 dam^3 per annum (the equivalent of a continuous pumping rate of 161 Lps). Of this total water available for allocation, almost the entire amount has been allocated to a single user. There is also a waiting list of 13 applicants for a Water Rights License on this sub-basin, including an application made by the City of Brandon in September 2011 for 7,400 dam^3 per annum. The City of Brandon is the most junior applicant. If water came available for allocation on this sub-basin, the more senior applicants would likely be given priority.

Water could come available in the sub-basin if the allocation limits were raised. Wang and Betcher (2011) have noted that the original allocation limits were developed in the 1980's and early 1990's when groundwater levels were declining due to the prolonged drought that occurred at that time. Since then, several wet and dry cycles have occurred and significant additional data has been obtained on the long term average recharge rates. If average recharge rates over the entire period of record were now considered, the rate would likely be greater than the early estimates. If the same water allocation policies were used, the result would be an increase in the allowable withdrawal volumes. At this time, there is no known formal timeframe for the province to conduct such a review of the recharge rates and update the allocation limits.

The need for a review of the allocation limits for the Assiniboine West Sub-basin is highlighted by the current situation for allocation in that sub-basin. Prior to the setting of the allocation limits, Water Rights Licenses had already been issued that exceeded that allocation limit. In recognition of the fact that the water user had licenses prior to the setting of the limits, and that the pumping was not having an effect on water levels in that sub-basin, a series of temporary authorizations has been issued to that user which allow pumping in excess of the allocation limit. The total volume of water use under these authorizations is 822 dam^3 per annum (the equivalent of a continuous pumping rate of 31 Lps). The fact that groundwater has been pumped from this sub-basin at rates in excess of the allocation limits without adversely affecting the water levels is further reinforcement of the interpretation by Wang and Betcher (2011) that the original estimates of recharge were conservative, and that the actual long term average annual recharge rate, based on the information available now, is higher.

Assuming that the allocation limits for the sub-basin are not changed, there are two other potential options for the City to access water from this sub-basin. These include:

- The Spruce Woods Provincial Forest area was specifically excluded from the calculation of the allocation limits because it was considered unavailable for development. If the City could get approval from the province to develop a water supply within the provincial forest, and the province was prepared to issue a Water Rights License for this, a significant volume of water could potentially be accessed.
- The Water Rights Act does allow for the transfer of an existing Water Rights License in certain situations. Approval of the Minister is required before the transfer can occur. Given that the majority of the water in this sub-basin has been allocated to a single user, the potential exists for the city to obtain access to the water by acquiring the existing Water Rights Licenses. Discussions with the regulators are strongly recommended to confirm that the Minister will approve the transfer of the licenses, or if there are any other regulatory mechanisms that would allow the transfer of the Water Rights License. It is noted that the user in question has Water Rights Licenses authorizing the annual withdrawal of approximately 5,092 dam^3 per annum (the equivalent of a continuous pumping rate of 161 Lps), excluding the temporary authorizations (822 dam^3/annum, 31 Lps).

4.2.2 Oak Lake Aquifer

The Oak Lake Aquifer (Figure 05) is a 2,070 km^2 surficial sand and gravel deposit located west of Souris, MB and approximately 32 km, to its eastern limit, from the City of Brandon. The aquifer is comprised of fine to medium sand with some coarser sands and gravels near its western margin. Similar to the ADA, recharge to the aquifer is by direct infiltration of precipitation. Discharge is to the water courses that drain the area.

The allocation limit for this aquifer is 9,250 dam^3 per annum. The limit was set at approximately the same time as the ADA limits using the same methodology, and as such may be conservative. Development of this aquifer has been limited due primarily to the relatively thin saturated thickness which limits the potential to develop high capacity wells. Some potential does exist to develop high capacity wells in the portion of the aquifer located approximately 115 kms from the City. However, the development of a groundwater withdrawal system of the magnitude required by the City would result in extensive drawdown effects, and the associated third party and environmental effects.

Based on the difficulty in developing wells of suitable capacity, the likely third party and environmental effects, and the length of pipeline that would be required to deliver the water to the city, the potential to obtain water from the Oak Lake Aquifer is considered to be very low.

4.2.3 Margaret-Killarney-Cartwright Aquifer Complex

The Margaret-Killarney-Cartwright Aquifer Complex (Figure 06) is an assemblage of sand and gravel deposits located a distance of 60 to 100 kms southeast of the City of Brandon. The aquifer complex is 15 to 20 kms wide and has been interpreted to be the northern extension of the major Spiritwood Aquifer system which extend up to 500 km to the south into the United States (Geologic Survey of Canada, 2010). The core of the aquifer complex consists of sands and gravels deposited within a buried valley eroded into the shale bedrock which is overlain by glacial tills with intertill sand and gravel layers.

Past work in the area has found locations showing potential for high yield wells capable of producing 76 L/s. This includes the recent development of a water supply for the Municipality of Killarney-Turtle Mountain with wells capable of being pumped at 62 Lps for a total approved withdrawal rate of 925 dam^3 per annum. Development of the aquifer system has been limited due primarily to the low demands for water in the area. Because of this low demand, only a limited amount of work has been done to investigate this aquifer system and determine its potential capacity for larger scale water withdrawals. Given the size of the aquifer system, and that high capacity wells have been successfully developed in it, the potential does exist for it to be utilized as a possible source of water for the City of Brandon. Pursuing this potential source as an option would require a substantive groundwater exploration program to define the aquifer limits and characteristics, identify areas suitable for the development of high capacity wells, and the completion of significant testing to confirm that the withdrawal rate is sustainable. As with all such groundwater exploration programs, there would be no guarantees that the work would result in the development of a water supply suitable for Brandons needs.

4.2.4 Other Aquifers Within The Assiniboine River Valley

The Assiniboine River Valley Aquifer from which the City of Brandon currently withdraws water is one of a series of similar aquifers contained within the river valley upstream of the city. For example, water supply systems are currently being operated from very similar deposits within the valley at Virden and at the RM of Wallace near the Saskatchewan border. In general, the extents of these deposits and their potential to be developed as water supplies have never been investigated to any significant degree, nor are there maps available which show the locations of any potentially suitable aquifers. However, databases do exist which contain the information from previous drilling within the valley upstream of the city that may be useful in identifying potentially suitable alternate aquifers that could be developed. The first step in assessing whether potentially suitable aquifers exist would involve the commissioning of a study to review these databases to identify areas with enough potential to warrant follow-up investigations. The second step would be to complete follow-up investigations consisting initially of test hole drilling to confirm that the geology is suitable to host an aquifer of sufficient size, and then the installation of pumping wells and the completion of the necessary tests to confirm the presence of a suitable aquifer and obtain information on the potential yield. As with all such groundwater exploration programs, there would be no guarantees that the work would result in the development of a water supply suitable for Brandons needs.

4.2.5 Buried Valley Aquifers

Buried valley aquifers consist of sand and gravel deposits deposited in valleys eroded into the bedrock surface and then subsequently covered by glacial till and other sediments. These deposits form significant aquifers in Saskatchewan and Alberta and are known to be present in Manitoba. However, less exploration for these aquifers has been done in Manitoba due primarily to the greater abundance of shallow sand and gravel and bedrock aquifers. Significant known buried valley aquifers in Southwestern Manitoba include the Medora-Waskada Channel, the Pierson Valley, the Qu-Appelle/Assiniboine River Valleys, and the Hatfield-Rocanville Aquifer Systems (Betcher, Matile and Keller, 2007).

A significant issue with buried valley aquifers is that it is vey difficult to predetermine the sustainable yield of these aquifers. Case studies (ie: Maathuis and van der Kamp, 2003) have shown that the yield of these aquifers can only be reliably determined after the aquifer has been pumped for long periods of time (often years) and the response of the aquifer monitored and evaluated to determine the long term recharge rate. Case studies have also shown that where the initial estimates of recharge rates are too high, it has been necessary for the proponent to reduce and even stop pumping. Given the risks associated with developing these types of deposits, consideration of pursuing these deposits as a source should be approached with a high level of caution.

5.0 Recommendations

From the preceding assessment of the potential groundwater supply options available to the City of Brandon, it is clear that there is no single source of groundwater that is likely to be able to meet the cities future average day demand of 289 Lps. However, the potential does exist to develop multiple groundwater sources that may be capable of meeting this demand. In all cases, there is a considerable amount of study that needs to be done before the availability of groundwater can be confirmed.

5.1 Existing City Groundwater Supply Wells

The results of the pumping program from the existing city wells initiated in 2009 indicate that the potential exists to withdraw a significant volume of groundwater from these two wells. Based on the cursory projection of the measured drawdown rates to date, there are indications that up to 190 Lps could be withdrawn for a period of in excess of 20 years. The analysis only considers the withdrawal of groundwater from storage in the aquifer, and neglects the effects of recharge. Long term pumping coupled with a comprehensive monitoring program are required to determine if that rate is sustainable, and it is recommended that the city continue its current testing program so that the required information to determine sustainability is obtained.

As the wells are established and are connected to the existing water treatment plant, the costs of undertaking this long term study is limited to the operating costs of the wells, the costs to complete the monitoring program, and the costs to retain the services of a qualified person to oversee the work and complete the annual evaluations of the data (as outlined in Section 3.4.1).

5.2 Assiniboine Delta Aquifer

Based on current provincial water allocation policies, there is little to no groundwater available for new allocations within the Assiniboine Delta Aquifer. However, there are three potential scenarios where the City of Brandon may be able to get access to groundwater from the aquifer that are worth pursuing. They are:

- Within the Assiniboine West Sub-basin of the ADA, almost all of the water available for allocation has been assigned to a single user. The provincial Water Rights Act does allow for the transfer of Water Rights Licenses in certain situations. If a suitable arrangement can be made with the existing licensee, the City could potentially have access to 161 Lps of groundwater. Note: The hydrogeology of the ADA is well understood and as such, this volume of water is considered to be a firm, sustainable yield. As such, capital funds expended to develop this source would not be subject to the risks associated with developing the other alternative sources. It is recommended that the potential to access these Water Rights Licenses be investigated. One of the first steps would be to determine the potential costs of acquiring these licenses, and discussions with the provincial regulators to confirm that the licenses would be transferred to the city (the transfer of licenses is at the discretion of the Minister and is not guaranteed). Approximately 20 to 25 kilometers of pipeline would be required to develop this option. There a number of potential scenarios under which a suitable arrangement could be made with the existing user, including but not limited to:

- Outright purchase of the lands and the business being operated on the lands. This is the most common scenario under which licenses are transferred.

- Acquisition of the Water Rights for the groundwater by providing the existing user with water from the Assiniboine River to replace the groundwater being used. In a situation like this, the City of Brandon would be responsible for all costs associated with developing the surface water pumping infrastructure for the existing user.

- When the allocation limits were set for the Assiniboine West sub-basin, the area underlying the Spruce Woods Provincial Forest was specifically excluded from the calculation of the allocation limits because it was considered unavailable for development. If the City could get approval from the province to develop a water supply within the provincial forest, and the province was prepared to issue a Water Rights License for this, a significant volume of water could potentially be accessed. Discussions with the appropriate provincial representatives would be required in order to further investigate this as a potential option. Approximately 30 to 50 kilometers of pipeline would be required to develop this option.

- The allocation limits for the ADA were set in the mid-1980's when recharge rates to the aquifer were low due to the prolonged drought prevailing at that time. Current research (Wang and Betcher, 2011) indicates that a recalculation of the recharge rates with the information accumulated since that time would likely result in an increase in the allocation limits. If the province were to conduct this reevaluation, the potential exists that the City may be allowed to access the aquifer for groundwater. However, it should be noted that there is a waiting list for Water Rights licenses on the Assiniboine West sub-basin, and the more senior applicants would likely be given priority over the City of Brandons application.

5.3 Other Wells in the ARVA

Investigations to date (KGS, Jan. 18, 2012) have found that there is the potential to develop additional groundwater supply wells within the Assiniboine River Valley Aquifer at other locations. The highest potential identified to date is in the area between 1st Street North and PTH 110. Preliminary indications are that it may be possible to develop a well at this location with a capacity of 75 Lps. However, as with the two existing city wells, there are concerns with the potential to adversely affect existing groundwater users and the long term sustainable yield is unknown. Determining the long term rate at which a well at this location could be pumped would require long term pumping complete with a comprehensive monitoring program. If the groundwater from the ADA could be acquired, and the pipeline was routed near this location, a pumping well could be installed and a long term multi-year pumping test completed, similar to that currently being undertaken for the two existing city wells.

5.4 Summary

Conceptually, the City of Brandons average day water supply need could be met by operating the existing two city wells, and acquiring access to groundwater from the Assiniboine Delta Aquifer. The key steps in confirming the viability of this include: completing the multi-year studies required to confirm the sustainable yield of the two existing city wells; and obtaining access to groundwater from the Assinboine Delta Aquifer by one of a number of options.

Assiniboine River

If a pipeline were built to access groundwater from the Assiniboine Delta Aquifer, and it was routed near the Assiniboine River Valley Aquifer, it would be possible to investigate the potential to develop additional wells within the ARVA to the east of the existing wells. If these investigation were successful, the potential could exist to develop additional groundwater supplies and/or pumping capacity.

6.0 Closure

The information and data contained in this report, including without limitation the results of any sampling and analyses conducted by W.L. Gibbons & Associates Inc. (WLG) pursuant to its agreement with the Client, has been developed or obtained through the exercise of WLG's professional judgement and are set forth to the best of WLG's knowledge, information and belief. Although every effort has been made to confirm that this information is factual, complete, and accurate, WLG makes no guarantees or warranties whatsoever, whether expressed or implied, with respect to such information or data.

WLG shall not by act of issuing this report be deemed to have represented thereby that any assessment conducted by it have been exhaustive or will identify all risks associated with the development of water supplies within the study area. Persons relying on the results thereof do so at their own risk.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the Client, their officers and employees, and others having legitimate business relations with the Client. Any such use and reliance shall be subject to the limitations set forth in the preceding paragraphs.

Respectfully Submitted.

W.L. Gibbons & Associates Inc.

Steve Wiecek, P.Geo., P.Eng.
Senior Geologic Engineer

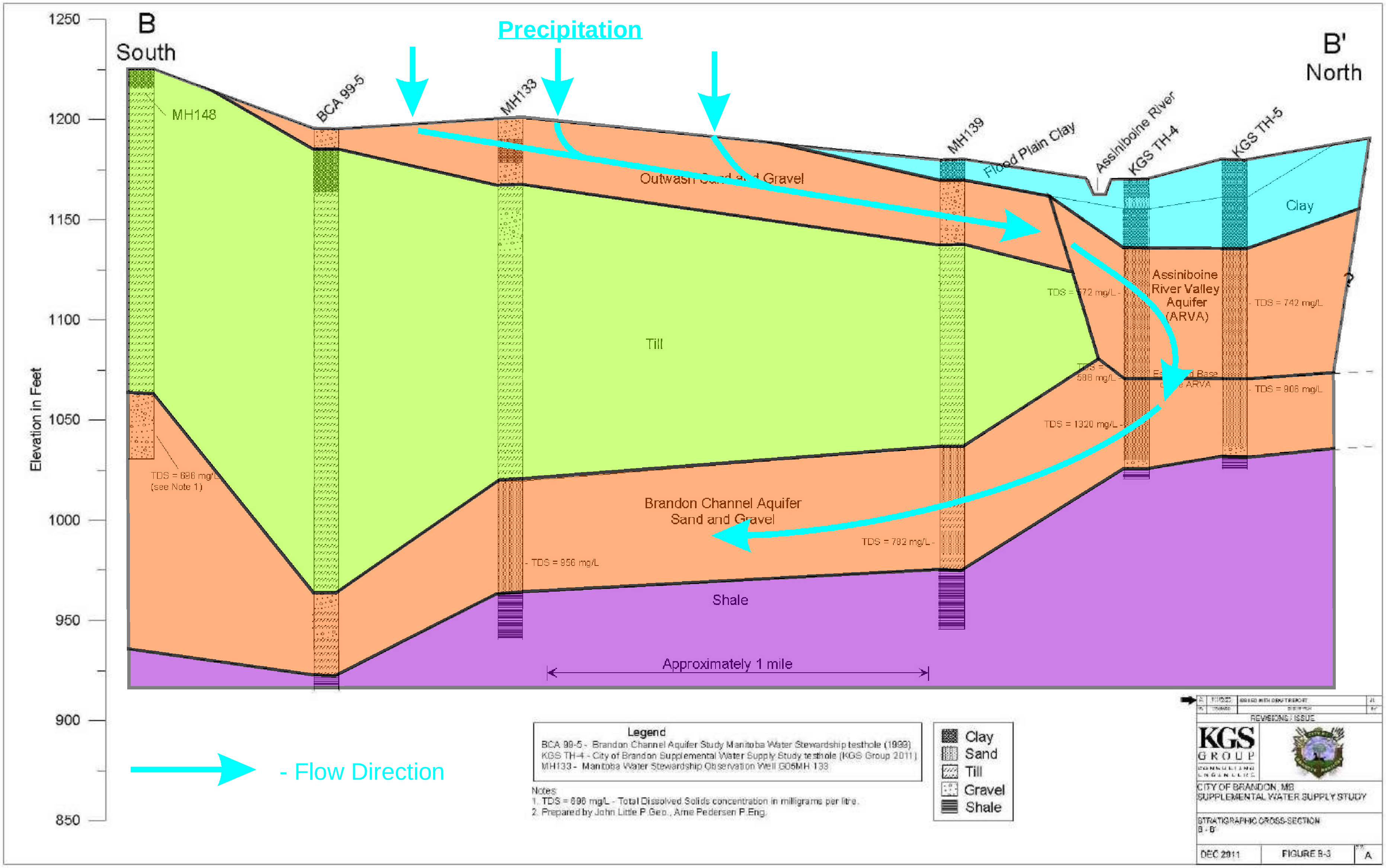
Figures

W. L. GIBBONS & ASSOC. INC.

HYDROGEOLOGY - GEOLOGICAL ENGINEERING

Designed By: BW
Approved By: SW
Date: 02/13

City of Brandon
Water Supply Master Plan
Existing Supply Wells
Figure No. 1



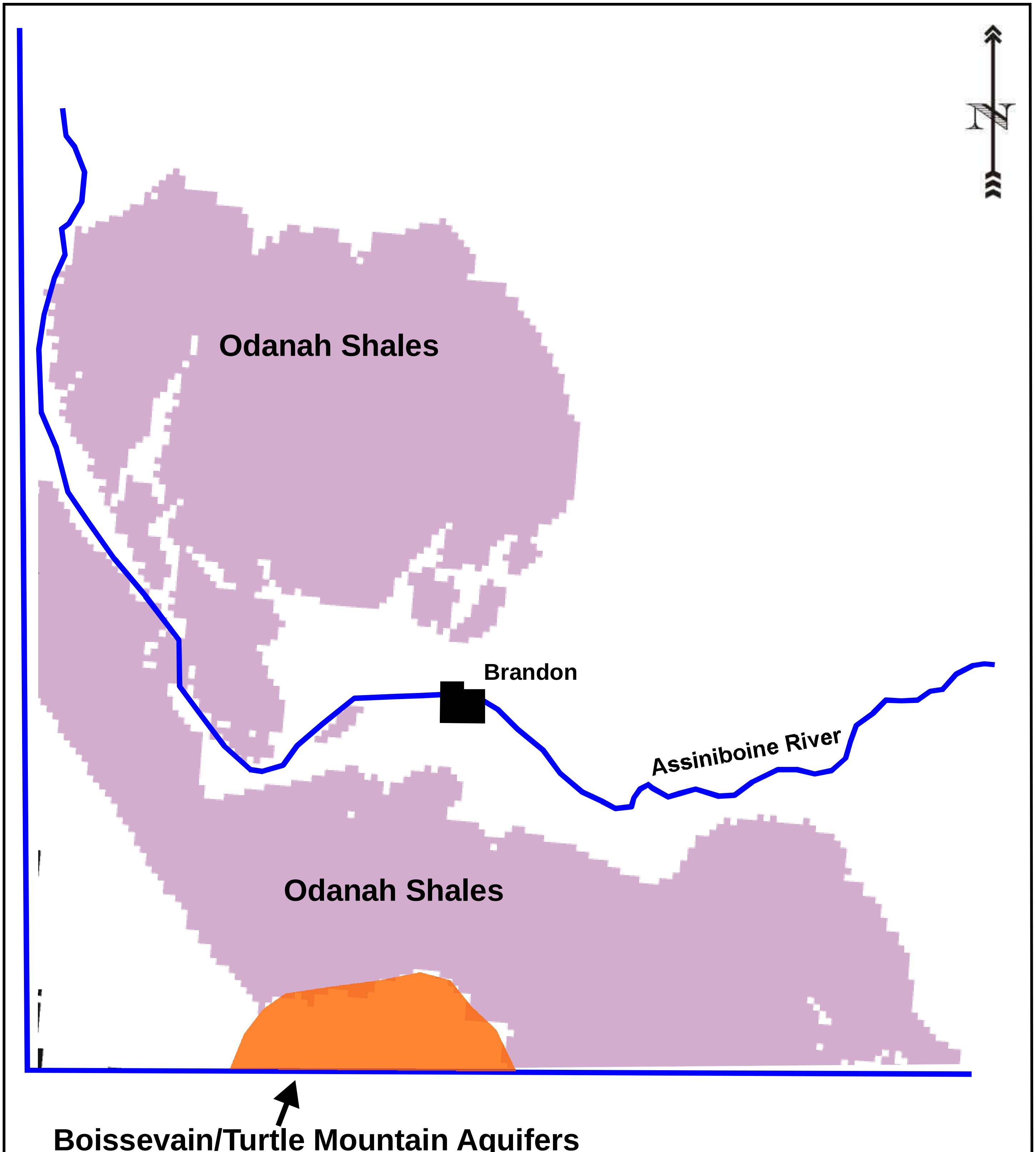
Source: KGS, 2012

City of Brandon
Water Supply Master Plan
Geologic Cross-section

W. L. GIBBONS & ASSOC. INC.
HYDROGEOLOGY - GEOLOGICAL ENGINEERING

Designed By: BW
Approved By: SW
Date: 02/13

Figure No. 2



City of Brandon
Water Supply Master Plan

Bedrock Aquifers

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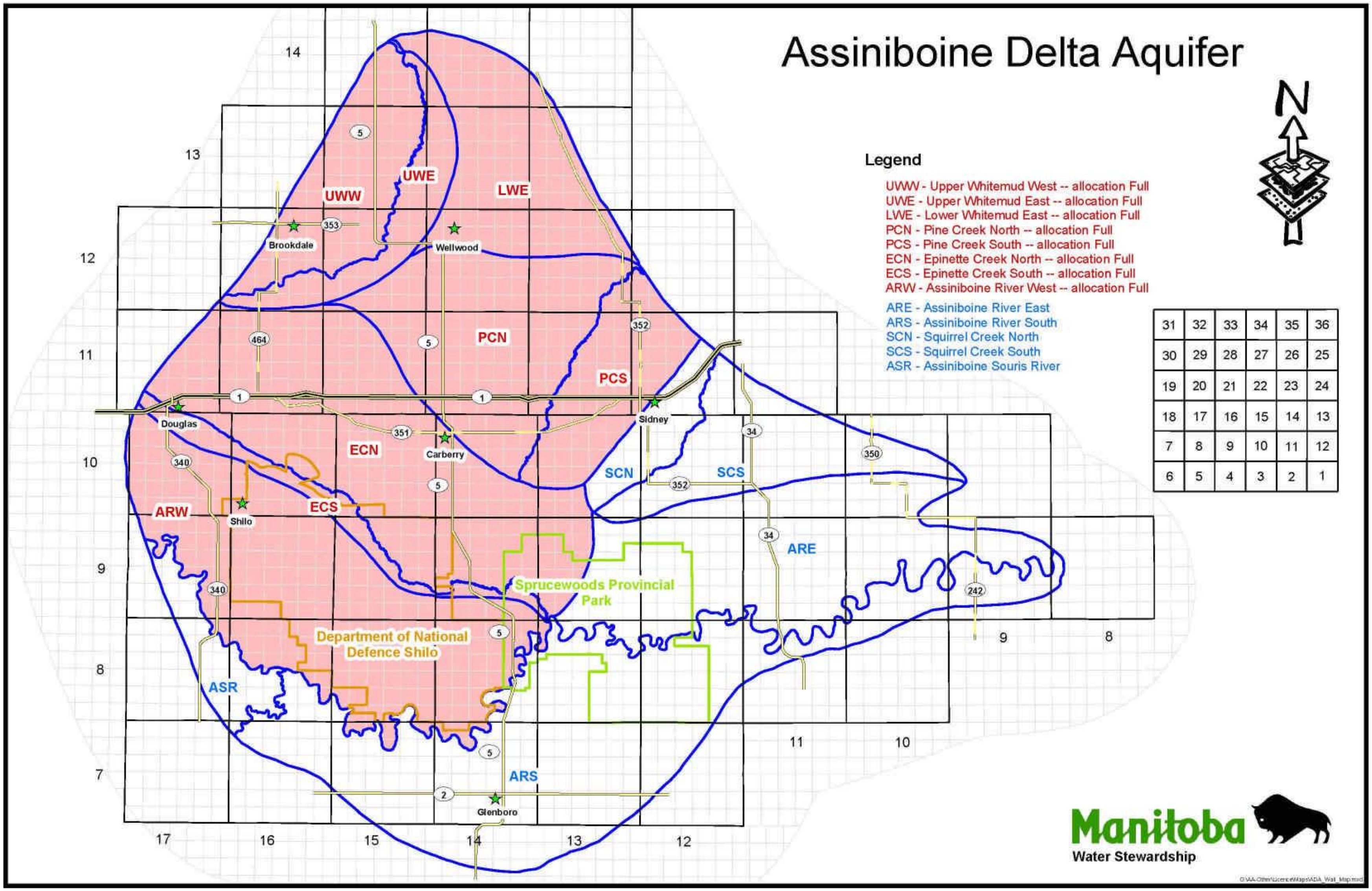
HYDROGEOLOGY - GEOLOGICAL ENGINEERING

Designed By: BW
Approved By: SW
Date: 02/13

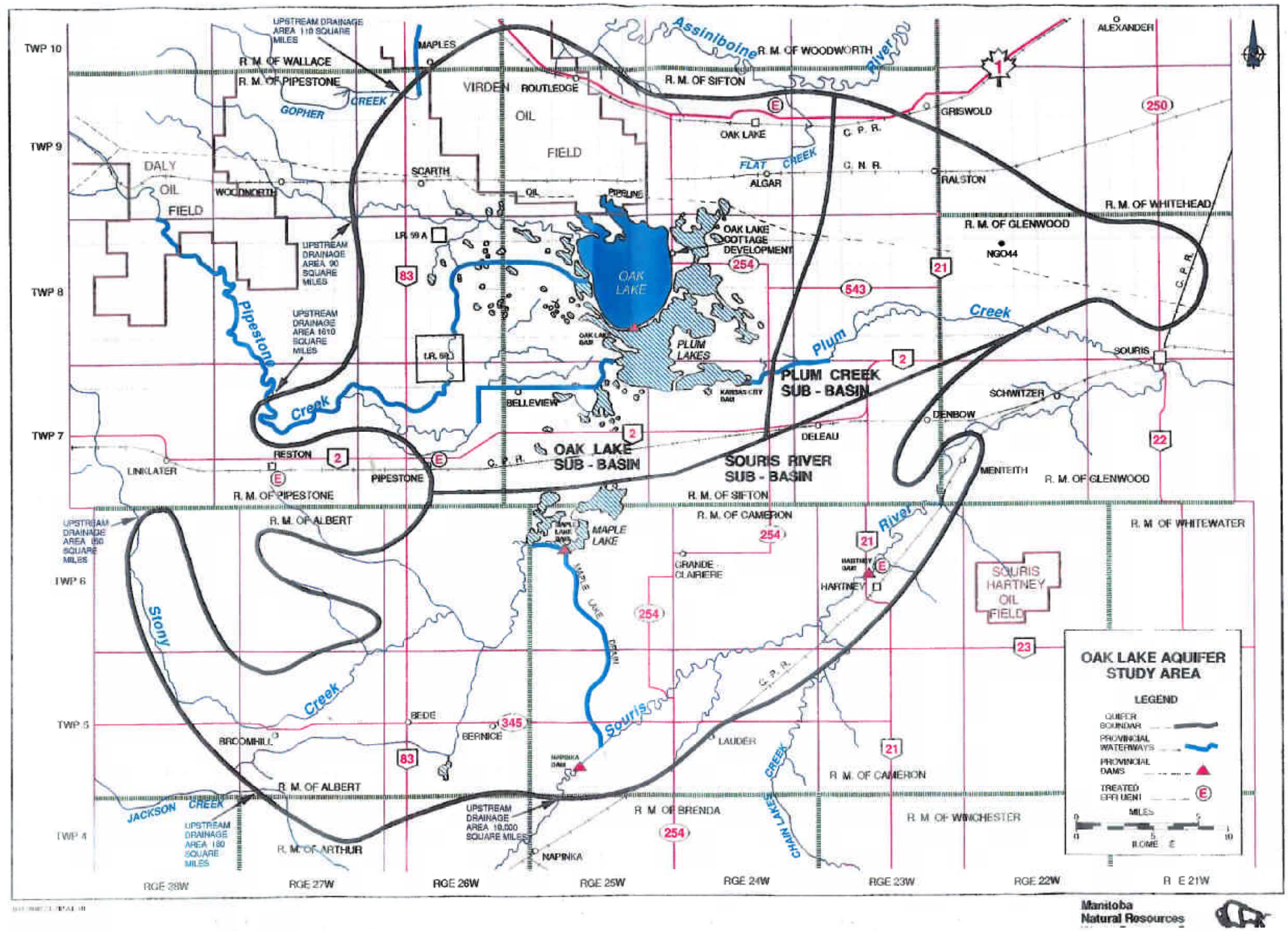
Figure No. 02



City of Brandon
Water Supply Master Plan
Assiniboine Delta Aquifer
Figure No. 4

W. L. GIBBONS & ASSOC. INC.
HYDROGEOLOGY - GEOLOGICAL ENGINEERING

Designed By: BW
Approved By: SW
Date: 01/09



City of Brandon
Water Supply Master Plan
Oak Lake Aquifer

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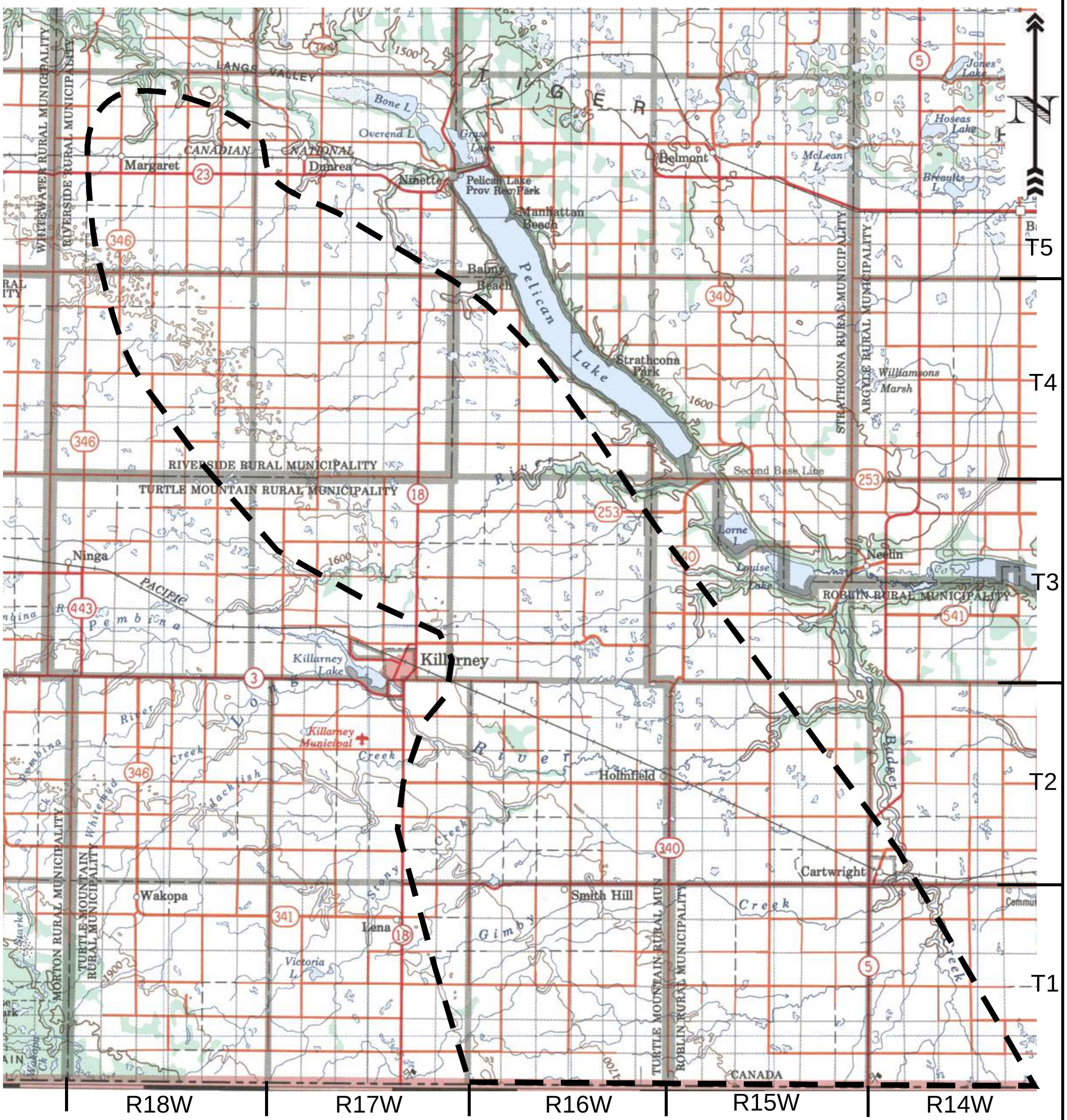
Approved By: SW
Date: 02/13

Figure No. 5



- Approximate Limit of Cartwright - Killarney - Margaret Aquifer Complex

Source: Cochrane, 2004

0 5 10 15
kms

City of Brandon
Water Supply Master Plan
Cartwright - Killarney - Margaret Aquifer Complex

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HYDROGEOLOGY - GEOLOGICAL ENGINEERING

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Approved By: SW
Date: 02/13

Figure No. 6

Appendix G.

- **Triple Bottom Line Raw Water Source Option Score Sheets**

City of Brandon WTP Master Plan
Summary of Total Triple Bottom Line Scores

				Option 1 Assiniboine River		Option 2 Groundwater (Koch)		Option 3 Groundwater (Shilo)		Option 4 Blend Koch + Assiniboine River		Option 5 Blend Shilo + Assiniboine River	
				Total TBL Score	0.0	Total TBL Score	75.9	Total TBL Score	-51.4	Total TBL Score	-8.2	Total TBL Score	-74.4
Criterion Abbrev	**Criterion**	**Overall Weight**	**Importance in Index**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**
F-1	Capital Cost	17.8	High	0.0	0.0	-1.0	-17.8	-4.0	-71.1	-1.0	-17.8	-3.0	-53.3
F-2	O&M Cost	4.4	Low	0.0	0.0	2.0	8.9	4.0	17.8	1.0	4.4	3.0	13.3
F-3	Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	4.4	Low	0.0	0.0	2.0	8.9	3.0	13.3	0.0	0.0	0.0	0.0
F-4	Dependence on Commodities that are Subject to Market Variability	8.9	Medium	0.0	0.0	3.0	26.7	4.0	35.6	1.0	8.9	4.0	35.6
F-5	Capital Costs Eligible for Potential External Funding	4.4	Low	0.0	0.0	3.0	13.3	-2.0	-8.9	2.0	8.9	-1.0	-4.4
	Subtotal	**40.0**			**0.0**		**40.0**		**-13.3**		**4.4**		**-8.9**
E-1	Water Quality	3.3	Low	0.0	0.0	2.0	6.7	4.0	13.3	1.0	3.3	2.0	6.7
E-2	Water Supply Capacity	13.3	High	0.0	0.0	-2.0	-26.7	-4.0	-53.3	-1.0	-13.3	-2.0	-26.7
E-3	Water Supply Contamination	6.7	Medium	0.0	0.0	4.0	26.7	2.0	13.3	0.0	0.0	0.0	0.0
E-4	Water Supply Flood Risk	3.3	Low	0.0	0.0	4.0	13.3	4.0	13.3	0.0	0.0	2.0	6.7
E-5	Sustainable Outcomes	3.3	Low	0.0	0.0	4.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**30.0**			**0.0**		**33.3**		**-13.3**		**-10.0**		**-13.3**
S-1	Consistent with the City's Vision	2.6	Medium	0.0	0.0	2.0	5.2	-2.0	-5.2	1.0	2.6	-2.0	-5.2
S-2	Public Safety	5.2	High	0.0	0.0	2.0	10.4	4.0	20.9	0.0	0.0	1.0	5.2
S-3	Staff Safety	5.2	High	0.0	0.0	1.0	5.2	4.0	20.9	0.0	0.0	0.0	0.0
S-4	Quality of Community Life	1.3	Low	0.0	0.0	2.0	2.6	1.0	1.3	0.0	0.0	0.0	0.0
S-5	Public Acceptance	5.2	High	0.0	0.0	1.0	5.2	-4.0	-20.9	0.0	0.0	-4.0	-20.9
S-6	Regional and Socio-economic growth	5.2	High	0.0	0.0	-4.0	-20.9	-4.0	-20.9	0.0	0.0	-2.0	-10.4
S-7	Impacts During Construction	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-8	Land Use	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-9	Licencing	5.2	High	0.0	0.0	-1.0	-5.2	-4.0	-20.9	-1.0	-5.2	-4.0	-20.9
	Subtotal	**30.0**			**0.0**		**2.6**		**-24.8**		**-2.6**		**-52.2**
	Total	**0.0**			**0.0**		**75.9**		**-51.4**		**-8.2**		**-74.4**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 1 - Basecase: Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Financial	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	44.4%	17.8%	Prorated based on capital cost	0.0	0.0
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Low	1.0	11.1%	4.4%	Prorated based on NPV of O&M cost	0.0	0.0
	F-3 Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	Capital costs in 2013 dollars for 25% capacity upgrade and CEC limit. The goal is to minimize the costs of a possible future expansion	Low	1.0	11.1%	4.4%	Prorated based on additional capital cost	0.0	0.0
	F-4 Dependence on Commodities that are Subject to Market Variability	20 year net present value of commodities (chemicals, electricity, fuels). The goal is to reduce risks associated with dependence on commodities that are subject to fluctuating prices. If long term contracts are available where pricing is assured, risks for unforeseen costs are reduced.	Medium	2.0	22.2%	8.9%	The required use of power, fuel and chemicals and the potential length and cost of contracts. Options lower in NPV than the base case are awarded a positive score	0.0	0.0
	F-5 Capital Costs Eligible for Potential External Funding	Potential for external funding of capital and or generation of revenue. The goal is to maximize the opportunity for external funding.	Low	1.0	11.1%	4.4%	Qualitative assessment. Options higher in the ability to achieve funding (i.e., regional systems) are awarded a positive score.	0.0	0.0
	Subtotal			9.0	100.0%	40.0%			0.0
Environmental	E-1 Water Quality	Ability to achieve a higher treatment standard without additional capital costs (qualitative)	Low	1.0	11.1%	3.3%	Qualitative assessment of the expected water quality from each source. It is recognized that all feasible options will meet regulatory requirements.	0.0	0.0
	E-2 Water Supply Capacity	The goal is to minimize the risk associated with obtaining the necessary water quantity.	High	4.0	44.4%	13.3%	Qualitative assessment of the capacity of each water source. Options that have unknown capacities or capacities that limit growth are awarded a negative score.	0.0	0.0
	E-3 Water Supply Contamination	The goal is to minimize risk associated contamination of the water supply.	Medium	2.0	22.2%	6.7%	Qualitative estimate of the risks associated with contamination of the water supply. Options with less risk than the base case will be awarded a positive score.	0.0	0.0
	E-4 Water Supply Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	11.1%	3.3%	Qualitative estimate of the risks associated with flooding. Options that result in a treatment facility constructed in outside the flood plain will be awarded a positive score compared to the base case	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 1 - Basecase: Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Environmental (Continued)	E-5 Sustainable Outcomes	Some options will require the City to provide reclaimed water to industry to off-set groundwater consumption. This in-turn will result in a reduction in overall effluent discharged to the Assiniboine River. The goal is to minimize the impacts to the River and have a "zero discharge" from wastewater facility.	Low	1.0	11.1%	3.3%		0.0	0.0
	Subtotal			9.0	100.0%	30.0%			0.0
Social	S-1 Consistent with the City's Vision	The goal is to remain consistent with Brandon's Environmental Strategic Plan (October, 2007)	Medium	2.0	8.7%	2.6%	Qualitative assessment of water sources and the overall ability to comply with the City's Vision (i.e., GHG emissions, energy efficiency, water conservation etc)	0.0	0.0
	S-2 Public Safety	The goal is to minimize the risk to the public from air/other exposure during processing, handling, transportation.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk of chemical spills or other hazards to the public. Options having lesser risk than the base case will be awarded a positive score.	0.0	0.0
	S-3 Staff Safety	The goal is to minimize the potential impact on staff safety. Options requiring more equipment or chemicals will have a higher risk of impacting worker safety.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk to plant operations and maintenance personnel as a result of the nature and complexity of the process required for the water supply. Options have a lesser likelihood of impacting workers relative to the base case will be awarded a positive score.	0.0	0.0
	S-4 Quality of Community Life	The goal is to minimize current and future community impacts during normal plant operation.	Low	1.0	4.3%	1.3%	Qualitative assessment of potential impacts of noise, dust, aesthetics and other parameters resulting from normal plant operation. Options having a reduced likelihood of community impact relative to the base case will be awarded a positive score.	0.0	0.0
	S-5 Public Acceptance	The goal is to minimize the risk of negative public opinion. Some options may create increased public anxiety regardless of the technical merits.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative acceptance of options relative to the base case. Options having reduced risk of negative public opinion relative to the base case will be awarded a positive score.	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 1 - Basecase: Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social (Continued)	S-6 Regional and Socio-economic growth	The goal is to maximize opportunities for partnerships to support regional growth initiatives and socio-economic benefits.	High	4.0	17.4%	5.2%	Qualitative assessment of the regional growth opportunities of options relative to the base case. Options having increased regional growth relative to the base case are awarded a positive score.	0.0	0.0
	S-7 Impacts During Construction					0.0%	Qualitative estimate of the increase in vehicle traffic relative to current volumes. Options requiring fewer vehicles to/from the construction site relative to the base case will be awarded a positive score.	0.0	0.0
	S-8 Land Use					0.0%	Qualitative assessment of the possible impact to existing and future property values. Options having less risk of negatively affecting property values relative to the base case will be awarded a positive score.	0.0	0.0
	S-9 Licencing	The goal is to minimize any risk associated with the regulatory licensing of the selected water supply.	High	4.0	17.4%	5.2%	Qualitative assessment of the possible risks associated with regulatory licensing of the various water sources.	0.0	0.0
	Subotal			23.0	100.0%	30.0%			0.0
	Total TBL Score								**0.0**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 2 -Groundwater (Koch)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	75.9

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	44.4%	17.8%	Prorated based on capital cost	-1.0	-17.8
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Low	1.0	11.1%	4.4%	Prorated based on NPV of O&M cost	2.0	8.9
	F-3 Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	Capital costs in 2013 dollars for 25% capacity upgrade and CEC limit. The goal is to minimize the costs of a possible future expansion	Low	1.0	11.1%	4.4%	Prorated based on additional capital cost	2.0	8.9
	F-4 Dependence on Commodities that are Subject to Market Variability	20 year net present value of commodities (chemicals, electricity). The goal is to reduce risks associated with dependence on commodities that are subject to fluctuating prices. If long term contracts are available where pricing is assured, risks for unforeseen costs are reduced.	Medium	2.0	22.2%	8.9%	The required use of power, fuel and chemicals and the potential length and cost of contracts. Options lower in NPV than the base case are awarded a positive score	3.0	26.7
	F-5 Capital Costs Eligible for Potential External Funding	Potential for external funding of capital and or generation of revenue. The goal is to maximize the opportunity for external funding.	Low	1.0	11.1%	4.4%	Qualitative assessment. Options higher in the ability to achieve funding (i.e., regional systems) are awarded a positive score.	3.0	13.3
	Subtotal			9.0	100.0%	40.0%			40.0
Environmental	E-1 Water Quality	Ability to achieve a higher treatment standard without additional capital costs (qualitative)	Low	1.0	11.1%	3.3%	Qualitative assessment of the expected water quality from each source. It is recognized that all feasible options will meet regulatory requirements.	2.0	6.7
	E-2 Water Supply Capacity	The goal is to minimize the risk associated with obtaining the necessary water quantity.	High	4.0	44.4%	13.3%	Qualitative assessment of the capacity of each water source. Options that have unknown capacities or capacities that limit growth are awarded a negative score.	-2.0	-26.7
	E-3 Water Supply Contamination	The goal is to minimize risk associated contamination of the water supply.	Medium	2.0	22.2%	6.7%	Qualitative estimate of the risks associated with contamination of the water supply. Options with less risk than the base case will be awarded a positive score.	4.0	26.7

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 2 -Groundwater (Koch)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	75.9

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Environmental (Continued)	E-4 Water Supply Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	11.1%	3.3%	Qualitative estimate of the risks associated with flooding. Options that result in a treatment facility constructed in outside the flood plain will be awarded a positive score compared to the base case	4.0	13.3
	E-5 Sustainable Outcomes	Some options will require the City to provide reclaimed water to industry to off-set groundwater consumption. This in-turn will result in a reduction in overall effluent discharged to the Assiniboine River. The goal is to minimize the impacts to the River and have a "zero discharge" from wastewater facility.	Low	1.0	11.1%	3.3%		4.0	13.3
	Subtotal			9.0	100.0%	30.0%			33.3
Social	S-1 Consistent with the City's Vision	The goal is to remain consistent with Brandon's Environmental Strategic Plan (October, 2007)	Medium	2.0	8.7%	2.6%	Qualitative assessment of water sources and the overall ability to comply with the City's Vision (i.e., GHG emissions, energy efficiency, water conservation etc)	2.0	5.2
	S-2 Public Safety	The goal is to minimize the risk to the public from air/other exposure during processing, handling, transportation.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk of chemical spills or other hazards to the public. Options having lesser risk than the base case will be awarded a positive score.	2.0	10.4
	S-3 Staff Safety	The goal is to minimize the potential impact on staff safety. Options requiring more equipment or chemicals will have a higher risk of impacting worker safety.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk to plant operations and maintenance personnel as a result of the nature and complexity of the process required for the water supply. Options have a lesser likelihood of impacting workers relative to the base case will be awarded a positive score.	1.0	5.2
	S-4 Quality of Community Life	The goal is to minimize current and future community impacts during normal plant operation.	Low	1.0	4.3%	1.3%	Qualitative assessment of potential impacts of noise, dust, aesthetics and other parameters resulting from normal plant operation. Options having a reduced likelihood of community impact relative to the base case will be awarded a positive score.	2.0	2.6

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 2 -Groundwater (Koch)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	75.9

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social (Continued)	S-5 Public Acceptance	The goal is to minimize the risk of negative public opinion. Some options may create increased public anxiety regardless of the technical merits.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative acceptance of options relative to the base case. Options having reduced risk of negative public opinion relative to the base case will be awarded a positive score.	1.0	5.2
	S-6 Regional and Socio-economic growth	The goal is to maximize opportunities for partnerships to support regional growth initiatives and socio-economic benefits.	High	4.0	17.4%	5.2%	Qualitative assessment of the regional growth opportunities of options relative to the base case. Options having increased regional growth relative to the base case are awarded a positive score.	-4.0	-20.9
	S-7 Impacts During Construction					0.0%	Qualitative estimate of the increase in vehicle traffic relative to current volumes. Options requiring fewer vehicles to/from the construction site relative to the base case will be awarded a positive score.	0.0	0.0
	S-8 Land Use					0.0%	Qualitative assessment of the possible impact to existing and future property values. Options having less risk of negatively affecting property values relative to the base case will be awarded a positive score.	0.0	0.0
	S-9 Licencing	The goal is to minimize any risk associated with the regulatory licensing of the selected water supply.	High	4.0	17.4%	5.2%	Qualitative assessment of the possible risks associated with regulatory licensing of the various water sources.	-1.0	-5.2
	Subotal			23.0	100.0%	30.0%			2.6
	Total TBL Score								**75.9**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 3 - Groundwater (Shilo)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-51.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	44.4%	17.8%	Prorated based on capital cost	-4.0	-71.1
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Low	1.0	11.1%	4.4%	Prorated based on NPV of O&M cost	4.0	17.8
	F-3 Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	Capital costs in 2013 dollars for 25% capacity upgrade and CEC limit. The goal is to minimize the costs of a possible future expansion	Low	1.0	11.1%	4.4%	Prorated based on additional capital cost	3.0	13.3
	F-4 Dependence on Commodities that are Subject to Market Variability	20 year net present value of commodities (chemicals, electricity). The goal is to reduce risks associated with dependence on commodities that are subject to fluctuating prices. If long term contracts are available where pricing is assured, risks for unforeseen costs are reduced.	Medium	2.0	22.2%	8.9%	The required use of power, fuel and chemicals and the potential length and cost of contracts. Options lower in NPV than the base case are awarded a positive score	4.0	35.6
	F-5 Capital Costs Eligible for Potential External Funding	Potential for external funding of capital and or generation of revenue. The goal is to maximize the opportunity for external funding.	Low	1.0	11.1%	4.4%	Qualitative assessment. Options higher in the ability to achieve funding (i.e., regional systems) are awarded a positive score.	-2.0	-8.9
	Subtotal			9.0	100.0%	40.0%			-13.3
Environmental	E-1 Water Quality	Ability to achieve a higher treatment standard without additional capital costs (qualitative)	Low	1.0	11.1%	3.3%	Qualitative assessment of the expected water quality from each source. It is recognized that all feasible options will meet regulatory requirements.	4.0	13.3
	E-2 Water Supply Capacity	The goal is to minimize the risk associated with obtaining the necessary water quantity.	High	4.0	44.4%	13.3%	Qualitative assessment of the capacity of each water source. Options that have unknown capacities or capacities that limit growth are awarded a negative score.	-4.0	-53.3
	E-3 Water Supply Contamination	The goal is to minimize risk associated contamination of the water supply.	Medium	2.0	22.2%	6.7%	Qualitative estimate of the risks associated with contamination of the water supply. Options with less risk than the base case will be awarded a positive score.	2.0	13.3

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 3 - Groundwater (Shilo)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-51.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Environmental (Continued)	E-4 Water Supply Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	11.1%	3.3%	Qualitative estimate of the risks associated with flooding. Options that result in a treatment facility constructed in outside the flood plain will be awarded a positive score compared to the base case	4.0	13.3
	E-5 Sustainable Outcomes	Some options will require the City to provide reclaimed water to industry to off-set groundwater consumption. This in-turn will result in a reduction in overall effluent discharged to the Assiniboine River. The goal is to minimize the impacts to the River and have a "zero discharge" from wastewater facility.	Low	1.0	11.1%	3.3%		0.0	0.0
	Subtotal			9.0	100.0%	30.0%			-13.3
Social	S-1 Consistent with the City's Vision	The goal is to remain consistent with Brandon's Environmental Strategic Plan (October, 2007)	Medium	2.0	8.7%	2.6%	Qualitative assessment of water sources and the overall ability to comply with the City's Vision (i.e., GHG emissions, energy efficiency, water conservation etc)	-2.0	-5.2
	S-2 Public Safety	The goal is to minimize the risk to the public from air/other exposure during processing, handling, transportation.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk of chemical spills or other hazards to the public. Options having lesser risk than the base case will be awarded a positive score.	4.0	20.9
	S-3 Staff Safety	The goal is to minimize the potential impact on staff safety. Options requiring more equipment or chemicals will have a higher risk of impacting worker safety.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk to plant operations and maintenance personnel as a result of the nature and complexity of the process required for the water supply. Options have a lesser likelihood of impacting workers relative to the base case will be awarded a positive score.	4.0	20.9
	S-4 Quality of Community Life	The goal is to minimize current and future community impacts during normal plant operation.	Low	1.0	4.3%	1.3%	Qualitative assessment of potential impacts of noise, dust, aesthetics and other parameters resulting from normal plant operation. Options having a reduced likelihood of community impact relative to the base case will be awarded a positive score.	1.0	1.3
	S-5 Public Acceptance	The goal is to minimize the risk of negative public opinion. Some options may create increased public anxiety regardless of the technical merits.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative acceptance of options relative to the base case. Options having reduced risk of negative public opinion relative to the base case will be awarded a positive score.	-4.0	-20.9

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 3 - Groundwater (Shilo)

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-51.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social (Continued)	S-6 Regional and Socio-economic growth	The goal is to maximize opportunities for partnerships to support regional growth initiatives and socio-economic benefits.	High	4.0	17.4%	5.2%	Qualitative assessment of the regional growth opportunities of options relative to the base case. Options having increased regional growth relative to the base case are awarded a positive score.	-4.0	-20.9
	S-7 Impacts During Construction					0.0%	Qualitative estimate of the increase in vehicle traffic relative to current volumes. Options requiring fewer vehicles to/from the construction site relative to the base case will be awarded a positive score.	0.0	0.0
	S-8 Land Use					0.0%	Qualitative assessment of the possible impact to existing and future property values. Options having less risk of negatively affecting property values relative to the base case will be awarded a positive score.	0.0	0.0
	S-9 Licencing	The goal is to minimize any risk associated with the regulatory licensing of the selected water supply.	High	4.0	17.4%	5.2%	Qualitative assessment of the possible risks associated with regulatory licensing of the various water sources.	-4.0	-20.9
	Subotal			23.0	100.0%	30.0%			-24.8
	Total TBL Score								**-51.4**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 4 - Blend of Groundwater (Koch) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-8.2

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	44.4%	17.8%	Prorated based on capital cost	-1.0	-17.8
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Low	1.0	11.1%	4.4%	Prorated based on NPV of O&M cost	1.0	4.4
	F-3 Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	Capital costs in 2013 dollars for 25% capacity upgrade and CEC limit. The goal is to minimize the costs of a possible future expansion	Low	1.0	11.1%	4.4%	Prorated based on additional capital cost	0.0	0.0
	F-4 Dependence on Commodities that are Subject to Market Variability	20 year net present value of commodities (chemicals, electricity). The goal is to reduce risks associated with dependence on commodities that are subject to fluctuating prices. If long term contracts are available where pricing is assured, risks for unforeseen costs are reduced.	Medium	2.0	22.2%	8.9%	The required use of power, fuel and chemicals and the potential length and cost of contracts. Options lower in NPV than the base case are awarded a positive score	1.0	8.9
	F-5 Capital Costs Eligible for Potential External Funding	Potential for external funding of capital and or generation of revenue. The goal is to maximize the opportunity for external funding.	Low	1.0	11.1%	4.4%	Qualitative assessment. Options higher in the ability to achieve funding (i.e., regional systems) are awarded a positive score.	2.0	8.9
	Subtotal			9.0	100.0%	40.0%			4.4
Environmental	E-1 Water Quality	Ability to achieve a higher treatment standard without additional capital costs (qualitative)	Low	1.0	11.1%	3.3%	Qualitative assessment of the expected water quality from each source. It is recognized that all feasible options will meet regulatory requirements.	1.0	3.3
	E-2 Water Supply Capacity	The goal is to minimize the risk associated with obtaining the necessary water quantity.	High	4.0	44.4%	13.3%	Qualitative assessment of the capacity of each water source. Options that have unknown capacities or capacities that limit growth are awarded a negative score.	-1.0	-13.3
	E-3 Water Supply Contamination	The goal is to minimize risk associated contamination of the water supply.	Medium	2.0	22.2%	6.7%	Qualitative estimate of the risks associated with contamination of the water supply. Options with less risk than the base case will be awarded a positive score.	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 4 - Blend of Groundwater (Koch) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-8.2

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Environmental (Continued)	E-4 Water Supply Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	11.1%	3.3%	Qualitative estimate of the risks associated with flooding. Options that result in a treatment facility constructed in outside the flood plain will be awarded a positive score compared to the base case	0.0	0.0
	E-5 Sustainable Outcomes	Some options will require the City to provide reclaimed water to industry to off-set groundwater consumption. This in-turn will result in a reduction in overall effluent discharged to the Assiniboine River. The goal is to minimize the impacts to the River and have a "zero discharge" from wastewater facility.	Low	1.0	11.1%	3.3%		0.0	0.0
	Subtotal			9.0	100.0%	30.0%			-10.0
Social	S-1 Consistent with the City's Vision	The goal is to remain consistent with Brandon's Environmental Strategic Plan (October, 2007)	Medium	2.0	8.7%	2.6%	Qualitative assessment of water sources and the overall ability to comply with the City's Vision (i.e., GHG emissions, energy efficiency, water conservation etc)	1.0	2.6
	S-2 Public Safety	The goal is to minimize the risk to the public from air/other exposure during processing, handling, transportation.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk of chemical spills or other hazards to the public. Options having lesser risk than the base case will be awarded a positive score.	0.0	0.0
	S-3 Staff Safety	The goal is to minimize the potential impact on staff safety. Options requiring more equipment or chemicals will have a higher risk of impacting worker safety.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk to plant operations and maintenance personnel as a result of the nature and complexity of the process required for the water supply. Options have a lesser likelihood of impacting workers relative to the base case will be awarded a positive score.	0.0	0.0
	S-4 Quality of Community Life	The goal is to minimize current and future community impacts during normal plant operation.	Low	1.0	4.3%	1.3%	Qualitative assessment of potential impacts of noise, dust, aesthetics and other parameters resulting from normal plant operation. Options having a reduced likelihood of community impact relative to the base case will be awarded a positive score.	0.0	0.0
	S-5 Public Acceptance	The goal is to minimize the risk of negative public opinion. Some options may create increased public anxiety regardless of the technical merits.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative acceptance of options relative to the base case. Options having reduced risk of negative public opinion relative to the base case will be awarded a positive score.	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 4 - Blend of Groundwater (Koch) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-8.2

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social (Continued)	S-6 Regional and Socio-economic growth	The goal is to maximize opportunities for partnerships to support regional growth initiatives and socio-economic benefits.	High	4.0	17.4%	5.2%	Qualitative assessment of the regional growth opportunities of options relative to the base case. Options having increased regional growth relative to the base case are awarded a positive score.	0.0	0.0
	S-7 Impacts During Construction					0.0%	Qualitative estimate of the increase in vehicle traffic relative to current volumes. Options requiring fewer vehicles to/from the construction site relative to the base case will be awarded a positive score.	0.0	0.0
	S-8 Land Use					0.0%	Qualitative assessment of the possible impact to existing and future property values. Options having less risk of negatively affecting property values relative to the base case will be awarded a positive score.	0.0	0.0
	S-9 Licencing	The goal is to minimize any risk associated with the regulatory licensing of the selected water supply.	High	4.0	17.4%	5.2%	Qualitative assessment of the possible risks associated with regulatory licensing of the various water sources.	-1.0	-5.2
	Subotal			23.0	100.0%	30.0%			-2.6
	Total TBL Score								**-8.2**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 5 - Blend of Groundwater (Shilo) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-74.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	44.4%	17.8%	Prorated based on capital cost	-3.0	-53.3
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Low	1.0	11.1%	4.4%	Prorated based on NPV of O&M cost	3.0	13.3
	F-3 Costs for Future Expansions and to Meet More Stringent Regulatory Requirements	Capital costs in 2013 dollars for 25% capacity upgrade and CEC limit. The goal is to minimize the costs of a possible future expansion	Low	1.0	11.1%	4.4%	Prorated based on additional capital cost	0.0	0.0
	F-4 Dependence on Commodities that are Subject to Market Variability	20 year net present value of commodities (chemicals, electricity, fuels). The goal is to reduce risks associated with dependence on commodities that are subject to fluctuating prices. If long term contracts are available where pricing is assured, risks for unforeseen costs are reduced.	Medium	2.0	22.2%	8.9%	The required use of power, fuel and chemicals and the potential length and cost of contracts. Options lower in NPV than the base case are awarded a positive score	4.0	35.6
	F-5 Capital Costs Eligible for Potential External Funding	Potential for external funding of capital and or generation of revenue. The goal is to maximize the opportunity for external funding.	Low	1.0	11.1%	4.4%	Qualitative assessment. Options higher in the ability to achieve funding (i.e., regional systems) are awarded a positive score.	-1.0	-4.4
	Subtotal			9.0	100.0%	40.0%			-8.9
Environmental	E-1 Water Quality	Ability to achieve a higher treatment standard without additional capital costs (qualitative)	Low	1.0	11.1%	3.3%	Qualitative assessment of the expected water quality from each source. It is recognized that all feasible options will meet regulatory requirements.	2.0	6.7
	E-2 Water Supply Capacity	The goal is to minimize the risk associated with obtaining the necessary water quantity.	High	4.0	44.4%	13.3%	Qualitative assessment of the capacity of each water source. Options that have unknown capacities or capacities that limit growth are awarded a negative score.	-2.0	-26.7
	E-3 Water Supply Contamination	The goal is to minimize risk associated contamination of the water supply.	Medium	2.0	22.2%	6.7%	Qualitative estimate of the risks associated with contamination of the water supply. Options with less risk than the base case will be awarded a positive score.	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 5 - Blend of Groundwater (Shilo) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-74.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Environmental (Continued)	E-4 Water Supply Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	11.1%	3.3%	Qualitative estimate of the risks associated with flooding. Options that result in a treatment facility constructed in outside the flood plain will be awarded a positive score compared to the base case	2.0	6.7
	E-5 Sustainable Outcomes	Some options will require the City to provide reclaimed water to industry to off-set groundwater consumption. This in-turn will result in a reduction in overall effluent discharged to the Assiniboine River. The goal is to minimize the impacts to the River and have a "zero discharge" from wastewater facility.	Low	1.0	11.1%	3.3%		0.0	0.0
	Subtotal			9.0	100.0%	30.0%			-13.3
Social	S-1 Consistent with the City's Vision	The goal is to remain consistent with Brandon's Environmental Strategic Plan (October, 2007)	Medium	2.0	8.7%	2.6%	Qualitative assessment of water sources and the overall ability to comply with the City's Vision (i.e., GHG emissions, energy efficiency, water conservation etc)	-2.0	-5.2
	S-2 Public Safety	The goal is to minimize the risk to the public from air/other exposure during processing, handling, transportation.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk of chemical spills or other hazards to the public. Options having lesser risk than the base case will be awarded a positive score.	1.0	5.2
	S-3 Staff Safety	The goal is to minimize the potential impact on staff safety. Options requiring more equipment or chemicals will have a higher risk of impacting worker safety.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative risk to plant operations and maintenance personnel as a result of the nature and complexity of the process required for the water supply. Options have a lesser likelihood of impacting workers relative to the base case will be awarded a positive score.	0.0	0.0
	S-4 Quality of Community Life	The goal is to minimize current and future community impacts during normal plant operation.	Low	1.0	4.3%	1.3%	Qualitative assessment of potential impacts of noise, dust, aesthetics and other parameters resulting from normal plant operation. Options having a reduced likelihood of community impact relative to the base case will be awarded a positive score.	0.0	0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Option 5 - Blend of Groundwater (Shilo) + Assiniboine River

TBL Index	Index Weight
Economic	40%
Environmental	30%
Social	30%
Total	100%

Total TBL Score	-74.4

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social (Continued)	S-5 Public Acceptance	The goal is to minimize the risk of negative public opinion. Some options may create increased public anxiety regardless of the technical merits.	High	4.0	17.4%	5.2%	Qualitative assessment of the relative acceptance of options relative to the base case. Options having reduced risk of negative public opinion relative to the base case will be awarded a positive score.	-4.0	-20.9
	S-6 Regional and Socio-economic growth	The goal is to maximize opportunities for partnerships to support regional growth initiatives and socio-economic benefits.	High	4.0	17.4%	5.2%	Qualitative assessment of the regional growth opportunities of options relative to the base case. Options having increased regional growth relative to the base case are awarded a positive score.	-2.0	-10.4
	S-7 Impacts During Construction					0.0%	Qualitative estimate of the increase in vehicle traffic relative to current volumes. Options requiring fewer vehicles to/from the construction site relative to the base case will be awarded a positive score.	0.0	0.0
	S-8 Land Use					0.0%	Qualitative assessment of the possible impact to existing and future property values. Options having less risk of negatively affecting property values relative to the base case will be awarded a positive score.	0.0	0.0
	S-9 Licencing	The goal is to minimize any risk associated with the regulatory licensing of the selected water supply.	High	4.0	17.4%	5.2%	Qualitative assessment of the possible risks associated with regulatory licensing of the various water sources.	-4.0	-20.9
	Subotal			23.0	100.0%	30.0%			-52.2
	Total TBL Score								**-74.4**

Appendix H.

- **Triple Bottoms Line Water Treatment Plant Siting Options Score Sheets**

City of Brandon WTP Master Plan
Summary of Total Triple Bottom Line Scores

				Option 1 Hydro		Option 2 1st and Rosser		Option 3 Aberdeen		Option 4 Jail		Option 5 Existing	
				Total TBL Score	-52.5	Total TBL Score	-102.5	Total TBL Score	-72.5	Total TBL Score	-242.5	Total TBL Score	0.0
Criterion Abbrev	**Criterion**	**Overall Weight**	**Importance in Index**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**
F-1	Capital Cost	40.0	High	-1.0	-40.0	-1.0	-40.0	-2.0	-80.0	-4.0	-160.0	0.0	0.0
F-2	Reuse of Assets	20.0	Medium	-4.0	-80.0	-4.0	-80.0	-4.0	-80.0	-4.0	-80.0	0.0	0.0
	Subtotal	**60.0**			**-120.0**		**-120.0**		**-160.0**		**-240.0**		**0.0**
E-1	Disposal of Reject Water	10.0	High	4.0	40.0	2.0	20.0	2.0	20.0	1.0	10.0	0.0	0.0
E-2	Site Access	5.0	Medium	4.0	20.0	0.0	0.0	4.0	20.0	3.0	15.0	0.0	0.0
E-3	Site Security	2.5	Low	1.0	2.5	0.0	0.0	1.0	2.5	1.0	2.5	0.0	0.0
E-4	Flood Risk	2.5	Low	1.0	2.5	1.0	2.5	3.0	7.5	1.0	2.5	0.0	0.0
E-5	Hydraulics	10.0	High	1.0	10.0	0.0	0.0	3.0	30.0	-2.0	-20.0	0.0	0.0
	Subtotal	**30.0**			**75.0**		**22.5**		**80.0**		**10.0**		**0.0**
S-1	Land Use Suitability	2.5	Low	2.0	5.0	0.0	0.0	3.0	7.5	1.0	2.5	0.0	0.0
S-2	Public Image	2.5	Low	-1.0	-2.5	-2.0	-5.0	2.0	5.0	-2.0	-5.0	0.0	0.0
S-3	Within City Limits	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-4	City Owned/Available	5.0	Medium	-2.0	-10.0	0.0	0.0	-1.0	-5.0	-2.0	-10.0	0.0	0.0
	Subtotal	**10.0**			**-7.5**		**-5.0**		**7.5**		**-12.5**		**0.0**
	Total	**100.0**			**-52.5**		**-102.5**		**-72.5**		**-242.5**		**0.0**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Hydro

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	-52.5

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Financial	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	66.7%	40.0%	Prorated based on capital cost	-1.0	-40.0
	F-2 Reuse of Assets	Estimated Value of Existing Assets	Medium	2.0	33.3%	20.0%	Prorated based on capital cost	-4.0	-80.0
	Subtotal			6.0	100.0%	60.0%			-120.0
Environmental	E-1 Disposal of Reject Water	Ability to dispose of reject water in alternate location other than sewer system	High	4.0	33.3%	10.0%	Qualitative	4.0	40.0
	E-2 Site Access	The goal is to facilitate access to the site for operations, delivery of consumables and residual disposal.	Medium	2.0	16.7%	5.0%	Qualitative	4.0	20.0
	E-3 Site Security	The ability of the site to support appropriate security and emergency response.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-4 Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-5 Hydraulics	Impact on overall distribution system hydraulics	High	4.0	33.3%	10.0%	Qualitative	1.0	10.0
	Subtotal			12.0	100.0%	30.0%			75.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Hydro

TBL Index	Index Weight
Economic	**60%**
Environmental	**30%**
Social	**10%**
Total	**100%**

Total TBL Score	**-52.5**

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social	S-1 Land Use Suitability	Is the area suitable for WTP. Any land planning/zoning issues that need to be resolved in order to received development approval.	Low	1.0	25.0%	2.5%	Qualitative	2.0	5.0
	S-2 Public Image	The ability fo the site to to contribute to a positive public image for the City.	Low	1.0	25.0%	2.5%	Qualitative	-1.0	-2.5
							Qualitative	0.0	0.0
	S-4 City Owned/Available	Is the property City owned. If not, is the land available	Medium	2.0	50.0%	5.0%	Qualitative	-2.0	-10.0
	Subotal			4.0	100.0%	10.0%			-7.5
	Total TBL Score								**-52.5**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
1st and Rosser

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	-102.5

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	66.7%	40.0%	Prorated based on capital cost	-1.0	-40.0
	F-2 Reuse of Assets	Estimated Value of Existing Assets	Medium	2.0	33.3%	20.0%	Prorated based on capital cost	-4.0	-80.0
	Subtotal			6.0	100.0%	60.0%			-120.0
Environmental	E-1 Disposal of Reject Water	Ability to dispose of reject water in alternate location other than sewer system	High	4.0	33.3%	10.0%	Qualitative	2.0	20.0
	E-2 Site Access	The goal is to facilitate access to the site for operations, delivery of consumables and residual disposal.	Medium	2.0	16.7%	5.0%	Qualitative	0.0	0.0
	E-3 Site Security	The ability of the site to support appropriate security and emergency response.	Low	1.0	8.3%	2.5%	Qualitative	0.0	0.0
	E-4 Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-5 Hydraulics	Impact on overall distribution system hydraulics	High	4.0	33.3%	10.0%	Qualitative	0.0	0.0
	Subtotal			12.0	100.0%	30.0%			22.5

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
1st and Rosser

TBL Index	Index Weight
Economic	**60%**
Environmental	**30%**
Social	**10%**
Total	**100%**

Total TBL Score	**-102.5**

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social	S-1 Land Use Suitability	Is the area suitable for WTP. Any land planning/zoning issues that need to be resolved in order to received development approval.	Low	1.0	25.0%	2.5%	Qualitative	0.0	0.0
	S-2 Public Image	The ability fo the site to to contribute to a positive public image for the City.	Low	1.0	25.0%	2.5%	Qualitative	-2.0	-5.0
					0.0%	0.0%	Qualitative	0.0	0.0
	S-4 City Owned/Available	Is the property City owned. If not, is the land available	Medium	2.0	50.0%	5.0%	Qualitative	0.0	0.0
	Subotal			4.0	100.0%	10.0%			-5.0
	Total TBL Score								**-102.5**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Aberdeen

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	-72.5

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	66.7%	40.0%	Prorated based on capital cost	-2.0	-80.0
	F-2 Reuse of Assets	Estimated Value of Existing Assets	Medium	2.0	33.3%	20.0%	Prorated based on capital cost	-4.0	-80.0
	Subtotal			6.0	100.0%	60.0%			-160.0
Environmental	E-1 Disposal of Reject Water	Ability to dispose of reject water in alternate location other than sewer system	High	4.0	33.3%	10.0%	Qualitative	2.0	20.0
	E-2 Site Access	The goal is to facilitate access to the site for operations, delivery of consumables and residual disposal.	Medium	2.0	16.7%	5.0%	Qualitative	4.0	20.0
	E-3 Site Security	The ability of the site to support appropriate security and emergency response.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-4 Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	8.3%	2.5%	Qualitative	3.0	7.5
	E-5 Hydraulics	Impact on overall distribution system hydraulics	High	4.0	33.3%	10.0%	Qualitative	3.0	30.0
	Subtotal			12.0	100.0%	30.0%			80.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Aberdeen

TBL Index	Index Weight
Economic	**60%**
Environmental	**30%**
Social	**10%**
Total	**100%**

Total TBL Score	**-72.5**

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social	S-1 Land Use Suitability	Is the area suitable for WTP. Any land planning/zoning issues that need to be resolved in order to received development approval.	Low	1.0	25.0%	2.5%	Qualitative	3.0	7.5
	S-2 Public Image	The ability fo the site to to contribute to a positive public image for the City.	Low	1.0	25.0%	2.5%	Qualitative	2.0	5.0
	S-3 Within City Limits				0.0%	0.0%	Qualitative	0.0	0.0
	S-4 City Owned/Available	Is the property City owned. If not, is the land available	Medium	2.0	50.0%	5.0%	Qualitative	-1.0	-5.0
	Subotal			4.0	100.0%	10.0%			7.5
	Total TBL Score								**-72.5**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Jail

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	-242.5

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	66.7%	40.0%	Prorated based on capital cost	-4.0	-160.0
	F-2 Reuse of Assets	Estimated Value of Existing Assets	Medium	2.0	33.3%	20.0%	Prorated based on capital cost	-4.0	-80.0
	Subtotal			6.0	100.0%	60.0%			-240.0
Environmental	E-1 Disposal of Reject Water	Ability to dispose of reject water in alternate location other than sewer system	High	4.0	33.3%	10.0%	Qualitative	1.0	10.0
	E-2 Site Access	The goal is to facilitate access to the site for operations, delivery of consumables and residual disposal.	Medium	2.0	16.7%	5.0%	Qualitative	3.0	15.0
	E-3 Site Security	The ability of the site to support appropriate security and emergency response.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-4 Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	8.3%	2.5%	Qualitative	1.0	2.5
	E-5 Hydraulics	Impact on overall distribution system hydraulics	High	4.0	33.3%	10.0%	Qualitative	-2.0	-20.0
	Subtotal			12.0	100.0%	30.0%			10.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Jail

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	-242.5

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social	S-1 Land Use Suitability	Is the area suitable for WTP. Any land planning/zoning issues that need to be resolved in order to received development approval.	Low	1.0	25.0%	2.5%	Qualitative	1.0	2.5
	S-2 Public Image	The ability fo the site to to contribute to a positive public image for the City.	Low	1.0	25.0%	2.5%	Qualitative	-2.0	-5.0
	S-3 Within City Limits				0.0%	0.0%	Qualitative	0.0	0.0
	S-4 City Owned/Available	Is the property City owned. If not, is the land available	Medium	2.0	50.0%	5.0%	Qualitative	-2.0	-10.0
	Subotal			4.0	100.0%	10.0%			-12.5
	Total TBL Score								**-242.5**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Existing

TBL Index	Index Weight
Economic	**60%**
Environmental	**30%**
Social	**10%**
Total	**100%**

Total TBL Score	**0.0**

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	High	4.0	66.7%	40.0%	Prorated based on capital cost	0.0	0.0
	F-2 Reuse of Assets	Estimated Value of Existing Assets	Medium	2.0	33.3%	20.0%	Prorated based on capital cost	0.0	0.0
	Subtotal			6.0	100.0%	60.0%			0.0
Environmental	E-1 Disposal of Reject Water	Ability to dispose of reject water in alternate location other than sewer system	High	4.0	33.3%	10.0%	Qualitative	0.0	0.0
	E-2 Site Access	The goal is to facilitate access to the site for operations, delivery of consumables and residual disposal.	Medium	2.0	16.7%	5.0%	Qualitative	0.0	0.0
	E-3 Site Security	The ability of the site to support appropriate security and emergency response.	Low	1.0	8.3%	2.5%	Qualitative	0.0	0.0
	E-4 Flood Risk	The goal is to minimize risks associated with flooding.	Low	1.0	8.3%	2.5%	Qualitative	0.0	0.0
	E-5 Hydraulics	Impact on overall distribution system hydraulics	High	4.0	33.3%	10.0%	Qualitative	0.0	0.0
	Subtotal			12.0	100.0%	30.0%			0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Existing

TBL Index	Index Weight
Economic	60%
Environmental	30%
Social	10%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Social	S-1 Land Use Suitability	Is the area suitable for WTP. Any land planning/zoning issues that need to be resolved in order to received development approval.	Low	1.0	25.0%	2.5%	Qualitative	0.0	0.0
	S-2 Public Image	The ability fo the site to to contribute to a positive public image for the City.	Low	1.0	25.0%	2.5%	Qualitative	0.0	0.0
	S-3 Within City Limits						Qualitative	0.0	0.0
	S-4 City Owned/Available	Is the property City owned. If not, is the land available	Medium	2.0	50.0%	5.0%	Qualitative	0.0	0.0
	Subotal			4.0	100.0%	10.0%			0.0
	Total TBL Score								**0.0**

Appendix I.

- **Triple Bottom Line Disinfection Options Score Sheets**

City of Brandon WTP Master Plan
Summary of Total Triple Bottom Line Scores

				Chlorine Gas with Scrubber		On-Site Generation		Liquid Sodium Hypochlorite	
				Total TBL Score	0.0	Total TBL Score	94.7	Total TBL Score	104.7
Criterion Abbrev	**Criterion**	**Overall Weight**	**Importance in Index**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**	**Criterion Scoring**	**TBL Score**
F-1	Capital Cost	6.7	Low	0.0	0.0	-0.5	-3.3	0.5	3.3
F-2	O&M Cost	13.3	Medium	0.0	0.0	-0.6	-8.0	0.0	0.0
	Subtotal	**20.0**			**0.0**		**-11.3**		**3.3**
T-1	Regulatory Approval	4.0	Medium	0.0	0.0	0.0	0.0	0.0	0.0
T-2	Robustness	8.0	High	0.0	0.0	1.0	8.0	1.0	8.0
T-3	Ability to meet more stringent regulatory standards	4.0	Medium	0.0	0.0	0.0	0.0	0.0	0.0
T-4	Proven at similar scale elsewhere	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
T-5	Use of proprietary technology	4.0	Medium	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**20.0**			**0.0**		**8.0**		**8.0**
O-1	Reliability	4.0	High	0.0	0.0	1.0	4.0	1.0	4.0
O-2	Ease of Maintenance	4.0	High	0.0	0.0	-1.0	-4.0	1.0	4.0
O-3	Operational Complexity	2.0	Medium	0.0	0.0	-1.0	-2.0	1.0	2.0
	Subtotal	**10.0**			**0.0**		**-2.0**		**10.0**
S-1	Public Safety	22.22	High	0.0	0.0	3.0	66.7	1.0	22.2
S-2	Staff Safety	22.22	High	0.0	0.0	1.0	22.2	2.0	44.4
S-3	Public Acceptance	5.56	Low	0.0	0.0	2.0	11.1	3.0	16.7
	Subtotal	**50.0**			**0.0**		**100.0**		**83.3**
	Total	**100.0**			**0.0**		**94.7**		**104.7**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Basecase: Chlorine Gas

TBL Index	Index Weight
Financial	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Financial	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	Low	1.0	33.3%	6.7%	Prorated based on capital cost	0.0	0.0
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Medium	2.0	66.7%	13.3%	Prorated based on NPV of O&M cost	0.0	0.0
	Subtotal			3.0	100.0%	20.0%			0.0
Technical	T-1 Regulatory Approval	Will there be risks associated with obtaining the necessary regulatory approval	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-2 Robustness	Ability to deal with abnormal operating conditions .	High	4.0	40.0%	8.0%	Qualitative	0.0	0.0
	T-3 Ability to meet more stringent regulatory standards	Ability to achieve a higher treatment standard without additional capital costs.	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-4 Proven at similar scale elsewhere						Qualitative	0.0	0.0
	T-5 Use of proprietary technology	Preferred processes should not use proprietary technology thereby not committing the City to one supplier or manufacturer	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	Subtotal			10.0	100.0%	20.0%			0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Basecase: Chlorine Gas

TBL Index	Index Weight
Financial	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Operational	O-1 Reliability	Ability to maintain its function under normal expected operating conditions	High	4.0	40.0%	4.0%	Qualitative	0.0	0.0
	O-2 Ease of Maintenance	Process should facilitate efficient operation and maintenance. Processes that do not have specialized maintenance requirements are preferred .	High	4.0	40.0%	4.0%	Qualitative	0.0	0.0
	O-3 Operational Complexity	Processes that do not rely on the integration of many subsystems to achieve process performance are preferred.	Medium	2.0	20.0%	2.0%	Qualitative	0.0	0.0
	Subtotal			10.0	100.0%	10.0%			0.0
Social	S-1 Public Safety	Risk from exposures during processing, handling, and transportation.	High	4.0	44.4%	22.2%	Qualitative	0.0	0.0
	S-2 Staff Safety	Potential impact on staff safety	High	4.0	44.4%	22.2%	Qualitative	0.0	0.0
	S-3 Public Acceptance		Low	1.0	11.1%	5.6%	Qualitative	0.0	0.0
	Subtotal			9.0	100.0%	50.0%			0.0
	Total TBL Score								**0.0**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Chlorine Gas + Scrubber

TBL Index	Index Weight
Financial	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	Low	1.0	33.3%	6.7%	Prorated based on capital cost	0.0	0.0
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Medium	2.0	66.7%	13.3%	Prorated based on NPV of O&M cost	0.0	0.0
	Subtotal			3.0	100.0%	20.0%			0.0
Technical	T-1 Regulatory Approval	Will there be risks associated with obtaining the necessary regulatory approval	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-2 Robustness	Ability to deal with abnormal operating conditions .	High	4.0	40.0%	8.0%	Qualitative	0.0	0.0
	T-3 Ability to meet more stringent regulatory standards	Ability to achieve a higher treatment standard without additional capital costs.	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-4 Proven at similar scale elsewhere					0.0%	Qualitative	0.0	0.0
	T-5 Use of proprietary technology	Preferred processes should not use proprietary technology thereby not committing the City to one supplier or manufacturer	Medium	2.0	20.0%	4.0%		0.0	0.0
	Subtotal			10.0	100.0%	20.0%			0.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Chlorine Gas + Scrubber

TBL Index	Index Weight
Financial	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	0.0

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Operational	O-1 Reliability	Ability to maintain its function under normal expected operating conditions	High	4.0	40.0%	4.0%	Qualitative	0.0	0.0
	O-2 Ease of Maintenance	Process should facilitate efficient operation and maintenance. Processes that do not have specialized maintenance requirements are preferred .	High	4.0	40.0%	4.0%	Qualitative	0.0	0.0
	O-3 Operational Complexity	Processes that do not rely on the integration of many subsystems to achieve process performance are preferred.	Medium	2.0	20.0%	2.0%	Qualitative	0.0	0.0
	Subotal			10.0	100.0%	10.0%			0.0
Social	S-1 Public Safety	Risk from exposures during processing, handling, and transportation.	High	4.0	44.4%	22.2%	Qualitative	0.0	0.0
	S-2 Staff Safety	Potential impact on staff safety	High	4.0	44.4%	22.2%	Qualitative	0.0	0.0
	S-3 Public Acceptance		Low	1.0	11.1%	5.6%	Qualitative	0.0	0.0
	Subtotal			9.0	100.0%	50.0%			0.0
	Total TBL Score								**0.0**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
On-Site Generation

TBL Index	Index Weight
Economic	**20%**
Technical	**20%**
Operational	**10%**
Social	**50%**
Total	**100%**

Total TBL Score	**94.7**

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	Low	1.0	33.3%	6.7%	Prorated based on capital cost	-0.5	-3.3
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Medium	2.0	66.7%	13.3%	Prorated based on NPV of O&M cost	-0.6	-8.0
	Subtotal			3.0	100.0%	20.0%			-11.3
Technical	T-1 Regulatory Approval	Will there be risks associated with obtaining the necessary regulatory approval	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-2 Robustness	Ability to deal with abnormal operating conditions .	High	4.0	40.0%	8.0%	Qualitative	1.0	8.0
	T-3 Ability to meet more stringent regulatory standards	Ability to achieve a higher treatment standard without additional capital costs.	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-4 Proven at similar scale elsewhere						Qualitative	0.0	0.0
	T-5 Use of proprietary technology	Preferred processes should not use proprietary technology thereby not committing the City to one supplier or manufacturer	Medium	2.0	20.0%	4.0%		0.0	0.0
	Subtotal			10.0	100.0%	20.0%			8.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
On-Site Generation

TBL Index	Index Weight
Economic	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	94.7

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Operational	O-1 Reliability	Ability to maintain its function under normal expected operating conditions	High	4.0	40.0%	4.0%	Qualitative	1.0	4.0
	O-2 Ease of Maintenance	Process should facilitate efficient operation and maintenance. Processes that do not have specialized maintenance requirements are preferred .	High	4.0	40.0%	4.0%	Qualitative	-1.0	-4.0
	O-3 Operational Complexity	Processes that do not rely on the integration of many subsystems to achieve process performance are preferred.	Medium	2.0	20.0%	2.0%	Qualitative	-1.0	-2.0
	Subotal			10.0	100.0%	10.0%			-2.0
Social	S-1 Public Safety	Risk from exposures during processing, handling, and transportation.	High	4.0	44.4%	22.2%	Qualitative	3.0	66.7
	S-2 Staff Safety	Potential impact on staff safety	High	4.0	44.4%	22.2%	Qualitative	1.0	22.2
	S-3 Public Acceptance		Low	1.0	11.1%	5.6%	Qualitative	2.0	11.1
	Subtotal			9.0	100.0%	50.0%			100.0
	Total TBL Score								**94.7**

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Liquid Sodium Hypochlorite

TBL Index	Index Weight
Economic	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	104.7

Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Economic	F-1 Capital Cost	Estimated capital costs of the project. The goal is to minimize capital costs.	Low	1.0	33.3%	6.7%	Prorated based on capital cost	0.5	3.3
	F-2 O&M Cost	20 year net present value (NPV) of O&M costs at a 4 % discount rate. The goal is to minimize O&M costs.	Medium	2.0	66.7%	13.3%	Prorated based on NPV of O&M cost	0.0	0.0
	Subtotal			3.0	100.0%	20.0%			3.3
Technical	T-1 Regulatory Approval	Will there be risks associated with obtaining the necessary regulatory approval	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-2 Robustness	Ability to deal with abnormal operating conditions .	High	4.0	40.0%	8.0%	Qualitative	1.0	8.0
	T-3 Ability to meet more stringent regulatory standards	Ability to achieve a higher treatment standard without additional capital costs.	Medium	2.0	20.0%	4.0%	Qualitative	0.0	0.0
	T-4 Proven at similar scale elsewhere						Qualitative	0.0	0.0
	T-5 Use of proprietary technology	Preferred processes should not use proprietary technology thereby not committing the City to one supplier or manufacturer	Medium	2.0	20.0%	4.0%		0.0	0.0
	Subtotal			10.0	100.0%	20.0%			8.0

City of Brandon WTP Master Plan
Triple Bottom Line Scoresheet
Liquid Sodium Hypochlorite

TBL Index	Index Weight
Economic	20%
Technical	20%
Operational	10%
Social	50%
Total	100%

Total TBL Score	104.7

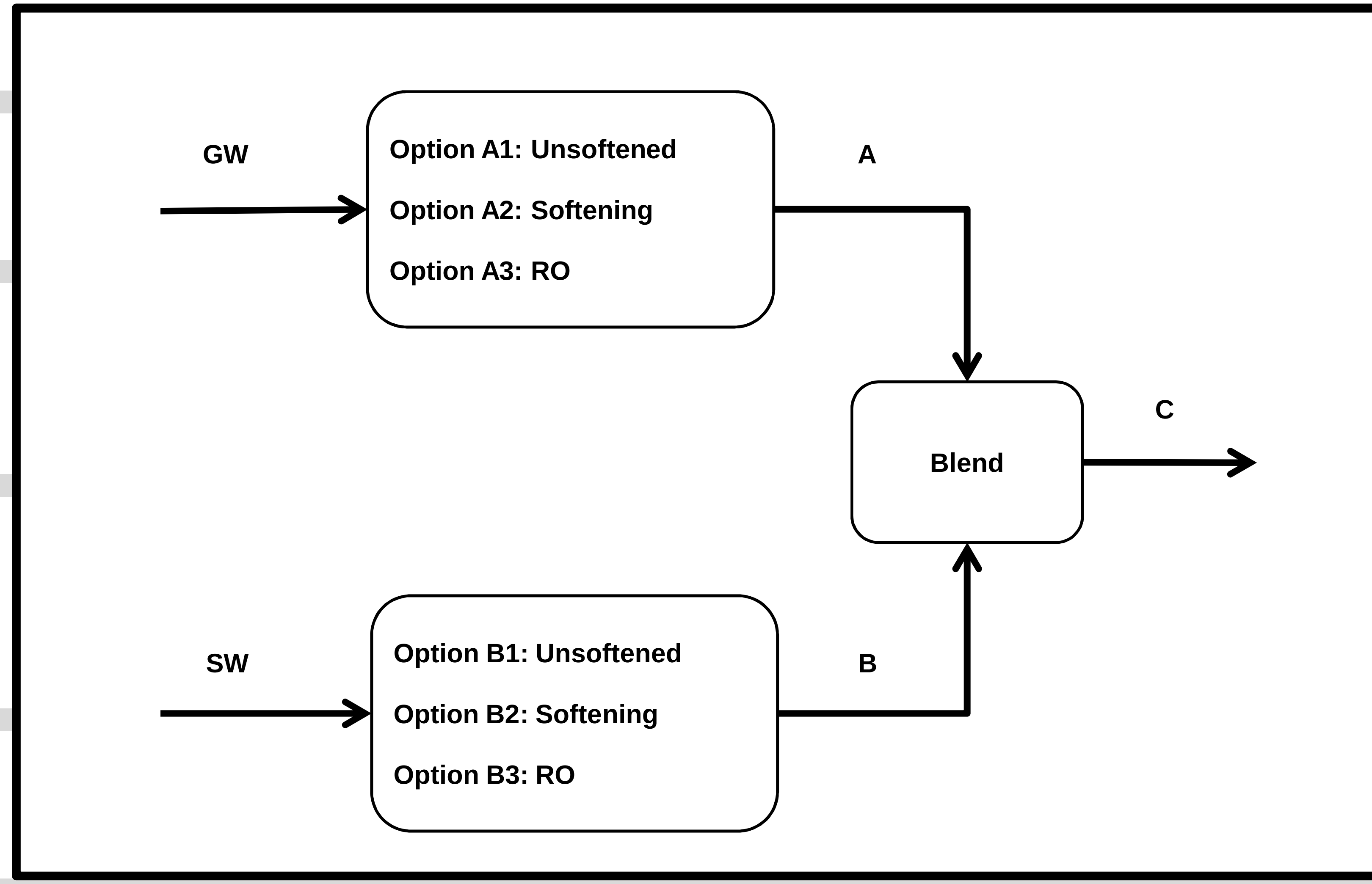
Criterion Scoring Summary
+4 very much better
+3 much better
+2 moderately better
+1 little better
0 Base Case
-1 little worse
-2 moderately worse
-3 much worse
-4 very much worse

TBL Index	Performance Criterion	Indicator (and Type)	Relative Importance within Index	Relative Weight within Index	Relative Percentage within Index	Overall Weighting within TBL	Discussion	Criterion Scoring	TBL Score
Operational	O-1 Reliability	Ability to maintain its function under normal expected operating conditions	High	4.0	40.0%	4.0%	Qualitative	1.0	4.0
	O-2 Ease of Maintenance	Process should facilitate efficient operation and maintenance. Processes that do not have specialized maintenance requirements are preferred .	High	4.0	40.0%	4.0%	Qualitative	1.0	4.0
	O-3 Operational Complexity	Processes that do not rely on the integration of many subsystems to achieve process performance are preferred.	Medium	2.0	20.0%	2.0%	Qualitative	1.0	2.0
	Subotal			10.0	100.0%	10.0%			10.0
Social	S-1 Public Safety	Risk from exposures during processing, handling, and transportation.	High	4.0	44.4%	22.2%	Qualitative	1.0	22.2
	S-2 Staff Safety	Potential impact on staff safety	High	4.0	44.4%	22.2%	Qualitative	2.0	44.4
	S-3 Public Acceptance		Low	1.0	11.1%	5.6%	Qualitative	3.0	16.7
	Subtotal			9.0	100.0%	50.0%			83.3
	Total TBL Score								**104.7**

Appendix J.

- **Water Quality Data Blending Ratios**

Brandon WTP Master Plan - Surface and Groundwater Blending



Inlet Conditions

Average Day Flow	L/s	300				
Blend Ratios	% groundwater	25%	50%	60%	75%	*Percentage
Groundwater (GW) flow	L/s	75	150	180	225	*Average flow
Surface Water (SW) flov	L/s	225	150	120	75	*Average flow

A1: Unsoftened Groundwater (GW) Quality
Koch representative well sample

		Average
Alkalinity	mg/L as $CaCO_3$	248
Hardness	mg/L as $CaCO_3$	318
TOC	mg/L	3
Iron	mg/L	1.37
Manganese	mg/L	0.116

A2: Softened GW Quality
Table 5.1 - COB Water Supply Assessment, AECOM

		Minimum	Maximum	Average
Alkalinity	mg/L as $CaCO_3$	30	188	81
Hardness	mg/L as $CaCO_3$	28	210	149
% TOC reduction	%			45%
TOC	mg/L			**1.65**
Iron	mg/L	0	3.27	0.2
Manganese	mg/L	0	0.18	0.01

A3: RO Treated GW Quality

		Average
Alkalinity	mg/L as $CaCO_3$	0
Hardness	mg/L as $CaCO_3$	0
TOC	mg/L	0
Iron	mg/L	0
Manganese	mg/L	0

B1: Unsoftened Surface Water (SW) Quality
Table 3.4 - COB Water Supply Assessment, AECOM

		Minimum	Maximum	Average
Alkalinity	mg/L as $CaCO_3$	0	295	213
Hardness	mg/L as $CaCO_3$	140	448	360
TOC	mg/L	4	61	13
Iron	mg/L	0.13	13.4	2.18
Manganese	mg/L	0.03	0.6	0.15

B2: Softened SW Quality
Table 5.1 - COB Water Supply Assessment, AECOM

		Minimum	Maximum	Average
Alkalinity	mg/L as $CaCO_3$	30	188	81
Hardness	mg/L as $CaCO_3$	28	210	149
% TOC reduction	%			45%
TOC	mg/L			**7.15**
Iron	mg/L	0	3.27	0.2
Manganese	mg/L	0	0.18	0.01

B3: RO Treated SW Quality

		Average
Alkalinity	mg/L as $CaCO_3$	0
Hardness	mg/L as $CaCO_3$	0
TOC	mg/L	0
Iron	mg/L	0
Manganese	mg/L	0

Blended Water Quality

A1: Unsoftened GW

	Blend ratio (%GW)	25%	50%	60%	75%
Blended Stream (B1: Unsoftened SW)					
Alkalinity	mg/L as $CaCO_3$	222	231	234	239
Hardness	mg/L as $CaCO_3$	350	339	335	329
TOC	mg/L	11	8.0	7.0	5.5
Iron	mg/L	2.0	1.8	1.7	1.6
Manganese	mg/L	0.14	0.13	0.13	0.12
Blended Stream (B2: Softened SW)					
Alkalinity	mg/L as $CaCO_3$	123	165	181	206
Hardness	mg/L as $CaCO_3$	191	234	250	276
TOC	mg/L	6.1	5.1	4.7	4.0
Iron	mg/L	0.5	0.8	0.9	1.1
Manganese	mg/L	0.04	0.06	0.07	0.09
Blended Stream (B3: RO Treated SW)					
Alkalinity	mg/L as $CaCO_3$	62	124	149	186
Hardness	mg/L as $CaCO_3$	80	159	191	239
TOC	mg/L	0.8	1.5	1.8	2.3
Iron	mg/L	0.3	0.7	0.8	1.0
Manganese	mg/L	0.03	0.06	0.07	0.09

A2: Softened GW

	Blend ratio (%GW)	25%	50%	60%	75%
Blended Stream (B1: Unsoftened SW)					
Alkalinity	mg/L as $CaCO_3$	180	147	134	114
Hardness	mg/L as $CaCO_3$	307	255	233	202
TOC	mg/L	10.2	7.3	6.2	4.5
Iron	mg/L	1.7	1.2	1.0	0.7
Manganese	mg/L	0.12	0.08	0.07	0.05
Blended Stream (B2: Softened SW)					
Alkalinity	mg/L as $CaCO_3$	81	81	81	81
Hardness	mg/L as $CaCO_3$	149	149	149	149
TOC	mg/L	5.8	4.4	3.9	3.0
Iron	mg/L	0.2	0.2	0.2	0.2
Manganese	mg/L	0.01	0.01	0.01	0.01
Blended Stream (B3: RO Treated SW)					
Alkalinity	mg/L as $CaCO_3$	20	41	49	61
Hardness	mg/L as $CaCO_3$	37	75	89	112
TOC	mg/L	0.4	0.8	1.0	1.2
Iron	mg/L	0.1	0.1	0.1	0.2
Manganese	mg/L	0.00	0.01	0.01	0.01

A3: RO Treated GW

	Blend ratio (%GW)	25%	50%	60%	75%
Blended Stream (B1: Unsoftened SW)					
Alkalinity	mg/L as $CaCO_3$	160	107	85	53
Hardness	mg/L as $CaCO_3$	270	180	144	90
TOC	mg/L	9.8	6.5	5.2	3.3
Iron	mg/L	1.6	1.1	0.9	0.5
Manganese	mg/L	0.11	0.08	0.06	0.04
Blended Stream (B2: Softened SW)					
Alkalinity	mg/L as $CaCO_3$	61	41	32	20
Hardness	mg/L as $CaCO_3$	112	75	60	37
TOC	mg/L	5.4	3.6	2.9	1.8
Iron	mg/L	0.2	0.1	0.1	0.1
Manganese	mg/L	0.01	0.01	0.00	0.00
Blended Stream (B3: RO Treated SW)					
Alkalinity	mg/L as $CaCO_3$	0	0	0	0
Hardness	mg/L as $CaCO_3$	0	0	0	0
TOC	mg/L	0.0	0.0	0.0	0.0
Iron	mg/L	0.0	0.0	0.0	0.0
Manganese	mg/L	0.00	0.00	0.00	0.00

Parameter Comparisons

GCDWQ : Guidelines for Canadian Drinking Water Quality, 2012
MB DWQSR: Manitoba Drinking Water Quality Standards Regulation, 2007

Hardness Comparison (mg/L as $CaCO_3$)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	350	339	335	329
	B2: Softened SW	191	234	250	276
	B3: RO Treated SW	80	159	191	239
A2: Softened GW	B1: Unsoftened SW	307	255	233	202
	B2: Softened SW	149	149	149	149
	B3: RO Treated SW	37	75	89	112
A3: RO Treated GW	B1: Unsoftened SW	270	180	144	90
	B2: Softened SW	112	75	60	37
	B3: RO Treated SW	0	0	0	0

GCDWQ: 80-100 mg/L provides acceptable balance between corrosion & encrustation
< 200 mg/L required to prevent scaling in treatment works

Iron Comparison (mg/L)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	2.0	1.8	1.7	1.6
	B2: Softened SW	0.5	0.8	0.9	1.1
	B3: RO Treated SW	0.3	0.7	0.8	1.0
A2: Softened GW	B1: Unsoftened SW	1.7	1.2	1.0	0.7
	B2: Softened SW	0.2	0.2	0.2	0.2
	B3: RO Treated SW	0.1	0.1	0.1	0.2
A3: RO Treated GW	B1: Unsoftened SW	1.6	1.1	0.9	0.5
	B2: Softened SW	0.2	0.1	0.1	0.1
	B3: RO Treated SW	0.0	0.0	0.0	0.0

GCDWQ - Aesthetic objective: ≤ 0.3 mg/L

TOC Comparison (mg/L)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	10.5	8.0	7.0	5.5
	B2: Softened SW	6.1	5.1	4.7	4.0
	B3: RO Treated SW	0.8	1.5	1.8	2.3
A2: Softened GW	B1: Unsoftened SW	10.2	7.3	6.2	4.5
	B2: Softened SW	5.8	4.4	3.9	3.0
	B3: RO Treated SW	0.4	0.8	1.0	1.2
A3: RO Treated GW	B1: Unsoftened SW	9.8	6.5	5.2	3.3
	B2: Softened SW	5.4	3.6	2.9	1.8
	B3: RO Treated SW	0.0	0.0	0.0	0.0

Recommended range for control of disinfection by-products: 3-5 mg/L

Alkalinity Comparison (mg/L as $CaCO_3$)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	222	231	234	239
	B2: Softened SW	123	165	181	206
	B3: RO Treated SW	62	124	149	186
A2: Softened GW	B1: Unsoftened SW	180	147	134	114
	B2: Softened SW	81	81	81	81
	B3: RO Treated SW	20	41	49	61
A3: RO Treated GW	B1: Unsoftened SW	160	107	85	53
	B2: Softened SW	61	41	32	20
	B3: RO Treated SW	0	0	0	0

General range for lead and copper corrosion control: 30-75 mg/L
Higher alkalinity recommended for greater buffering capacity

Manganese Comparison (mg/L)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	0.14	0.13	0.13	0.12
	B2: Softened SW	0.04	0.06	0.07	0.09
	B3: RO Treated SW	0.03	0.06	0.07	0.09
A2: Softened GW	B1: Unsoftened SW	0.12	0.08	0.07	0.05
	B2: Softened SW	0.01	0.01	0.01	0.01
	B3: RO Treated SW	0.00	0.01	0.01	0.01
A3: RO Treated GW	B1: Unsoftened SW	0.11	0.08	0.06	0.04
	B2: Softened SW	0.01	0.01	0.00	0.00
	B3: RO Treated SW	0.00	0.00	0.00	0.00

GCDWQ - Aesthetic ojective: ≤ 0.05 mg/L

TTHM (µg/L @ 20 °C for 1 day)

		Blend Ratio (%GW)			
GW Treatment	SW Treatment	25%	50%	60%	75%
A1: Unsoftened GW	B1: Unsoftened SW	184	142	126	100
	B2: Softened SW	107	92	85	74
	B3: RO Treated SW	14	28	35	44
A2: Softened GW	B1: Unsoftened SW	177	128	109	79
	B2: Softened SW	98	75	67	57
	B3: RO Treated SW	6	14	18	23
A3: RO Treated GW	B1: Unsoftened SW	170	112	89	54
	B2: Softened SW	88	59	42	23
	B3: RO Treated SW	0	0	0	0

GCDWQ - Maximum Acceptable Concentration: 100 µg/L
MB DWQSR - Maximum Acceptable Concetration: 100 µg/L

TTHM data determined using the USEPA WTP Model v.2.1
Assumed SUVA = 2.48, as given in the MIEX Treatability Study
Assumed pH = 7.7, Cl2 Dose= 5 mg/L, Bromide= 0.1 mg/L, DOC ≈ TOC

Appendix K.

- **Road Map**

2013
2014
2015
2016
2017
2018 → 2020
Source
Estimate g/w to surface water ratio to meet TOC target
Confirm Demands
Initial screening of water sources
Confirm that alternative sources are available
YES
Assume dual water source
NO
(Site selection is more complex)
YES
YES
Evaluate capacity of ARVA ("Hydro Well")
• Potentially provides 50%
Does ARVA still have potential?
NO : Stop evaluation
YES
Continue evaluation
Does ARVA still have potential?
NO : Stop evaluation
YES : Continue evaluation
Make final decision on ARVA
Negotiate Water Rights Transfer with Koch
• BCA potentially provides 80%
Is deal still possible?
NO : Stop negotiations
YES : Continue negotiations
Is deal still possible?
NO : Stop negotiations
YES : Continue negotiations
Deadline to reach agreement with Koch
NO : Stop negotiations
YES : Determine delivery method for infrastructure requirements (such as reuse water line)
Assess ability to access G/W rights held by other users
Can other G/W rights be accessed?
NO : Stop discussions
YES : Continue discussions
Can other G/W rights be accessed?
NO : Stop evaluation
YES : Continue discussions
Can other G/W rights be accessed?
NO: Stop evaluation
YES: Continue discussions
Is 50% G/W likely to be achieved?
NO : Reconsider G/W target. Adjust WTP preliminary design.
YES : Continue
Is 50% G/W likely to be achieved?
NO : Reconsider G/W target. Adjust WTP preliminary design.
YES : 2016 preliminary design confirmed. Adjust as necessary.
Adjust WTP design as necessary
Site
Initial Assessment of Potential Sites
Short List Sites
Detailed Evaluation and Selection of Site
Existing site is best alternative
NO: Begin land acquisition activities for selected site
YES: No land acquisition required
Input site selection into conceptual design
Preferred Site Acquired
NO: Begin acquisition of alternate site
YES
Consider Phased Two Site Alternative
Infrastructure
Estimate value of existing plant if components reused
Input into conceptual design
Code and condition Assessment of existing WTP
Identify:
High priority upgrades at existing WTP that must be completed (Safety/ Reliability)
High priority upgrades: Preliminary/Detailed Design
Safety:
• Chlorine
• etc
Reliability:
• Electrical
• etc
Construction of High Priority Upgrades
High Priority Upgrades Complete
Proof of Concept of Reuse
Design and Construction of Reuse System
Second priority upgrades
Preliminary/Detailed Design of Second Priority Upgrades
Construction of Second Priority Upgrades
Conceptual Design and costing of WTP and System Upgrades:
• Existing site
• New site
• 50% surface water
• 100% surface water
Master Plan Report
Review key assumptions
Update Master Plan
Review key assumptions
Update Master Plan
Preliminary/Detailed Design of New WTP or Upgrade of Existing
Construction of New WTP or Upgrades of Existing
2020
Financial
Master Plan: $ 270,000
Ground Water Investigation
• Existing Wells
• $100,000 Base Investigation
• $50,000 Additional Investigations
• Hydro Wells
• Install high capacity well
• Install monitoring wells
• Pump Test (1 yr)
• $200,000
• High Priority Upgrades
• Engineering - $1.0M (10%)
Update Master Plan - $25,000
Ground Water Investigation
• Existing Wells
• $100,000 Base Investigation
• $50,000 Additional Investigations
• Hydro Wells
• Completion of longer term pump tests
• Additional follow-up investigations)
• $50,000
• High Priority Upgrades
• Engineering - $200,000
• Construction - $7.0M (includes $4.5M for electrical services)
Second Priority Upgrades
• Engineering - $250,000
Update Master Plan - $25,000
Ground Water Investigation
• Existing Wells
• $100,000 Base Investigation
• $50,000 Additional Investigations
• Koch Wells
• Develop new wells outside Koch
• Property limit - $500,000
• High Priority Upgrades
• Engineering - $100,000
• Construction - $3.8M
Update Master Plan - $25,000
Preliminary Design of New or Upgrade to Existing WTP - $400,000
• Second Priority Upgrades
• Construction - $1.5M
Ground Water Investigation
• Existing Wells
• $100,000 Base Investigation
• $50,000 Additional Investigations
• Koch Reuse Proof of Concept
• Second Priority Upgrades
• Engineering - $100,000
• Construction - $1.0M
Detailed Design of New or Upgrade to Existing WTP - $1.5M
Ground Water Investigation
• Existing Wells
• $100,000 Base Investigation
• $50,000 Additional Investigations
• Design and Construction of Koch Reuse Forcemain - $5.0M
Construction of New or Upgrade to Existing WTP - $22M