Associated Engineering | GLOBAL PERSPECTIVE. LOCAL FOCUS.

REPORT

Mackenzie County

Water Supply Treatment and Distribution Study

June 2015

CANADA'S BEST MANAGED COMPANIES Platinum member

Executive Summary

1 INTRODUCTION

Mackenzie County has seen steady growth within the rural communities in and around the Fort Vermilion and La Crete areas. Providing high quality drinking water supply to all residents within the County, especially the rural customers, has proven to be a challenge. In order to meet the Province's "*Water for Life*" strategy and the County's goals, a detailed comprehensive study is required to determine the best path forward. To deal with the anticipated growth, within Mackenzie County, a set of strategies needs to be developed to ensure the proper options for water supply and treatment.

The County engaged the services of Associated Engineering to complete a detailed comprehensive study to develop a strategy for meeting the water supply needs of the area. The objectives of the study are:

- To evaluate the existing water treatment facilities, in terms of:
  - Raw water quality and quantity;
  - Supply or treatment constraints; and
  - Upgrades to meet current standard.
- To evaluate the municipal water sources (the Peace River and groundwater wells) to supply the region.

In addition, the County wants to investigate the feasibility of mixing water from the two existing Water Treatment Plants (WTP) (located in Fort Vermilion and La Crete). Mixing of potable water from these two sources concerns the County, as there is a potential for physical and chemical reactions that may create undesirable effects and result in aesthetic or compliance issues.

2 WATER MIXING (BLENDING) ANALYSIS

Associated Engineering completed the following: computer modeling, a bench-scale analysis for scaling potential and disinfectant residual decay, and a simulated distribution system analysis. The scaling potential analysis looks at how water will interact with pipes. The distribution system operation in both La Crete and Fort Vermillion reportedly do not experience issues with corrosion or scaling. The desktop and bench-scale scaling or corrosion potential prediction do not exhibit dramatic changes when blending La Crete and Fort Vermillion treated waters indicating that the blending treated water likely will not significantly change current conditions for scaling or corrosion seen in either distribution system. The analysis also concluded the following:

- Free chlorine residual is a suitable secondary disinfectant for this regional system assuming pipeline residence time is less than 7 days.

- Disinfectant by-product formation potential did not show higher concentration at longer residence time.
- Boosting free chlorine residual did not increase disinfectant by-product formation in bench-scale testing.

3 WATER SUPPLY OPTIONS

Associated Engineering developed the design criteria in conjunction with the County and calculated the water demand requirements for meeting the future population growth in the region. Associated Engineering evaluated the existing water infrastructure (source to distribution) and identified capacity requirement for the following planning horizons:

Planning Horizon	Year
—	2016
10	2026
20	2036
30	2046

In order to provide long term sustainable potable water supply to the study area (the Fort Vermilion and La Crete supply areas), the County and Associated Engineering identified the following three water supply options:

Option 1 – Separate System

- Both Water Treatment Facilities (Fort Vermilion and La Crete) will continue to operate.
- Upgrades/expansions are required for each facility and will be targeted for the growth/expansion needs of the respective supply zones.
- The existing 150 mm transfer pipeline (Fort Vermilion to La Crete) will continue to operate, thus providing the ability to transfer water across the supply zone.

Option 2 – Regional System

Under this scenario, two additional water supply options were evaluated:

Option 2(a) – Fort Vermilion Regional Hub

- Central treatment facility located in Fort Vermilion will supply potable water to the entire study area.
- La Crete water supply and treatment facilities will be abandoned.
- The existing La Crete WTP will be converted into a distribution pump station; the existing distribution pump station and pipeline will continue to operate.
- Additional transfer pipeline and booster stations to facilitate water transfer.

Option 2(b) – La Crete Regional Hub

- Central treatment facility located in La Crete will supply potable water to the entire study area.
- The Fort Vermilion water supply and treatment facilities will be abandoned.
- The existing Fort Vermilion WTP will be converted into a distribution pump station; existing distribution pump station and pipeline will continue to operate.

Infrastructure deficiencies for the current and future conditions (10, 20, and 30 year planning horizons) were identified.

4 REGIONAL PIPELINE ANALYSIS

In 2013, the County installed a 150 mm regional rural pipeline between Fort Vermilion and La Crete. This pipeline is currently disconnected between Fort Vermilion and La Crete, via isolation valves, due to a concern with water mixing. The option for supplying a truckfill station approximately halfway between La Crete and Fort Vermilion, using the existing 150 mm rural waterline, was analysed. Using a delivery pressure of 14.3 (20 psi) and the operating pressure of the existing distribution system, the existing rural waterline can produce a maximum flow of 4.86 L/s when supplied from Fort Vermilion and 5.85 L/s when supplied from La Crete. In order to transfer more water, the existing pipeline needs to be upgraded.

A hydraulic analysis was completed in order to identify the pipeline and pumping requirements for the regional supply options (Option 2(a) and Option 2(b)). In addition, a hydraulic analysis was completed to supply water through a Truckfill system to the following communities:

- La Crete to Buffalo Head Prairie;
- La Crete to Tompkins Landing; and
- Fort Vermilion to Rocky Lane.

Based on the hydraulic analysis, the following infrastructure needs were identified:

Supply Route	Infrastructure
La Crete to Tompkins Landing Truckfill	Booster pump station and 21 km of 200 mm supply line
La Crete to Buffalo Head Prairie Truckfill	Booster pump station and 14.5 km of 200 mm supply line
Fort Vermilion to Rocky Lane	Booster pump station and 29.5 km of 200 mm supply line
Option 2(a): Regional Hub - Fort Vermilion to La Crete	Booster pump station and 46 km of 550 mm diameter supply line
Option 2(b): Regional Hub- La Crete to Fort Vermilion	46 km of 300 mm diameter supply line

5 COST ESTIMATES AND OPTION EVOLUTION

Conceptual cost estimates were prepared for all the three options for comparison purposes as shown in the following table:

Option	Capital Construction Cost 30 Year Total (2015 $ million)
Option 1: Separate System	$54.5
Option 2(a): Fort Vermilion Regional Hub	$88.9
Option 2(b): La Crete Regional Hub	$74.3

Option 1 provided the best value (least overall cost), followed by Option 2(b).

In addition to capital costs, a set of non-financial factors that have impact on the options, but are difficult to quantify financially, were identified. The three water supply options were ranked, based on the non-financial factors on a scale of 1 to 5, with 1 being least favorable to 5 being most favorable.

Option 1 has the best ranking overall, based on the non-financial ranking.

6 CONCLUSIONS

Option 1 provides the best capital value. It allows optimization of the capital investment (staged utilization). However, the following issues/disadvantages need to be considered with this option:

- Fort Vermilion WTP and intake pump chamber is located close to flood hazard zone;
- Upgrades and/or expansion of the La Crete plant are immediately required;
- Long term raw water availability for La Crete is an issue (may need a new river intake in the future); and
- Need for raw water storage at La Crete (future).

Option 2(b) is second best capital value overall. The facility is closer to the demand center in the long run. The following issues/disadvantages also need to be considered with this option:

- Raw water availability for La Crete is an issue and may need a new river intake (immediately);
- Raw water storage (immediately); and
- Plant upgrades/expansion (immediately).

Option 2(a) is the least capital value (highest capital cost) overall. This provides the ability to use the existing intake and raw water storage for the short/medium term. However, the following issues/disadvantages need to be considered with this option:

- Fort Vermilion intake and WTP are located close to flood zone; and
- Fort Vermilion WTP expansion (immediate).

In this respect, Option 1 is the best option, at this stage, as it provides an opportunity to continue the operation of existing facilities and potentially switch over to Option 2(b) at the right time.

The study identified the following issues that require further investigation/attention:

6.1 Fort Vermilion

The existing WTP and the intake transfer pump station are located in close proximity to the Peace River. Associated Engineering reviewed the Alberta Flood Hazard Map for this location. At this stage, it appears that the WTP and the raw water storage reservoirs are not located in the flood areas. However, the intake transfer pump station appears to be very close to the flood hazard area. Operational procedure would need to include operators closing the intake valve to avoid flooding of internal components in the intake chamber (flow transmitter, electrical components).

6.2 La Crete

The existing wells are classified as “Ground Water Under Direct Influence” (GWUDI) wells, due to their close proximity to surface water. It is also reported that one of the ground water wells is drawing sand. Water treatment systems supplied by GWUDI wells are required to be provided with a treatment system that can achieve a minimum 3-log removal credit for *Giardia* and *Cryptosporidium*, and 4-log removal credit for Virus. The current treatment scheme (green sand filters and ion-exchange softeners followed by chlorination) typically is not considered to provide any log removal credit for *Cryptosporidium*.

This issue was discussed with George Neurohr, with Alberta Environment and Parks (AEP), during the review meeting on February 27, 2015. Mr. Neurohr indicated the following:

- The County has applied for a renewal of the operating licence (EPEA), and the AEP is reviewing the application.
- After the review, AEP will advise the County of any additional level of treatment system required (such as Ultraviolet disinfection).

The existing ground water wells at La Crete are not adequate enough to meet the long term raw water demands for both Option 1 (separate system) and Option 2(b): Regional System. Depending on the actual growth in the region, the wells are likely to run out of capacity in 10-20 years’ time. In order to secure long term raw water supply, the County may need to migrate to a surface water source, which will require construction of a river intake structure in the Peace River.

Alternatively, the County can evaluate if additional wells can be constructed to provide additional capacity. However, it should be noted that this will require additional hydrogeological investigations, field well testing, etc. to identify a suitable well (which may or may not be feasible). In addition, the cost of a new well development and associated infrastructure (power supply, access road, etc.) needs to be considered.

The hydraulic capacity of the existing WTP is operating close to the immediate water demand needs under peak day demand conditions and may require upgrades/expansion or additional treatment, in the near future. Any upgrades/expansion requirement for the La Crete WTP should consider implications of potential future surface water from Peace River.

7 RECOMMENDATIONS

7.1 Short Term

- Continue with Option 1 – Operate two separate systems
- Fort Vermilion:
  - No major capital upgrade is required. Some operational improvements/minor upgrades may be implemented.
  - Evaluate the risk due to flooding and re-assess risk rating as necessary. Consider implementing flood defenses around the intake pump chamber.
- La Crete:
  - As a short term basis, carryout an on-site testing of the existing filters, to see if the filters can be operated at a higher flow rate.
  - Subject to direction from AEP, the County may be required to address issues related to the GWUDI status: Options include reclassification of wells as high quality water or additional treatment (UV).
  - Existing WTP is operating close to the hydraulic capacity under Peak Day Demand conditions. Any upgrades/expansion requirements for the La Crete WTP should consider implications of potential future surface water from Peace River.
  - County to develop a strategy for securing long term raw water supply. Options include constructing a new river intake structure in the Peace River, or evaluate if additional wells can be constructed to provide additional capacity.
- Utilize the existing 150 mm transfer pipeline between Fort Vermilion and La Crete. Consider construction of a new truckfill halfway between Fort Vermilion and La Crete to alleviate routing maintenance issues (flushing of the pipeline segments) and to provide water to rural customers.

7.2 Long Term

- Infrastructure planning for future growth needs is a continuous process. Therefore, the County should review the growth/demand needs of the community on a continuous basis (every 5-10 year interval) and revise the planning goals as required.
- Continue to monitor the risk from the river to potentially flood the water supply assets at Fort Vermilion (WTP and intake pump chamber). Any elevated risk due to flooding will require revaluation of the water supply options as this may require relocation of the existing WTP and intake to a higher ground. In this case, it may be worth implementing Option 2(b).

Table of Contents

List of Tables

PAGE NO.

List of Figures

1 Introduction

1.1 BACKGROUND

Mackenzie County has seen steady growth within the rural communities in and around the Fort Vermilion and La Crete areas. Providing high quality drinking water supply to all residents within the County, especially the rural customers, has proven to be a challenge. In order to meet the Province's "Water for Life" strategy and the County's goals, a detailed comprehensive study is required to determine the best path forward.

The County currently has three water treatment plants (WTP), located in Zama City, Fort Vermilion, and La Crete. To streamline the efforts for this study, the main focus will be on the supply, treatment, and distribution for Fort Vermilion, La Crete, and their surrounding rural residents.

To deal with the anticipated growth, within Mackenzie County, a set of strategies need to be developed to ensure the options for water supply, treatment, and distribution meet both the short term and long term potable water objectives.

1.2 PROJECT SCOPE

- Establish Design Criteria.
- Evaluate the existing water treatment facilities in terms of:
    - Raw water quality and quantity;
    - Supply or treatment constraints; and
    - Upgrades to meet current standards.
- Evaluate municipal water sources (the Peace River and groundwater wells) to supply the region.

This will include:

- Water quality and quantity investigation;
- Water chemistry and blending analysis;
- Establish an ultimate regional system concept;
- Establish interim regional supply and staging plan;
- Establish treatment upgrade options at La Crete and Fort Vermilion WTPs;
- Provide conceptual level drawings for each alternative; and
- Deliver Summary Report and present to Council.

The scope of the current study is limited to the Fort Vermilion and La Crete areas, as identified in Section 2.1.

2 Design Criteria and Water Demand

2.1 STUDY AREA

The project study area consists of the following areas (refer to Figure 2-1):

- Hamlet of Fort Vermilion (FV);
- Rocky Lane High Level Rural (RL);
- Fort Vermilion Rural Areas;
- Hamlet of La Crete; and
- La Crete Rural Areas: Buffalo Head Prairie and Tompkins Landing.

2.2 POPULATION

One of the variables in assessing a community's municipal servicing components is the population. The population will:

- Provide a measure of the quantity of water required.
- Impact the consumption peak factors.
- Impact the distribution system based on population concentration (density).

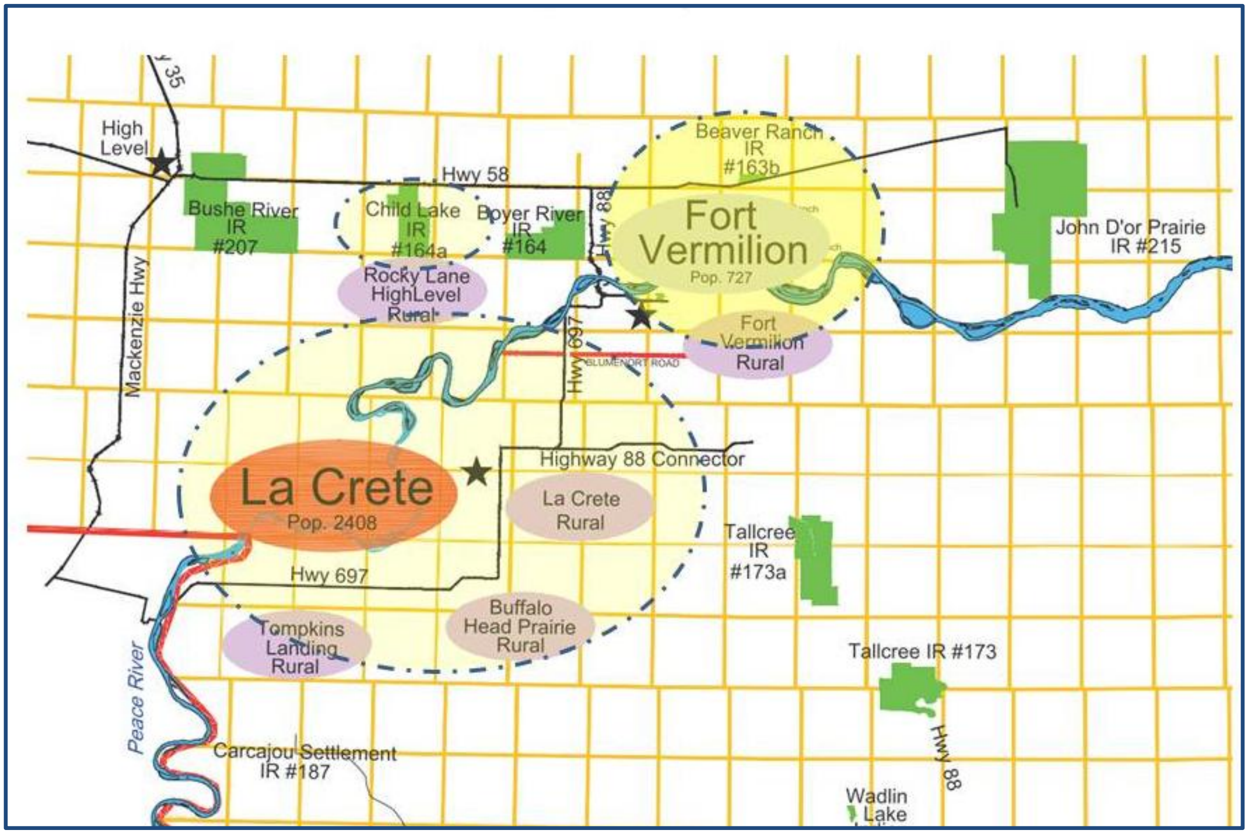
The population data for the study area was provided by Mackenzie County. Future population projections were estimated, based on the growth rates recommended by Mackenzie County (refer to Table 2-1).[1] [2]

Table 2-1
Population Projections

Planning Range	Year	Fort Vermilion (2%)	La Crete (20%)	Rural Areas				Totals
				La Crete	RL	FV	Total	
0	2016	742	2,890	5,976	1,015	1,393	8,384	12,015
10	2026	765	4,491	7101	1206	1655	9,961	15,217
20	2036	797	6,468	8436	1432	1966	11,835	19,100
30	2046	829	9,314	10023	1702	2336	14,061	24,204
50	2066	897	19,313	14148	2402	3298	19,849	40,059
75	2091	990	48,058	21,769	3,696	5,074	30,540	79,588

[1] Data compiled from: Population data provided by B. Peters, Makenzie County; Mackenzie County ASP, March 2013.
[2] Growth rate per 5 years.

Figure 2-1
Study Area



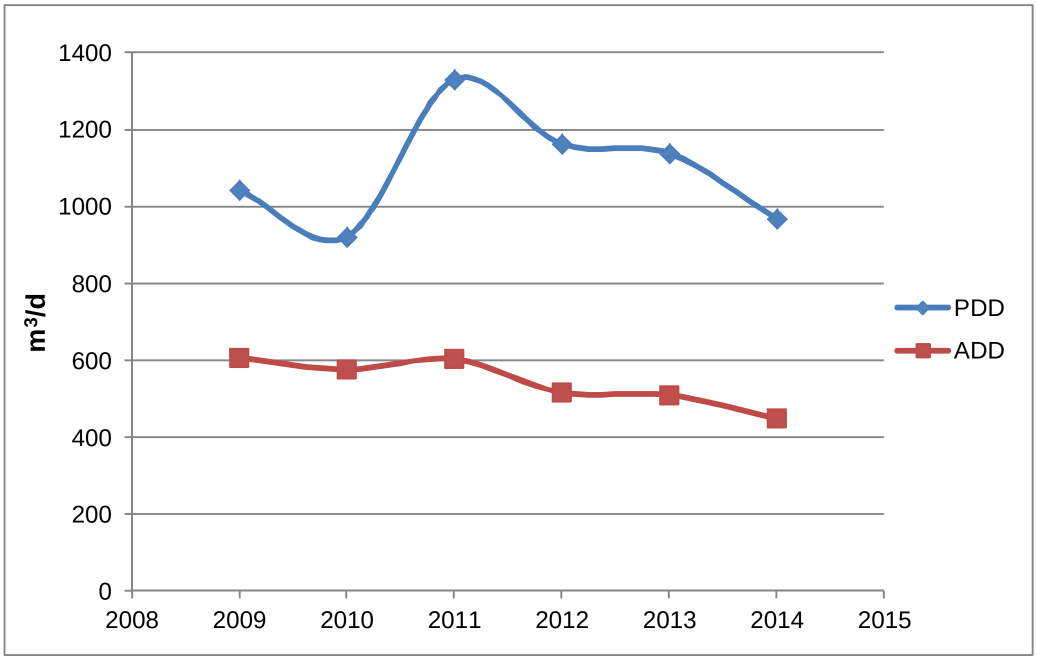
2.3 WATER DEMAND ANALYSIS

2.3.1 Historic Water Demand

Associated Engineering (AE) collected and analysed the historical operational data from the Makenzie County.

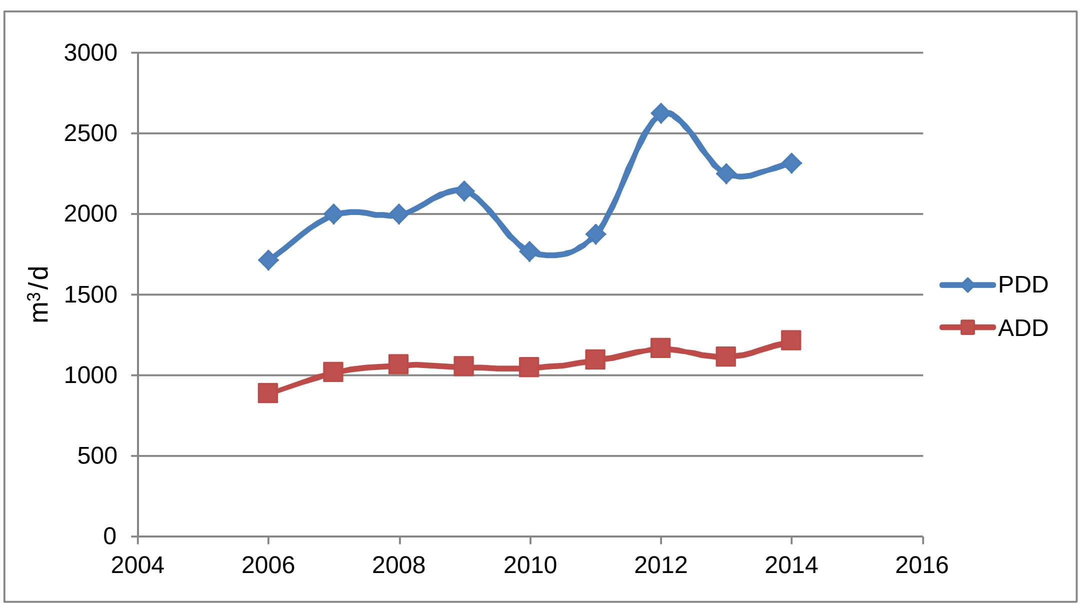
Figure 2-2 shows the historical flow trend for the Fort Vermilion WTP (2009 to 2014). As seen in Figure 2-2, the Average Day Demand (ADD) has reduced between 2009 and 2014. This is understood to be as a result of controlling bleeders in the distribution system. The Peak Day Demand (PDD) follows the ADD pattern, except in 2011 where there appears to be a large variation. It is understood that this was caused by a high truck fill usage from a commercial operation in 2011.

Figure 2-2
Historic Flow Trends for Fort Vermilion



The historical flow trend showing the ADD and PDD for La Crete for the period from 2009 to 2014 is shown in Figure 2-3. The water demand in La Crete has shown a steady increase.

Figure 2-3
Flow Trend for La Crete



2.3.2 Per Capita Water Consumption

Historic per capita water consumption is calculated by dividing the Average Day Demand by the population served and is expressed as Litres of water consumed per Person per Day (L/p/d). In calculating the per capita consumption, the distinction is made between communities serviced by fully piped system and those served by truck fill system. Communities served by truck fill tend to have lower per capita water consumption than those served by fully piped system.

Historic per capita consumption for Fort Vermilion and La Crete are shown in Table 2-2, for both fully piped and truck fill systems.

Table 2-2
Historic per Capita Consumption[3]

Location	Fully Piped (Distribution) System (L/p/d)	Truck Fill System (L/p/d)
Fort Vermilion	605 (369 in 2014)	74
La Crete	307	64

Based on the historical consumption and in discussion with the County, the per capita design values were agreed upon as shown in Table 2-3.

Table 2-3
per Capita Consumption: Recommended Design Value

Location	Fully Piped (Distribution) System (L/p/d)	Truck Fill System (L/p/d)
Design Value for both Fort Vermilion and La Crete	360	120

[3] Historic data 2011

2.3.3 Peaking Factors

Table 2-4 shows the 2009 to 2014 peak day factors and the recommended peak day factors for this study.

Table 2-4
Peak Day Factors (2009 to 2014)

Municipality	Peak Day Factor					Average Peak Day Factor	Recommended Peak Day Factor
	2009	2010	2011	2012	2014		
Fort Vermilion	1.7	1.6	2.2	2.25	2.15	1.98	2.0
La Crete	2.03	1.7	1.7	2.25	1.9	1.92	2.0

The peak hour demand is the maximum expected demand in a water distribution system (not transmission pipeline) over a short period of time. Most facilities are not equipped to measure peak hour demands; therefore, experience and judgement are often used to establish a rate. The peak hour demand is used to determine sizing and pumping requirements. For small communities, peak hour factors can range from 3 to 5. As this study does not include sizing of the distribution pumps, peak hour factors will not be used. In the subsequent design phases, the Peak hour factor will need to be established.

2.4 WATER DEMAND PROJECTIONS

Future water demand is calculated using the recommended per capita value in Table 2-3, based on the population projections (Table 2-1). The following tables show water demand projections for Fort Vermilion and La Crete.

Table 2-5
Fort Vermilion Water Demand

Planning Horizon	Year	ADD (m^3/d)	PDD (m^3/d)
0	2016	556	1,112
10	2026	619	1,237
20	2036	695	1,389
30	2046	783	1,566
50	2066	1,007	2,014
75	2091	1,409	2,818

Table 2-6
La Crete Water Demand

Planning Horizon	Year	ADD (m^3/d)	PDD (m^3/d)
0	2016	1,757	3,515
10	2026	2,469	4,938
20	2036	3,341	6,682
30	2046	4,556	9,112
50	2066	8,651	17,301
75	2091	19,913	39,826

2.5 TREATED WATER DISTRIBUTION

To estimate pipeline sizes, AE has made the following design assumptions, which are consistent with AWWA standards and with communities of similar size and demands.

2.5.1 Operating Pressures

The recommended normal operating system pressures are:

- Minimum pressure at peak hour demand — 280 kPa (40 psi)
- Target minimum pressure — 345 kPa (50 psi)
- Target maximum system pressure — 551 kPa (80 psi)
- Minimum delivery pressure to a reservoir — 140 kPa (20 psi)

The recommended minimum system pressures during a fire event are:

- Residual pressure at demand hydrant — 140 kPa (20 psi)
- Zone pressure — 280 kPa (40 psi)

Target minimum and maximum pressures identified above are as recommended by AE.

2.5.2 Pipe Roughness Coefficient (“C-Value”)

The “C-Value” (roughness co-efficient) is one of the variables in the Hazen-Williams equation for determining the liquid flow through a pipe. It represents the material and the condition of the pipe. It is recommended that a "C" value of 130 be applied for the proposed pipe, this will allow for a more conservative design.

2.5.3 Pipe Velocity

Water velocity is one of the main criteria in pipeline design. Sudden changes in velocity can create pressure surges and possibly negative pressure, which can cause serious pipe (equipment) damage. Increased velocities require higher pumping heads and can result in higher energy costs.

The recommended maximum velocity in the transmission line is 1.5 m/s, during peak flow conditions. If higher velocities are to be used, water hammer analysis and life cycle cost analysis should be undertaken.

2.6 TREATED WATER STORAGE

It is a good practice to provide adequate storage in a water system for operational needs (peak day), supply interruptions, and fire flow demands.

Alberta Environment and Parks' (AEP) Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems recommend the following empirical formula for calculating treated water storage volume:

$$S = A + B + \text{the greater of } C \text{ or } D$$

- S = total storage requirement, m^3
- A = Fire protection storage, m^3
- B = Equalization storage = 25% Peak Day, m^3
- C = Emergency storage = 15% of Average Day, m^3
- D = Disinfection contact (CT) storage, m^3

For regional systems supplied by long transmission mains, AE recommends the following formula, which is more conservative than the AEP formula:

$$S = A + \text{Peak Day Demand}$$

The above formula is used to reflect the inherent risks associated with a regional system where the supply zone relies solely on the transfer pipeline. Should any pipe break or leakage occurs in the regional transfer pipeline, then the above formula provides the storage capacity to sustain fire demand and one day peak day flow for the supply zone. This however will result in larger storage facilities and higher capital cost comparing to using the AEP formula. During detailed design stage, the County could consider using AEP formula if the County is prepared to accept the risks and have alternative contingency plans.

2.6.1 Fire Protection Storage

Fire storage requirements are generally designed in accordance with the Fire Underwriter's Survey; however, the provision of a designed fire protection system is at the discretion of the individual municipality. Fire Underwriters Survey (FUS) provides recommendations for fire flow rates and durations. This is the commonly accepted criteria for evaluating the volume of storage the municipality should maintain for fire protection purposes. If a municipality owns and operates a water distribution system with fire hydrants on the system, there is an expectation that a level of fire protection exists. Larger municipalities/larger distribution systems have accepted this expectation and strive to provide this form of protective service to their ratepayers.

Mackenzie County provided an extract from the draft General Municipal Improvement Standards, which recommends the fire flows shown in Table 2-7.

Table 2-7
General Municipal Improvement Standards Recommendations

Location	Fire Flow
Single Family Residential	61 L/s
Town Houses	91 L/s
Walk-up Apartments	152 L/s
Schools	91 L/s
Commercial	190 L/s
Industrial	227 L/s

Based on the fire flows from Table 2-7, the required duration of fire flow recommended by Fire Underwriters Survey (FUS) is shown in Table 2-8. Based on these two design values, storage for fire flow storage (A) is calculated as follows:

$$A = 227 \text{ L/s} \times 2.5 \text{ hours} = 2{,}046 \text{ m}^3$$

Table 2-8
Required Duration for Fire Flow

Fire Flow Required (L/s)	Duration (hours)
33	1.0
50	1.25
66	1.50
83	1.75
100	2.0
133	2.0

Fire Flow Required (L/s)	Duration (hours)
167	2.0
200	2.5
233	3.0

* Interpolate for Intermediate Figures.

2.7 RAW WATER REQUIREMENTS

Raw water demand estimation is critical to evaluate:

- Adequacy of the water supply source (Intake system/ wells) and transmission system; and
- Raw water storage requirements.

Raw water demand is calculated using the following formula:

Raw water demand = treated water demand + in-plant losses + raw water truckfill requirements

In- plant losses are typically estimated from the difference between raw water and treated water flow from past records and are expressed as a percentage of treated water flow or raw water flow. In-plant losses are typically dependent on the water treatment technology used and operational practices, and reflect the amount of water wasted in the treatment process.

The historical flow records for the existing WTPs indicate the following:

- Fort Vermilion WTP: In-plant loss = 22% of treated water.
- La Crete: In-plant loss = 10% of treated water.

For planning purpose, AE recommends the following:

- Fort Vermilion WTP: in-plant loss = 30% of treated water
- La Crete: In-plant loss = 20% of treated water

The above values will need to be re-visited, during subsequent design phases, depending on the technology selected for the water treatment facilities.

Raw water demand requirements are calculated based on the above criteria and are provided in Tables 2-9 and 2-10.

Table 2-9
Fort Vermilion Raw Water Demand

Planning Horizon	Year	ADD (m^3/d)	PDD (m^3/d)
—	2016	723	1,445
10	2026	804	1,609
20	2036	903	1,806
30	2046	1,018	2,036
50	2066	1,309	2,618
75	2091	1,832	3,663

Table 2-10
La Crete Raw Water Demand

Planning Horizon	Year	ADD (m^3/d)	PDD (m^3/d)
0	2016	2,109	4,218
10	2026	2,963	5,925
20	2036	4,009	8,018
30	2046	5,467	10,934
50	2066	10,381	20,761
75	2091	23,896	47,791

3 Water Supply System Assessment

Associated Engineering carried out a visual assessment of the water treatment facilities and reviewed the historical documents including as-built drawings and existing Drinking Water Safety Plans. A summary of the assessment is provided in this section.

3.1 FORT VERMILION

3.1.1 Raw Water Supply System

Fort Vermilion's raw water supply is from the Peace River. The intake system consists of 250 mm and 300 mm pipes that deliver water from the river to a pumping chamber by gravity. Water from the pumping chamber is pumped to the two raw water storage ponds (94,000 m^3 capacity each) via a 150 mm pipe and 200 mm pipes. There is ability to bypass the raw water storage ponds and pump directly to the WTP via the 150 mm pipe.

The storage ponds are aerated with a fine bubble aeration system. Air compressors for the aeration system are housed in a shed located along the berm.

It should be noted that any modification/upgrade to the existing intake pipe will require approval from provincial and federal regulators, including the Department of Fisheries and Ocean (DFO), Transport Canada (Navigable water), and AEP. Any modifications/upgrades of intake will need to comply with the latest (at the time of construction) regulations.

3.1.2 Treatment and Distribution System

Water from the raw water ponds is transferred to the treatment trains via two raw water pumps (duty/ standby). A dedicated raw water truckfill pump is also used to supply raw water.

Raw water flows to the package treatment system. The package treatment system (BCA/Corix system) consists of: rapid mix tanks, sedimentation (tube settlers), and dual media filtration. Filtered water from the package system flows via gravity to the underground clearwell cells (Cells 1, 2, and 3). The total treated water storage capacity (all cells combined) is 1,590 m^3.

Cell 1 has three distribution supply pumps and one engine driven fire pump. Cell 2 has a truckfill pump that supplies water to the truckfill and a barrel fill; and a backwash supply pump.

Backwash waste, de-sludge waste, and plant waste (with the exception of washroom waste) are collected in an underground tank and discharged back to Peace River via gravity.

3.1.3 Chemical Systems

- Polymer and poly aluminium chloride (PACL) are dosed at the flocculation chamber.
- Chlorine (gas) is dosed at the filter outlets.
- Chlorine gas and dosing equipment is housed in a separate room in the old WTP area.
- Polymer and PACL are dosed from day tanks located in the old WTP area.

3.1.4 Issues/Points Noted

- The package system (BCA systems -now a part of Corix) was installed in 1999. The modulating valves are manual (with pilots). Operator also indicated that there is no ability to adjust flow to individual filters.
- The package system tanks appear to be in good conditions. The condition of the underdrain and media are unknown.
- Operator indicated issue with isolating clearwells and potential short circuiting issues. In addition one of the inter-connecting valves has failed closed.

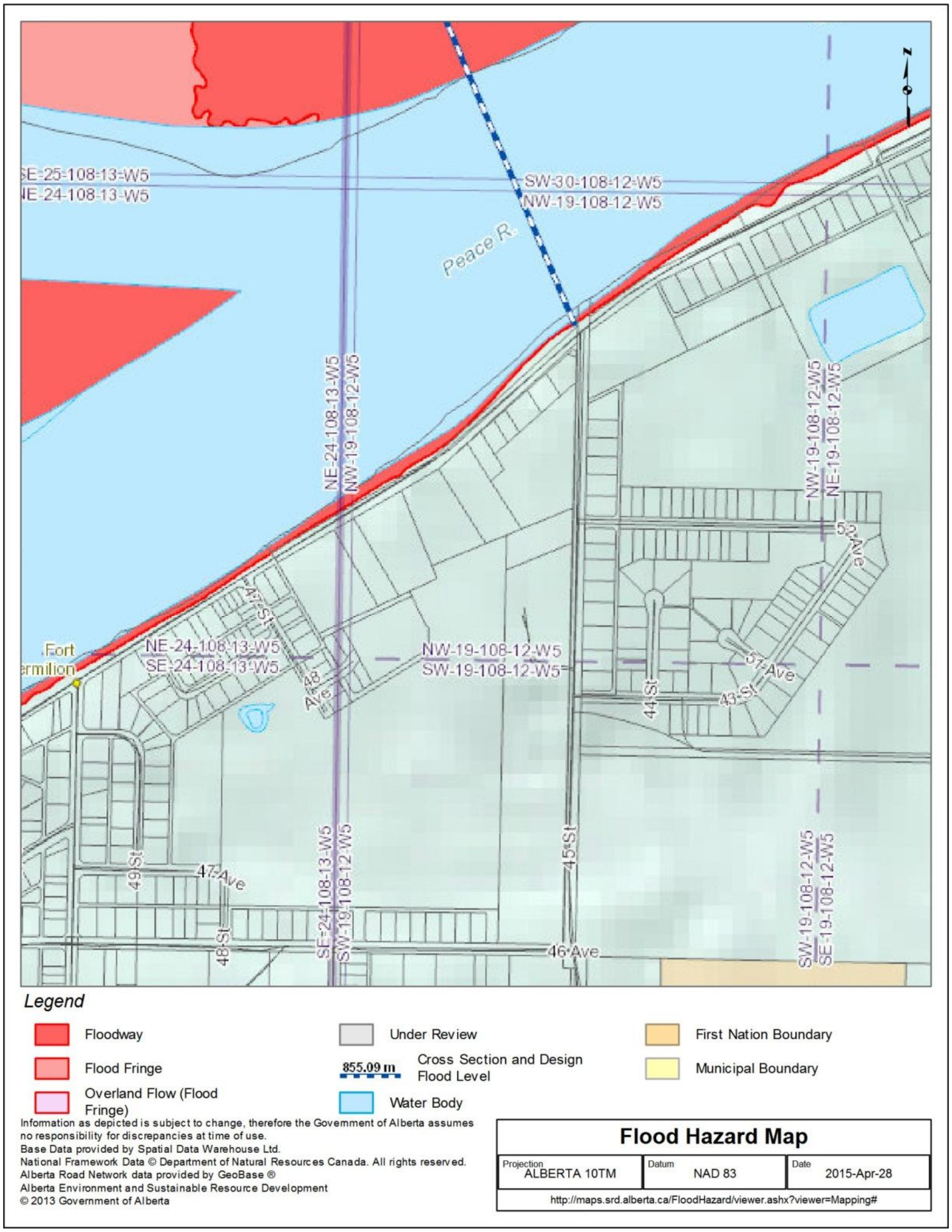
3.1.5 Existing Water Supply system risks/vulnerabilities

The existing WTP and the intake transfer pump station are located in the close proximity of the Peace River. AE reviewed the Alberta Flood Hazard map (refer to Figure 3-1) for this location. At this stage, it appears that the WTP and the raw water storage reservoirs are not located in the flood areas. However, the intake transfer pump station appears to be close to the flood hazard area.

The WTP's floor level is 257.5 m (based on DCL Siemen's drawings) and the design flood level is 253.36 m (1 in 100 flood level).

The top of this intake pump chamber is 255.118 m, which is above the design flood level. However, the intake transfer pump station appears to be close to the flood hazard area. The transfer pump station has electrical components (heater, lights, etc.) that would be flooded, if the river level rises. It is understood that the Operators close the inlet valves to the intake transfer pump station manually, if river level rises. In addition, flooding may happen in and around the surrounding areas thus limiting access. The County should periodically review the flood hazard map for any changes and consider strengthening flood defences around the intake transfer pump station.

Figure 3-1
Alberta Flood Hazard Map (2015)



3.2 LA CRETE

3.2.1 Raw Water Supply System

Raw water is supplied by three ground water wells, situated close to the Pace River, and conveyed via the 400 mm and 350 mm pipes. The well pumps pump raw water to a raw water truck fill station and the new WTP. There are no raw water storage ponds.

The existing wells are classified as “Ground Water Under Direct Influence” (GWUDI) wells by AEP, due to its close proximity to the River. It is also reported that one of the ground water wells is drawing sand.

A report by Omni-McCann (2004 Water Well Installation Program, Omni-McCann) concluded the following, based on a step draw down test and 24 hour aquifer test:

> “The potential yield from the aquifer is unknown at this time. However, it appears that the combined average day capacity of the wells is in the order of 2,300 m^3/day with a combined maximum pumping capacity of 6,100 m^3/day”.

A further report from Omni-McCann (2009 Well Replacement Program) indicate that the two of the wells (PW1 and PW2) were replaced in 2009 and additional testing was carried out. The report recommends that the production rate from the new wells be increased to 2,500 m^3/d. With new wells, the potential maximum pumping rate (combined) is 7,300 m^3/d.

Without additional testing, at this point for the purpose of this study, the above values are considered as limiting factors for water availability from the existing wells.

3.2.2 Treatment and Distribution

Water from the wells is initially passed through a 200 mm basket strainer to capture sand prior to the Green Sand (Iron and Manganese) filters. Filtered water from the green sand filters then flows to the Ion-exchange softeners. Currently, there are four filters and two softeners.

There are two underground clearwells (Cell 1 and Cell 2), downstream of the softeners. The capacity of existing treated water storage (Cells 1 and 2 combined) is 1,450 m^3. Cell 2 contains 2 distribution pumps, 1 barrel fill pump, 1 truckfill pump, and 1 backwash pump. There are two additional slots for future distribution pumps.

Backwash waste, softener waste, and plant waste (with the exception of washroom waste) are collected in an underground tank and discharged back to the local sewer.

The old plant, located along 94 Avenue (east of 100 Street), was abandoned, and converted into a distribution pumphouse. This distribution pumphouse has three distribution pumps and one engine driven fire pump. The treated water storage capacity of this distribution pumphouse is 1,792 m^2.

3.2.3 Chemical Systems

Chlorine (sodium hypochlorite) is dosed for pre-chlorination (u/s of filters) and at the softener outlets/ upstream of Cell 1.

Brine solution is prepared in a separate underground tank and pumped to the softeners for regeneration.

3.2.4 Issues/Points Noted

Water treatment systems, supplied by GWUDI wells, are required to be provided with a treatment system that can achieve a minimum 3-log removal credit for *Giardia* and *Cryptosporidium*, and 4-log removal credit for Virus. The current treatment scheme (green sand filters and ion-exchange softeners followed by chlorination) typically is not considered to provide any log removal credits for *Cryptosporidium*.

This issue was discussed with George Neurohr, with Alberta Environment and Parks (AEP), during the review meeting on February 27, 2015. Mr. Neurohr indicated the following:

- The County has applied for a renewal of the operating licence (EPEA), and the AEP is reviewing the application.
- After the review, AEP will advise the County of any additional level of treatment system required (such as Ultraviolet disinfection).
- If any additional treatment systems are required, then a time scale for implementing the system will be indicated in the approval.

Alternatively, the County can complete additional studies to certify the existing ground water wells as “high quality ground water wells”, in which case, no further treatment will be necessary.

4 Water Mixing (Blending) Study Summary

A suitable interim or staged regional supply system may require multiple sources in order to supplement shortages. Mixing of potable water from two sources (Fort Vermilion WTP and La Crete WTP) was concern for the County as there is potential for physical and chemical reactions creating undesirable effects, resulting in aesthetic or compliance issues.

AE completed a computer simulation, based on the water quality testing data supplied by the County and bench-scale testing, based on treated water samples collected on February 27, 2015, by AE. A detailed technical memorandum is attached in Appendix A.

AE carried out computer modeling and bench-scale analysis for scaling potential, disinfectant residual decay and simulated distribution system analysis. The scaling potential was computer and bench-scaled model at various mixing scenarios to see how the two treated water will interact over a large variety of possible operating conditions.

The desktop and bench-scale scaling or corrosion potential prediction do not exhibit dramatic changes when blending La Crete and Fort Vermillion treated waters indicating that the blending treated water likely will not significantly change current conditions for scaling or corrosion seen in either distribution system.

The other important water quality factor in operating a regional water system is disinfectant residual maintenance. Associated Engineering conducted a disinfectant residual decay and simulated distribution system study. The study looks at how long residual can be maintained in a distribution system, and determines how much disinfectant by-products can form in a distribution system. These studies found:

- Free chlorine residual is a suitable secondary disinfectant for this regional system assuming pipeline residence time is less than 7 days.
- Disinfectant by-product formation potential did not show higher concentration at longer residence time.
- Boosting free chlorine residual did not increase disinfectant by-product formation in bench-scale testing.

5 Water Supply Option Evaluation

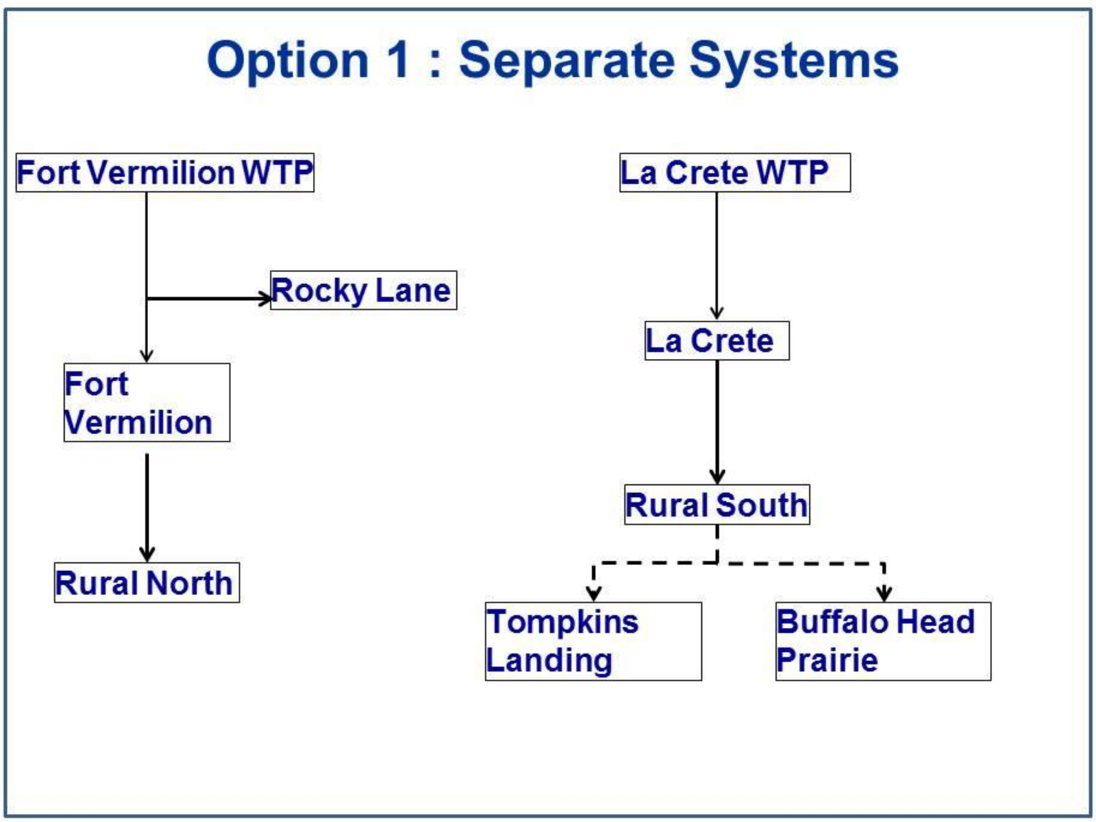
5.1 OVERVIEW OF OPTIONS

In order to meet the long term water supply requirements of the study areas, the following three water supply options are evaluated in this section.

5.1.1 Option 1: Separate System

- Both the Water Treatment Facilities (Fort Vermilion and La Crete) will continue to operate.
- Upgrades /expansion required for each facility will be targeted for the growth/expansion needs of the respective supply zones.
- The existing 150 mm transfer pipeline (Fort Vermilion to La Crete) will continue to operate thus providing the ability to transfer water across the supply zones.

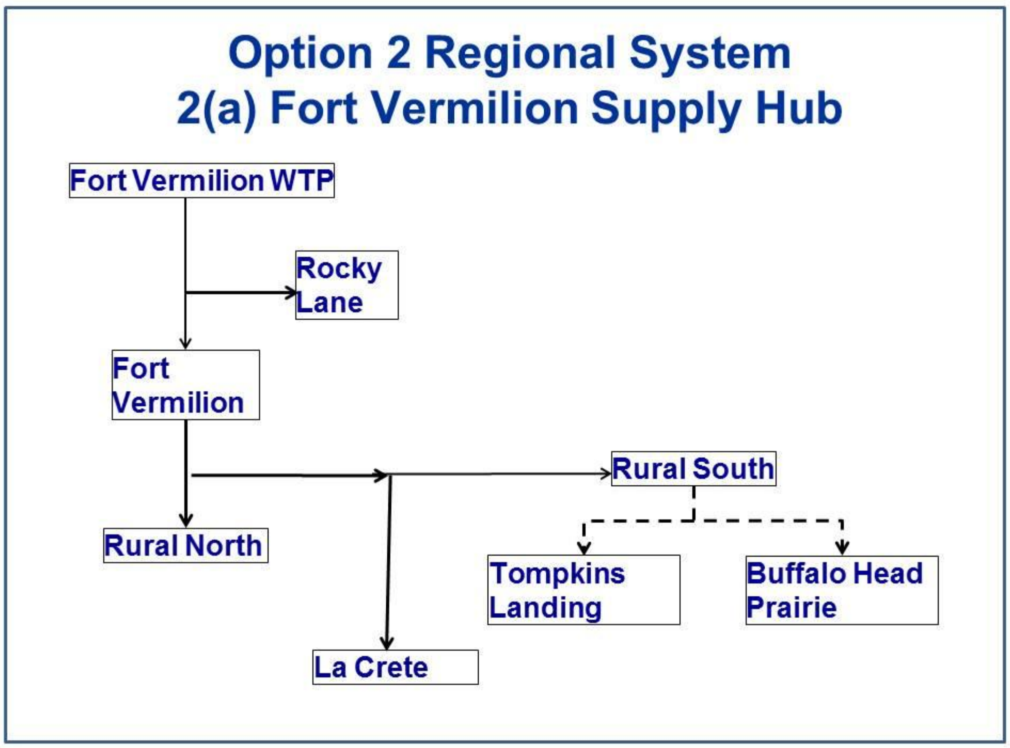
Figure 5-1
Option 1: Separate Systems



5.1.2 Option 2(a): Fort Vermilion Regional Hub

- Central treatment facility located at Fort Vermilion will supply potable water to the entire study area.
- La Crete Water supply and treatment facilities will be abandoned.
- Existing La Crete WTP will be converted as distribution pump station; existing distribution pump station and pipeline will continue to operate.
- Additional transfer pipeline and booster stations to facilitate water transfer.

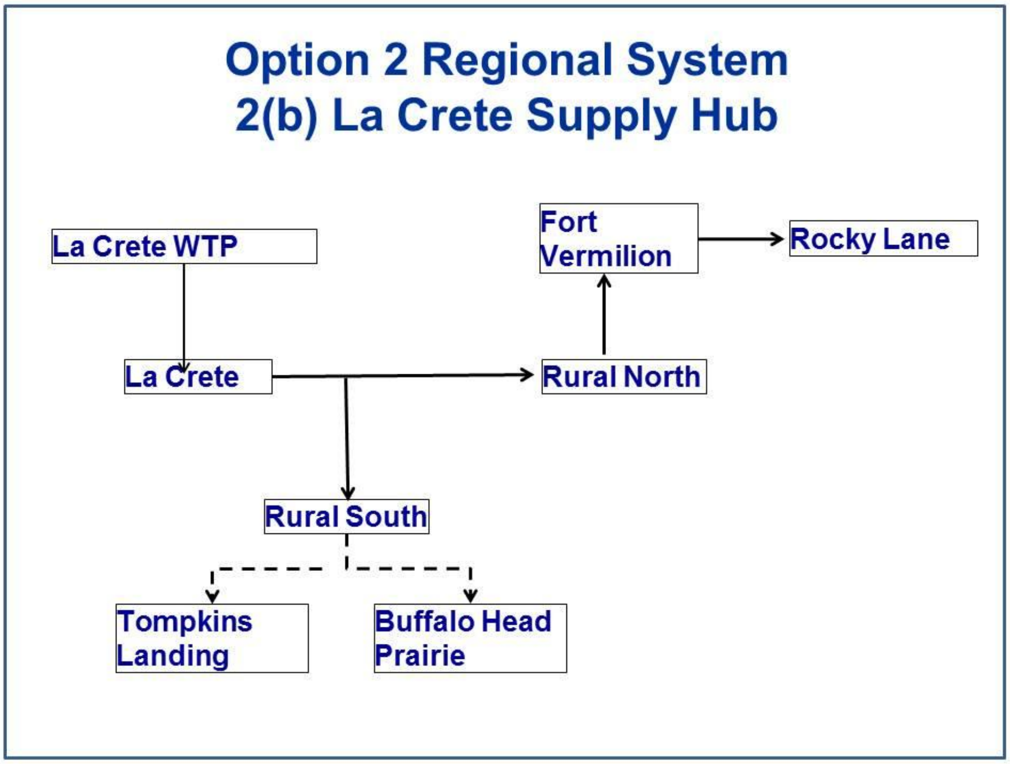
Figure 5-2
Option 2(a): Regional System/Fort Vermilion Supply Hub



5.1.3 Option 2(b): La Crete Regional Hub

- Central treatment facility located at La Crete will supply potable water to the entire study area.
- Fort Vermilion Water supply and treatment facilities will be abandoned.
- Existing Fort Vermilion WTP will be converted as distribution pump station; existing distribution pump station and pipeline will continue to operate.

Figure 5-3
Option 2(b): Regional System/La Crete Supply Hub



5.2 INFRASTRUCTURE NEEDS ASSESSMENT OVERVIEW

For each of the above identified supply option, an evaluation of the adequacy of the current infrastructure against future needs using a source to tap approach. The improvements/ additional infrastructure required to address the deficiency were identified. The overall goal was to evaluate the infrastructure requirement and associated capital investment requirement for all the supply options in order to identify the best way forward. The evaluation covers the following infrastructures:

- Raw water source (intake/wells) and transmission;
- Raw water storage;
- Treatment; and
- Potable water storage.

5.3 RAW WATER SOURCE AND TRANSMISSION

Based on the projected raw water demand for Fort Vermilion (FV) and La Crete (LC), the adequacy of the existing infrastructure is evaluated, and deficiencies are summarized in Table 5-1.

Table 5-1
Options Adequacy

Planning Horizon	Year	Option 1		Option 2(a) FV Hub	Option 2(b) La Crete Hub
		FV	La Crete		
0	2016	Intake	Wells	Raw water transfer pipe	New Intake
10	2026	—	New Intake	—	—
20	2036	—	—	Upgrade 250 mm intake	—
30	2046	—	—	—	—

- Option 1: La Crete raw water demand exceeds the capacity of the existing wells by 2026 and additional wells (if feasible) or a new river intake (more likely) will be required. For cost estimation purpose a new river intake is assumed.
- Option 2(a): The existing 250 mm River intake at Fort Vermilion will need to be upgraded by 2036. In addition the existing raw water transmission pipeline (150 mm) from the existing intake pump station to the raw water ponds need to be upgraded (immediate).
- Option 2(b): La Crete raw water demand exceeds the capacity of the existing wells for current conditions (Fort Vermilion and La Crete combined), and additional wells (if feasible) or a new river intake (more likely) will be required. For cost estimation purpose a new river intake is assumed. The existing raw water transmission pipeline will be adequate for current and future demands.
- Modification or new river intake will require new AEP and Federal approvals and river intake will need to comply with current (at the time of approval) regulatory standards/guidelines. Federal approvals include approval from Department of Fisheries and Ocean (DFO) and Transport Canada (navigable waters), and potential First Nation consultations.

5.4 RAW WATER STORAGE

It is a good practice to provide adequate amount of raw water storage to mitigate risks due to loss of supply or water quality issues. In the situation like Fort Vermilion that draws water from a river source that has all year flow, AE recommends adequate storage requirements to meet operational needs and emergency demands. There will be situations (as listed below), where the intake needs to be shut down and under these circumstances, the raw water storage will be utilized to sustain water production:

- Ice breaks and ice jams;
- Spring runoff/ice melt causing water quality issues (turbidity, TOC, colour spikes);
- Accidental spills; and
- Potential flooding of intake pump station.

The amount of storage required is dependent on the length of time the intake needs to be shut down. A detailed historic analysis of the river flow and ice conditions along with historic analysis of river water quality data will be required to establish the raw water storage requirements. At this stage, based on the review of the Drinking Water Safety Plan and input obtained from operators based on past experience, the following criteria will be used to establish the raw water storage volume:

Raw water storage volume (m^3) = 60 days X ADD (m^3/day) + Raw water truck fill volume

During predesign stage, depending on the option selected, this criterion can be re-evaluated to determine if this provides sufficient storage to mitigate the risk.

Table 5-2
Option 1: Raw Water Storage Requirement

Planning Range	Year	FV (m^3)		La Crete (m^3)	
		Required	Surplus (+)/ Deficit (-)	Required	Surplus (+)/ Deficit (-)
0	2016	43,960	144,040	127,735	—
10	2026	48,858	139,142	178,956	-178,956
20	2036	54,782	133,218	241,740	-241,740
30	2046	61,670	126,330	329,217	-329,217

Table 5-3
Option 2: Raw Water Storage Requirement

Planning Range	Year	Option 2(a) FV (m^3)		Option 2(b) La Crete (m^3)	
		Required	Surplus (+)/ Deficit (-)	Required	Surplus (+)/ Deficit (-)
0	2016	171,695	16,305	171,695	-171,695
10	2026	227,814	-39,814	227,814	-227,814
20	2036	296,522	-108,522	296,522	-296,522
30	2046	390,886	-202,886	390,886	-390,886

- Option 1: Existing raw water storage ponds at Fort Vermilion provides sufficient volume for the projected 30 year raw water flow for Fort Vermilion supply zone. La Crete, however, will need raw water storage (based on the assumption that a new river intake source is likely required by 2026).
- Option 2(a): existing raw water storage ponds need to be expanded by 2026. Land availability for raw water expansion need to be investigated if this option was selected.

- Option 2(b): La Crete will require new raw water storage ponds based on the assumption that a new river intake source is likely required. Land availability need to be investigated if this option was selected.

5.5 WATER TREATMENT

The following table provides the hydraulic treatment capacity required for the different options and identifies the deficiencies.

Table 5-4
Option 1: WTP Treatment Capacity Review

Planning Range	Year	FV (m^3)		La Crete (m^3)	
		Capacity Required[4]	Surplus (+)/ Deficit (-)	Capacity Required[3]	Surplus (+)/ Deficit (-)
0	2016	1112	630	3515	49
10	2026	1237	505	4938	-1374
20	2036	1389	353	6682	-3118
30	2046	1566	176	9112	-5548

- Option 1: Existing WTP at Fort Vermilion has hydraulic capacity for 30 year projected water demand of the Fort Vermilion supply zone. However routine operational upgrades as identified in Section 2 will be required. The WTP at La Crete is operating close to the hydraulic limit (under peak day flow conditions) and may need to be upgraded or expanded in the near future. In addition, subject to the review of the EPEA application by AEP, a UV system may be required in the near future. Also, if La Crete were to switch to a river intake from current wells, the current treatment scheme will not meet the regulatory requirements and will require an alternative treatment system (conventional treatment system, membrane filtration, etc., that is suitable for treating surface water).

Table 5-5
Option 2: WTP Treatment Capacity Review

Planning Range	Year	Option 2(a) FV (m^3)		Option 2(b) La Crete (m^3)	
		Capacity Required	Surplus (+)/ Deficit (-)	Capacity Required	Surplus (+)/ Deficit (-)
0	2016	4,627	-2,885	4,627	-1,063
10	2026	6,175	-4,433	6,175	-2,611
20	2036	8,071	-6,329	8,071	-4,507
30	2046	10,677	-8,935	10,677	-7,113

4 Capacity required is calculated based on projected peak day demands.

- Option 2(a) will require expansion of the existing Fort Vermilion WTP (or new WTP) in the immediate future.
- Option 2(b) will require expansion of the existing La Crete WTP (or new WTP) in the immediate future and depending on the water source alternative/additional treatment schemes may also be required.

At this stage, for cost analysis, a new Water Treatment scheme based on treating potential surface water (Peace River) is considered for La Crete for both Option 1 and Option 2(b).

5.6 TREATED WATER STORAGE

Treated water storage requirements were calculated based on the criteria indicated in Section 2.8. For Option 1, the storage volume is calculated based on AEP's formula.

For Option 2(a), storage volume is calculated as follows:

- For the supply side (Fort Vermilion WTP), AEP formula for storage requirement for the supply zone (Fort Vermilion); and
- At the distributing side (La Crete distribution) storage volume = Fire Flow (A) + PDD for La Crete.

For Option 2(b), the same approach is used. In this case, La Crete will be supply side and Fort Vermilion will be distribution side.

Storage requirements for the different options are provided in the following tables:

Table 5-6
Option 1: Treated Water Storage

Planning Range	Year	FV (m^3)	La Crete (m^3)
		Surplus (+)/ Deficit (-)	Surplus (+)/ Deficit (-)
0	2016	-817	54
10	2026	-858	-409
20	2036	-908	-976
30	2046	-965	-1,765

Table 5-7
Option 2: Treated Water Storage

Planning Range	Year	Option 2(a) FV – Hub		Option 2(b) La Crete – Hub	
		FV	La Crete	FV	La Crete
		Surplus (+)/ Deficit (-)	Surplus (+)/ Deficit (-)	Surplus (+)/ Deficit (-)	Surplus (+)/ Deficit (-)
0	2016	-817	-2,319	-1,568	54
10	2026	-858	-3,742	-1,693	-409
20	2036	-908	-5,486	-1,845	-976
30	2046	-965	-7,916	-2,022	-1,765

5.7 INFRASTRUCTURE NEEDS SUMMARY

Infrastructure needs are summarized in the Table 5-8 based on the following infrastructure planning timelines to determine capital investment requirement for different planning horizon:

- Intake/New Source: 50 years.
- Raw Water Storage: 30 years:
  - Footprint: 30 years.
  - Storage cells: 10 to 20 years and expand/upgrade as required.
- Water Treatment Plant: 20 years:
  - Footprint: 30 years.
  - Equipment: 10 to 20 years.
- Potable Storage System: 10 to 20 years.

Table 5-8
Option 1: Infrastructure Upgrades Summary

Planning Horizon	FV					La Crete				
	Intake	Raw Water Transfer PS & Main	Raw Storage	WTP	Treated Storage	Source/ Wells	Raw Storage	Raw Water Transfer PS & Main	WTP	Treated Storage
10				Minor Upgrades	1000 m^3				6,500 m^3/d	1,000 m^3
20						New Intake	328,000 m^3	PS Upgrade		
30									3,000 m^3/d	800 m^3

Table 5-9
Option 2(a): Fort Vermilion Hub Infrastructure Upgrades Summary

Planning Horizon	FV					La Crete				
	Intake	Raw Water Transfer PS & Main	Raw Storage	WTP	Treated Storage	Source/ Wells	Raw Storage	Raw Water Transfer PS & Main	WTP	Treated Storage
10		Upgrade		6,500 m^3/d	1,000 m^3				Abandon	5,500 m^3
20	Upgrade 250 mm pipe		200,000 m^3							
30				2,500 m^3/d						2,500 m^3

Table 5-10
Option 2(b): La Crete Infrastructure Upgrades Summary

Planning Horizon	FV					La Crete				
	Intake	Raw Water Transfer Main	Raw Storage	WTP	Treated Storage	Source/ Wells	Raw Storage	Raw Water Transfer Main	WTP	Treated Storage
10				Abandon	2,000 m^3	New Intake	390,000 m^3		8,000 m^3/d	1,000 m^3
20										
30									3,000 m^3/d	800 m^3

6 Regional Pipelines Analysis

In 2013, the County installed a 150 mm regional rural pipeline between Fort Vermilion and La Crete. This pipeline is currently disconnected in between Fort Vermilion and La Crete via isolation valves due to concerns with water mixing. The hydraulic capacity and adequacy of the existing 150 mm pipeline evaluated for the regional supply options (Option 2(a) and Option 2(b)), in this section. In addition, pipeline options to supply water through a Truckfill to the following communities were also investigated:

- La Crete to Buffalo Head Prairie;
- La Crete to Tompkins Landing; and
- Fort Vermilion to Rocky Lane.

6.1 ALIGNMENT

Alignments that follow County roads will be allowed to construct the pipeline inside the right-of-way. This option will eliminate most of the land acquisitions needed from Crown and private land owners. This alignment will reduce the environmental impact and a conservation and reclamation approval may not be needed, although the environmental protection guidelines will still need to be adhered to. The proposed waterline cross section within private land is shown in Figure 6-1.

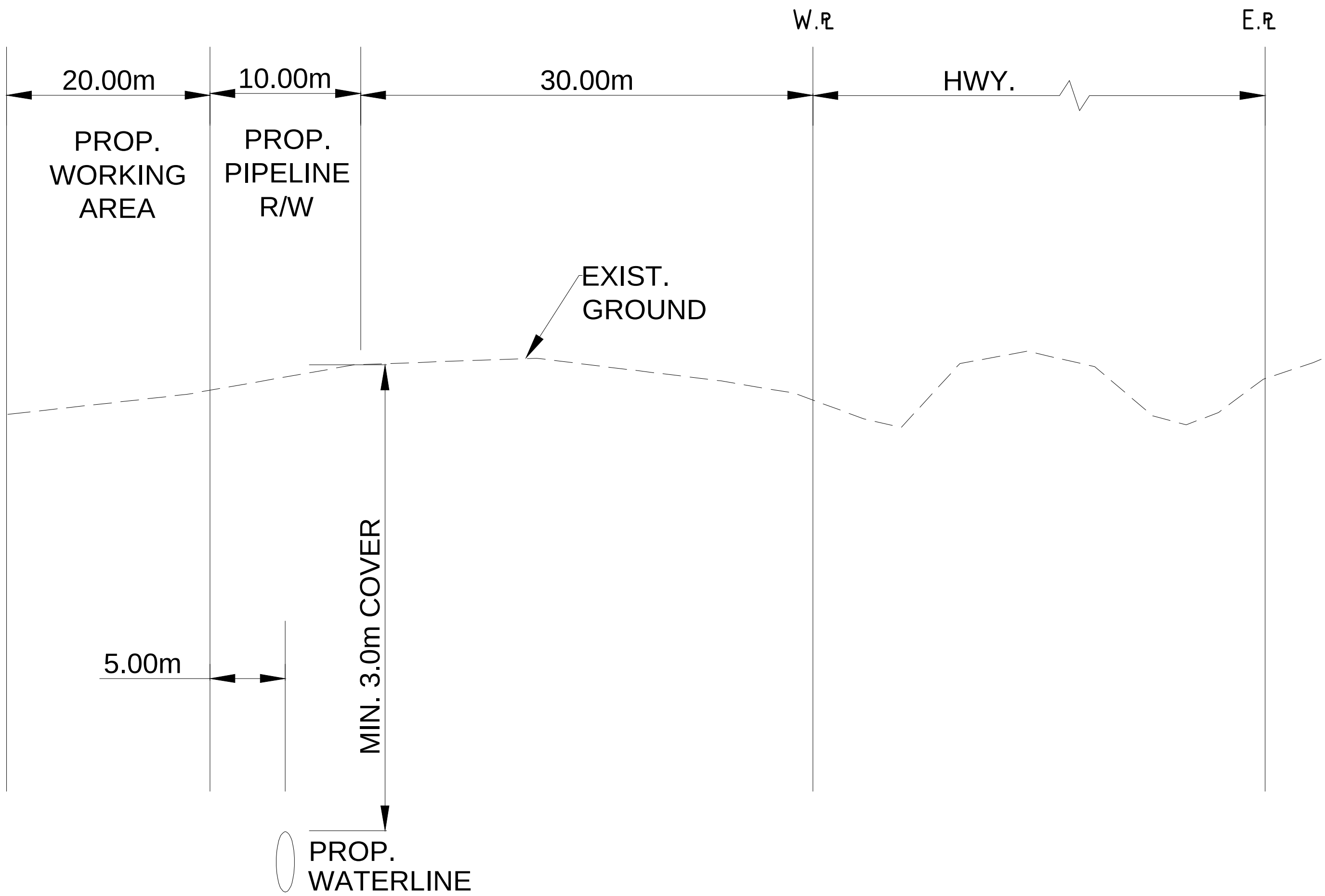
Although following the County road is the preferred option, part of the alignment may have to follow Alberta Transportation's right-of-ways. Based on Alberta Transportation regulations, any alignment following a highway will need to be constructed 30 m outside of the highway's right-of-way (R.O.W.). Due to this regulation, the alignment will need to pass through Crown and private land and will need to acquire a pipeline R.O.W. for each individual private land. The alignment will also pass through agricultural land and may require a Conservation and Reclamation approval, based on the Environmental Protection Enhancement Act. Further discussion on the Conservation and Reclamation approval is in Section 6.4 Environmental Approvals and Issues.

6.1.1 Buffalo Head Prairie Truckfill

The proposed alignment for the Buffalo Head Prairie Truckfill will start at La Crete and follow Highway 697 south for approximately 14.5 km, until it ends at Buffalo Head Prairie. The pipeline will need to cross township roads and creeks. The proposed alignment is shown in Figure 6-2.

6.1.2 Tompkins Landing Truckfill

The proposed alignment for the Tompkins Landing Truckfill will start at La Crete and follow Range Road 154 south, until Township Road 1052. Going along Township Road 1052, the pipeline will turn south again at Range Road 161, and follow Range Road 161, until it turns into Range Road 162. The pipeline will end at the intersection of Range Road 162 and Highway 697. The proposed alignment is approximately 21 km long, will need to cross both township roads and range roads, and is shown in Figure 6-2.



MACKENZIE COUNTY

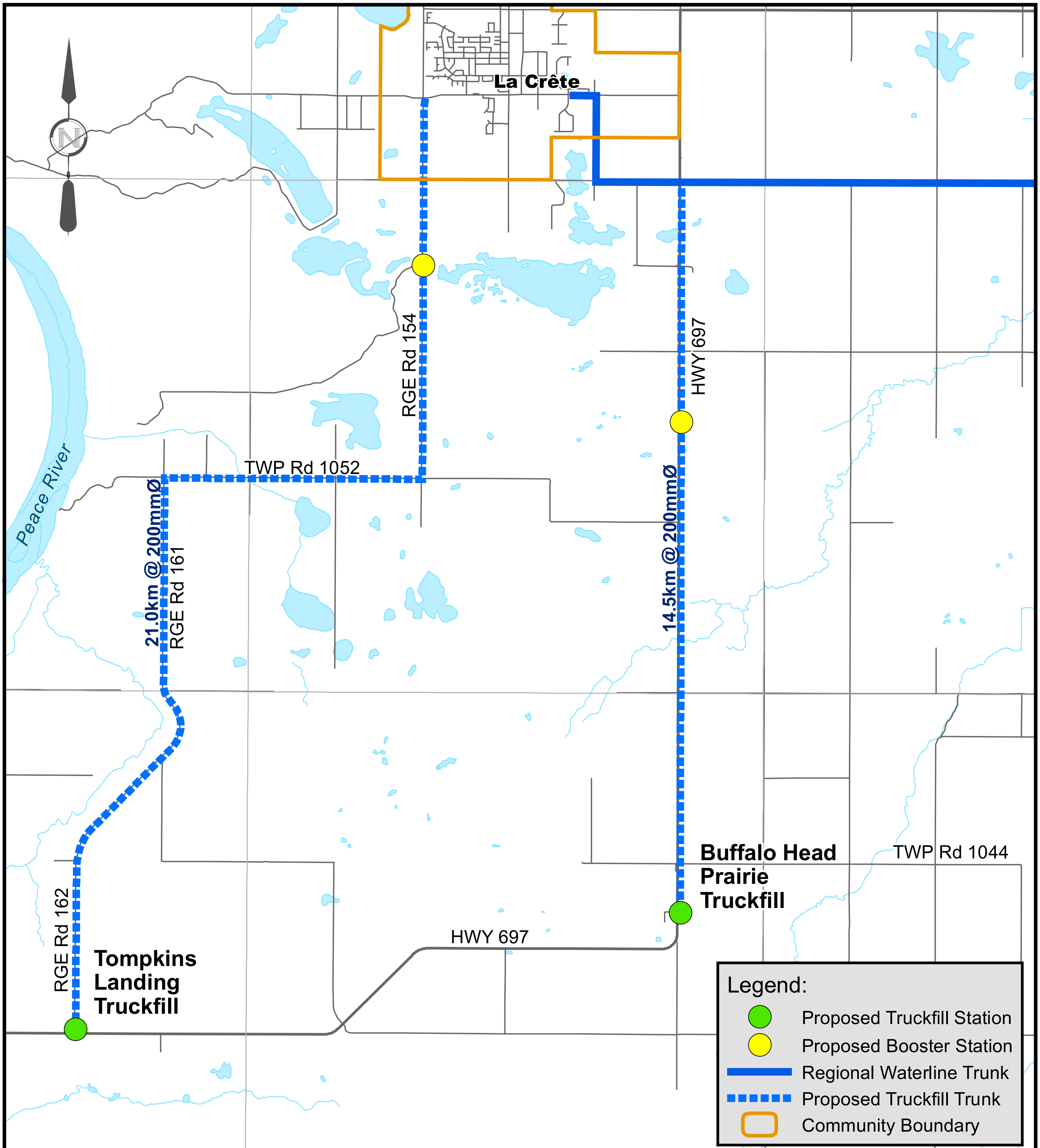
REGIONAL WATERLINE

PROPOSED WATERLINE
CROSS SECTION WITHIN PRIVATE LAND

Associated Engineering

FIGURE 6-1

Time: 12:41
Date: 2007/5/26
Lt/Drawing Scale: 1=5
AutoCAD File: CAD\AEAL\DWG\RPTBASE1-NEW_LOGO.DWG (BW)



Mackenzie County

Mackenzie County Regional Waterline

Figure 6-2

0 2 4

Kilometers

Scale: 1:100,000
Date: April, 2015
Project: 2014-3320.000.140
Coordinate System: NAD 1983 UTM Zone 11N
Drawn By: KR

Associated Engineering

6.1.3 Rocky Lane Truckfill

The proposed alignment for the Rocky Lane Truckfill will start at Fort Vermilion and follow Highway 88 west and then north until Township Road 1093. It will turn west and then north at Range Road 140. It will follow Range Road 140, until it turns west again on Township Road 1094. From there, the pipeline turns north on Range Road 143, until it reaches Highway 58. Following Highway 58 west, the pipeline ends at the intersection of Highway 58 and Range Road 145. This alignment is approximately 29.5 km long and will have to cross township roads, range roads, highways, creeks, and a river. The proposed alignment is shown in Figure 6-3.

6.1.4 Regional Water Supply Hub Options

The alignment for either Fort Vermilion or Le Crete to become a hub for supplying water will follow the existing 150 mm dia. rural line to connect the two areas with a truckfill option at the intersection of Township Road 1064 and Range Road 140. This alignment is approximately 46.0 km long and will have to cross township roads, range roads, highways, and creeks. The proposed alignment is shown in Figure 6-4.

6.2 LAND ACQUISITION

If an alignment follows an Alberta Highway, the proposed alignment will need to be 30 m outside of existing highway right-of-ways (R.O.W.), for which a pipeline R.O.W. acquisition will be required. This will put the pipeline R.O.W on private lands or Crown lands. For sections of the alignment within private lands, a 10 m R.O.W. and a 20 m working area will need to be acquired from the landowner. An agreement addressing landowner conditions, requirements, and compensation will also be required. For sections of the alignment within Crown lands, a proposed 10 m R.O.W. and a 20 m working easement will need to be acquired. The proposed R.O.W. cross section of the water transmission line is also shown in Figure 6-1. Again, this can be avoided, if the alignment follows County roads.

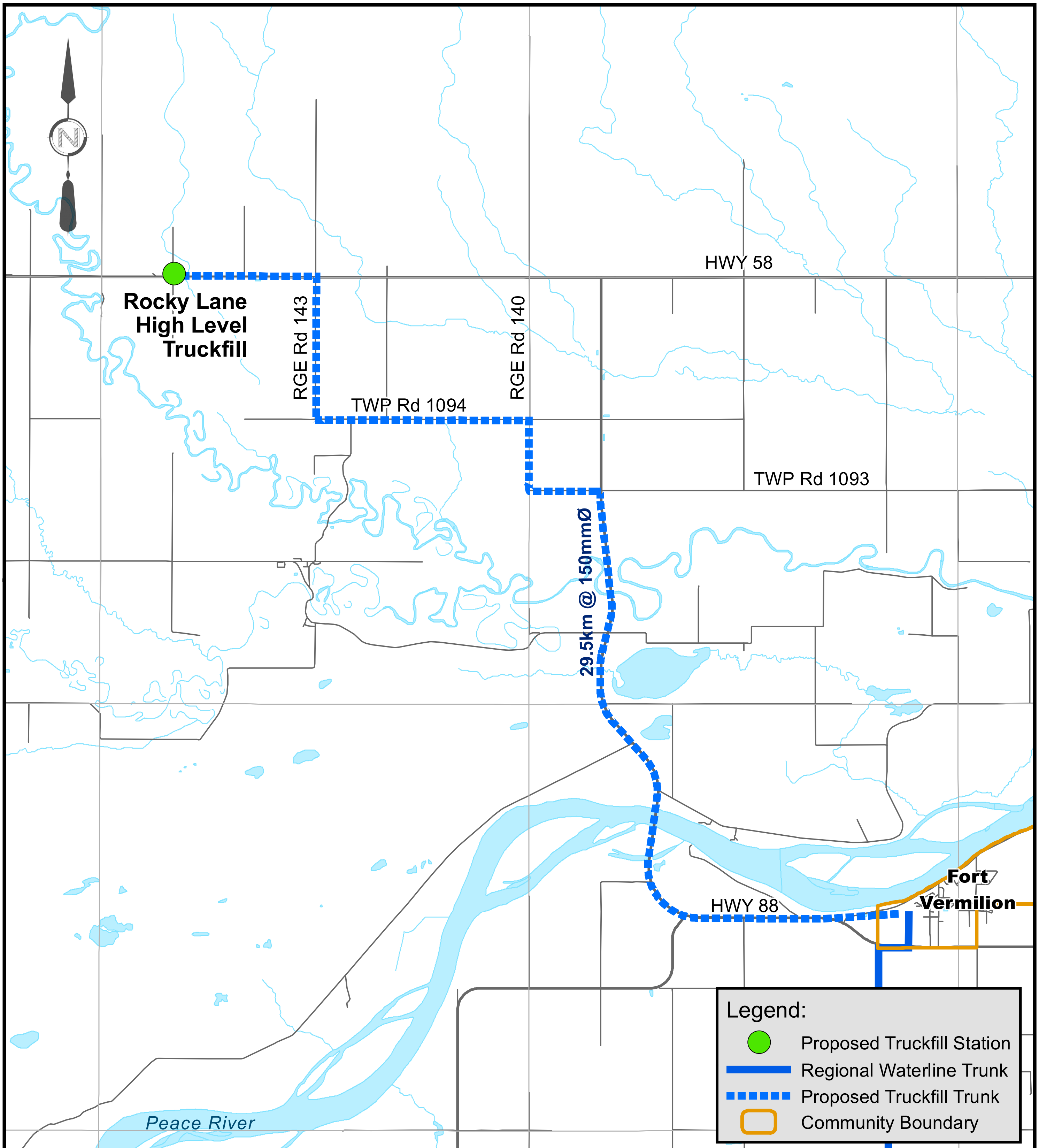
In addition to Municipal, Crown, and private lands, the proposed alignment passes through lands owned by Alberta Transportation and crosses creeks and utilities. These authorities will need to be contacted, in order to obtain crossing agreements.

6.3 HYDRAULIC ANALYSIS

A hydraulic analysis was completed on the proposed waterline options. The analysis is based on the pipeline conveying the 30-year peak day demand and a pipe material of HDPE DR 11.

During the initial phases of the transmission lines, the demands experienced in the pipe will be lower than the design, resulting in longer periods for the water to travel through the pipeline. Due to this, chlorine residuals will need to be investigated, during the detail design phase.

All conceptual hydraulic grade lines (HGL) are presented in Appendix B.



Mackenzie County

Mackenzie County Regional Waterline

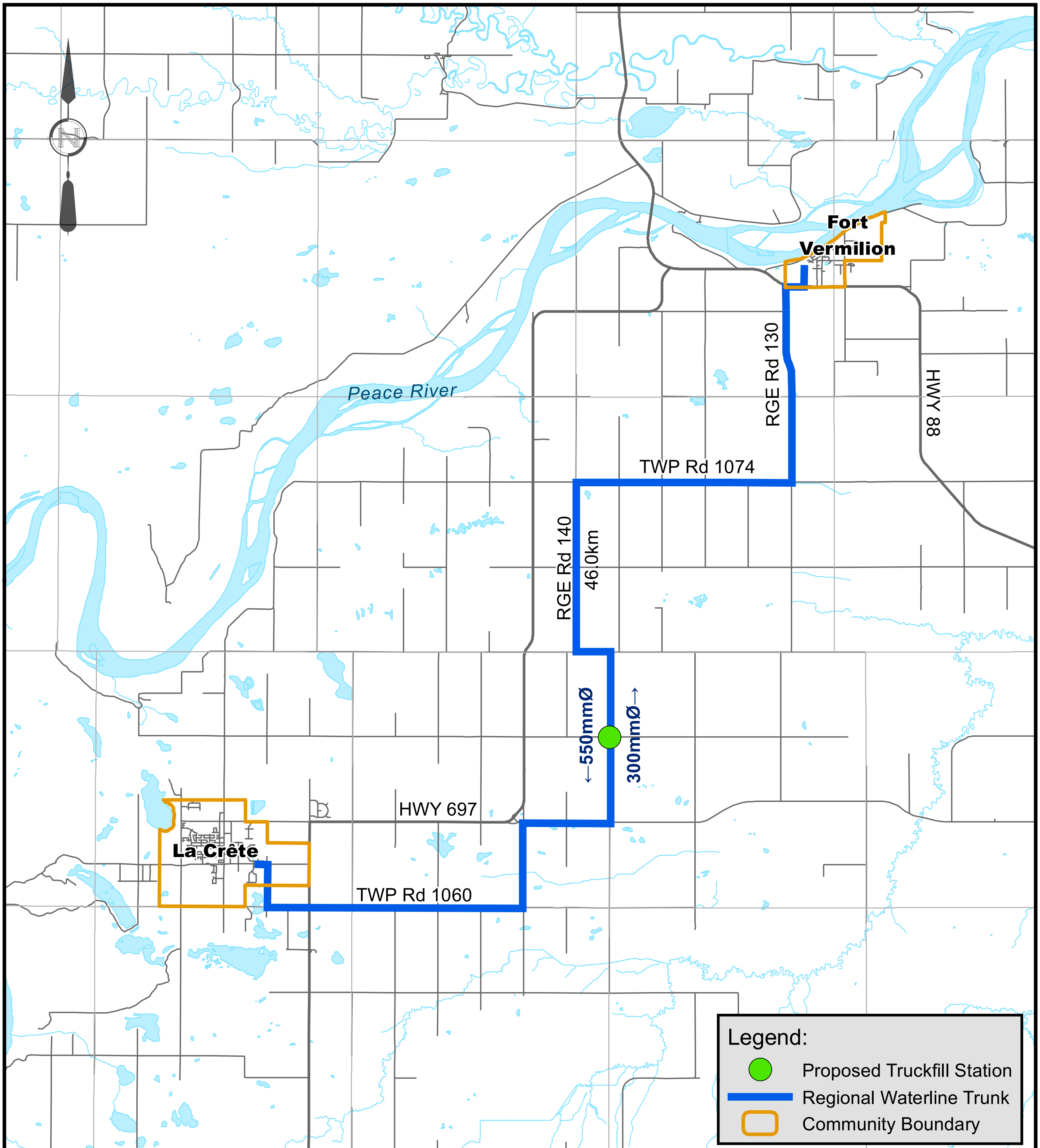
Figure 6-3

0 2.5 5

Kilometers

Scale: 1:120,000
Date: April, 2015
Project: 2014-3320.000.140
Coordinate System: NAD 1983 UTM Zone 11N
Drawn By: KR

Associated Engineering



Mackenzie County

Associated Engineering

Mackenzie County Regional Waterline

Figure 6-4

0 4 8
Kilometers

Scale: 1:200,000
Date: April, 2015
Project: 2014-3320.000.140
Coordinate System: NAD 1983 UTM Zone 11N
Drawn By: KR

6.3.1 Buffalo Head Prairie Truckfill

Based on the analysis, the Buffalo Head Prairie Truckfill option can convey the design flow of 13.9 L/s with a 200 mm diameter (nominal) pipe. Using the existing La Crete distribution pressure of 39.3 m (56 psi) and maintaining a minimum pressure of 14.3 m (20 psi), this option will require a booster station installed approximately halfway along the alignment to supply the required demand to the truckfill.

6.3.2 Tompkins Landing Truckfill

The Tompkins Landing Truckfill option can convey the design flow of 13.9 L/s with a 200 mm diameter (nominal) pipe. Using the existing La Crete distribution pressure and maintaining a minimum pressure of 14.3 m (20 psi), this option will require a booster station installed along the alignment to supply the required demand to the truckfill.

6.3.3 Rocky Lane Truckfill

The Rocky Lane Truckfill option can convey the design flow of 5.61 L/s with a 150 mm diameter (nominal) pipe. To maintain a minimum pressure of 14.3 m (20 psi) and using the existing distribution pressure of 59.7 m (85 psi) from Fort Vermilion, this option will require a booster station installed along the alignment to supply the required demand to the truckfill.

6.3.4 Fort Vermilion Supply Hub

The option for a combined distribution system with Fort Vermilion as the hub was analysed. To supply the La Crete required peak day demand of 105.46 L/s, the existing rural waterline will need to be upgraded to a 550 mm diameter (nominal). Using the existing Fort Vermilion distribution pressure, a booster station will need to be installed approximately halfway to supply the required demand to La Crete and surrounding area.

The option for Fort Vermilion to supply water to a truckfill station approximately halfway to La Crete using the existing 150 mm rural waterline was also analysed. Using a delivery pressure of 14.3 (20 psi) and the operating pressure of the existing distribution system, the existing rural waterline can produce a maximum flow of 4.86 L/s.

6.3.5 La Crete Supply Hub

The option for La Crete to be the hub in a combined distribution system was also analysed. To supply the required peak day demand of 23.4 L/s, the existing rural waterline will need to be upgraded to a 300 mm diameter (nominal). The existing La Crete distribution pressure of 39.3 m (56 psi) is enough pressure to supply the required demand to Fort Vermilion without the need for a booster station.

The option for La Crete to supply water to a truckfill station approximately halfway to Fort Vermilion using the existing 150 mm rural waterline was also analysed. Using a delivery pressure of 14.3 m (20 psi) and the existing operating pressure of the distribution system, the existing rural waterline can produce a maximum flow of 5.85 L/s.

6.4 ENVIRONMENTAL APPROVALS AND ISSUES

The following regulatory agencies have been identified as having potential regulatory interest, regarding the proposed WTPs:

- Alberta Environment and Parks;
- Transport Canada; and
- Fisheries and Oceans of Canada.

6.4.1 Regulatory Stakeholders

The following regulatory agencies will be contacted regarding project notifications or request for approvals or licenses:

- AEP:
    - Diversion Licences;
    - Approval to Construct; and
    - Approval to Operate.
- Navigable Waters: Approval for works within water bodies; and
- Fisheries and Oceans of Canada: Approval for works within water bodies.

6.4.2 Environmental Protection Act

The Environmental Protection Enhancement Act (EPEA), Conservation and Reclamation guidelines for pipelines separates pipelines into two classes. The classification of the pipeline is based on the pipeline index and is calculated based on the following formula:

- Outside diameter (OD) of the pipe (in mm) x length of the pipeline (in km);
- Pipelines with an index greater than 2,690 are considered to be Class 1 pipelines; and
- Pipelines with an index less than 2,690 are considered to be Class 2 pipelines.

Class 1 pipelines are required to obtain a Conservation and Reclamation approval prior to any surface disturbance. In addition Class 1 pipelines must meet the criteria for a reclamation certification. Class 2 pipelines do not require a Conservation and Reclamation Approval. Although Class 2 pipelines do not require a formal approval, they are still expected to adhere to the Environmental Protection Guidelines, and meet the criteria for reclamation certification.

The pipeline index only takes into consideration sections of pipeline that have been installed using an open cut or similar method of pipe installation. Pipelines that are “ploughed in”, horizontal directional drilled method or located within community boundaries do not count towards the overall index of the project.

The preliminary design has assumed horizontal directional drilling of construction for the majority of the alignments. Using the guidelines and calculation above, the pipeline index will be less than 2,690 and considered a Class 2 pipeline. A conservation and reclamation approval is not required.

6.4.3 Historical Resources Act

The Historical Resources Act (HRA) protects the collective heritage of the province for the knowledge and enjoyment of future generations. Section 34 of the HRA prohibits the damage of archaeological or paleontological resources.

An Application for Historical Resources Act Clearance should be sent to Alberta Culture to confirm if a Historic Resources Impact Assessment for archaeological resources needs to be done.

6.4.4 Wildlife Act

The Wildlife Act includes provisions for endangered species protection and recovery plans, including habitat critical to the listed species. The potential for effects on wildlife and wildlife habitat will be addressed through a desktop Biophysical Impact Assessment (BIA). The BIA is the environmental assessment process that is used to develop environmental mitigation plans for projects on public lands in Alberta. It includes sections on listed species (endangered, threatened, and of special concern) and sensitive habitat areas.

6.4.5 Water Act

6.4.5.1 Diversion License

Mackenzie County will need to get diversion licensing for each of the water treatment plants and work with Alberta Environment and Parks for Approval.

6.4.5.2 Water Course Crossings

Notification under Alberta Environment and Parks’ Water Act, Codes of Practice for the Crossing of Watercourses will be required for creeks/streams.

6.4.6 Fisheries Act

Fisheries and Oceans (DFO) will be notified of the proposed stream crossings along the alignment. Notification packages will be prepared, which will outline the details of the proposed crossings.

6.4.7 Navigable Waters Act

It is anticipated that there will not be any regulatory requirements under the Navigable Waters Act. If required, Horizontal Directional Drill methods will be used and not have any adverse impact on navigation. Again, notifications will be sent to Navigable Waters, regarding the proposed stream crossings, if necessary.

6.4.8 Spills and Contaminants

The construction contractor will be required to provide an approved spill and contaminant mitigation procedure which meets all regulatory acts.

6.5 CONSTRUCTION ISSUES

6.5.1 Construction Method for Pipeline

6.5.1.1 Horizontal Directional Drilling

Horizontal directional drilling is a trenchless construction technique capable of guided bored installations of new pipe and conduit. Developed in the 1970's through the merging of oil field and water well technologies, horizontal directional drilling has grown to encompass several hundred contractors across North America. Municipalities and utility providers have increasingly utilized this technique, as it is non-invasive and has the ability to cross surface structures and rivers with only minor surface disturbance at the start and finishing points of the installation.

Horizontal directional drilling is conducted in two phases. First, a pilot bore is launched from the drill rig at the surface and guided or steered utilizing an electronic locator system to the target or exit location also located at the surface. Once the drill string reaches the surface at the exit location, a back reamer is attached to the drill string and pulled back to the entry point. As the reamer is pulled through the pilot bore, the reamer enlarges the bore by cutting or displacing soil. This process increases the diameter of the borehole to be greater than that of the pipe being installed. The product pipe is pulled from the target location to the drill rig, after the borehole is of adequate diameter to accommodate the pipe. Throughout the installation process the drill rig injects drilling fluid through the drill stem to the reamer or drill head to assist in cutting and transporting soil out of the borehole to the surface. The drilling fluid is typically a mixture of bentonite and water, with additional admixtures to assist the installation by lubricating the bore for the pulling of the product pipe, as well as stabilizing the borehole.

The design elements related to HDD are topography and surface features, radius of curvature, exit angle, depth below surface, geotechnical conditions, pipe material and product pipe lay-down area.

To directional drill a pipeline, the pipe joints either need to be fused together, such as high density polyethylene (HDPE) pipe, welded together such as solvent welded polyvinyl chloride (PVC) pipe or welded steel pipe, or mechanically joined PVC pipe.

During design and analysis it should be noted that the inside diameter of HDPE pipe is smaller than the inside diameter of an equivalent nominal size PVC pipe for the same pressure rating. Hence, a larger HDPE pipe is required to provide similar capacity for the same velocity and hydraulic head.

The following work will be required to install the pipe using the directional drilling method:

- Excavation of an exit/entry pit (6 m x 10 m per pit).
- Supply and installation of the pipeline.
- A pipe lay down and stringing areas (preferably along the pipeline alignment).
- Stripping and stockpiling of soils within the temporary work area (20 m x 20 m per pit).
- Crop compensation associated with the temporary work area.
- Rehabilitation of the affected areas.
- Cleaning of equipment prior to leaving each individual property, to prevent the spread of club root and other noxious seeds or spores.

6.5.2 Construction Along Roadways

The contractor is to ensure one lane of traffic is allowed during construction of the pipeline. Construction traffic and equipment will rut up the existing roadways requiring additional maintenance, during the construction period.

6.5.3 Geotechnical Investigation

A geotechnical investigation is required to determine the anticipated ground conditions along the proposed alignment. This will help to anticipate the ground conditions and help the contractor to prepare for any potential problems.

6.5.4 Temporary Fencing

Use of temporary fencing may be required, in order to keep livestock out of construction zones and planted areas. The period in which these temporary fences remain on site depends on how soon the affected areas are restored to their original condition. These requirements will be refined following detailed discussions with landowners and recommendations from the conservation and reclamation plan.

6.5.5 Safety

Safety issues will need to be identified and addressed. Examples of safety issues are:

- Work adjacent to highways, roads, creeks and rivers;
- Work adjacent to pipelines, power lines;
- Ground conditions (i.e., soft soils); and
- Urban settings, rural residences.

The safety of both the contractor and the public must be ensured at all times. All regulatory guidelines by Occupational Health and Safety and Workers' Compensation Board will be enforced.

6.5.6 Disposal of Super Chlorinated Water

Disposal of super chlorinated water used to disinfect the pipeline must be completed to the Alberta Environmental Protection Act.

7 Cost Estimates

Capital Construction cost estimates were calculated for the different options and are shown in Table 7-1. The following assumptions should be noted:

- Cost estimates are conceptual, high-level, Order of Magnitude costs for option comparison and selection only and are based on extrapolated costs from benchmark data from previous projects.
- There are several cost Variability factors that can significantly influence the cost estimates, such as:
  - Technology selection for water treatment (future);
  - Type of intake (bank, mechanical screen, end of pipe screen, etc.);
  - Land costs;
  - Building architecture; and
  - Construction cost variability.
- Land, ROW, and G.S.T. are not included.

7.1 CAPITAL CONSTRUCTION COST SUMMARY

A capital construction cost summary is shown in Table 7-1.

7.2 COST ESTIMATE (STAGING)

Table 7-2 provides the capital cost distribution across the planning horizon based on the infrastructure needs identified in Section 5.

Table 7-1
Cost Summary by Infrastructure (2015 $ M*)

Item	Option 1			Option 2(a)			Option 2(b)		
	FV	La Crete	Totals	FV	La Crete	Totals	FV	La Crete	Totals
Intake	$0.2	$10.0	$10.2	$10.4	$0.0	$10.4	$0.0	$10.0	$10.0
Raw Water Reservoir	$0.0	$6.4	$6.4	$4.6	$0.0	$4.6	$0.0	$7.4	$7.4
WTP	$0.2	$32.1	$32.3	$30.0	$0.1	$30.1	$0.1	$34.0	$34.1
Potable Storage	$2.0	$3.6	$5.6	$2.0	$16.0	$18.0	$4.0	$3.6	$7.6
Pipelines	$0.0	$0.0	$0.0	$25.8	$0.0	$25.8	$0.0	$15.2	$15.2
Totals	**$2.4**	**$52.1**	**$54.5**	**$72.8**	**$16.1**	**$88.9**	**$4.1**	**$70.2**	**$74.3**

Table 7-2
Capital Cost Distribution (2015 $ M*)

Planning Year	Option 1			Option 2(a) FV Hub			Option 2(b) La Crete Hub		
	FV	La Crete	Totals	FV	La Crete	Totals	FV	La Crete	Totals
0-10	$2.4	$22.1	$24.5	$48.2	$11.1	$59.3	$4.1	$56.6	$60.7
10-20	$0.0	$16.4	$16.4	$14.6	$0.0	$14.6	$0.0	$0.0	$0.0
20-30	$0.0	$13.6	$13.6	$10.0	$5.0	$15.0	$0.0	$13.6	$13.6
Totals	**$2.4**	**$52.1**	**$54.5**	**$72.8**	**$16.1**	**$88.9**	**$4.1**	**$70.2**	**$74.3**

* M = Millions

7.3 NON-FINANCIAL FACTORS

In addition to capital costs, there are several non-finical factors that need to be taken into consideration. Table 7-3 provides a list of non-financial factors (risks, issues, and disadvantages):

Table 7-3
Non-Financial Factors

Criteria	Option 1	Option 2(a) FV Hub	Option 2(b) La Crete Hub
Regulatory Approvals	New River Intake for La Crete (medium to long term)	Upgrade existing intake/new intake (medium to long term)	New River Intake for La Crete (immediate)
Operational Resource	Need to operate and maintain two facilities	Only one facility to operate and maintain	Only one facility to operate and maintain
Intake Pump Station Operational Risks	Current location close to flood hazard area	Current location close to flood hazard area	Intake pump station can be located away from potential flood zones
Raw Water Source	La Crete need to switch to river intake (medium term) River water quantity/ availability (future risk)	River water quantity/ availability (future risk)	La Crete need to switch to river intake (immediate)
Operational Flexibility	High – either source can provide strategic back up	Limited to WTP built-in design features	Limited to WTP built-in design features
Capital Funding utilization	Optimized - Can be staged to meet the growth needs (between two zones). Wait and see approach	High initial investment	High initial investment
Land Availability	Future expansions	Future expansions	Need for new raw Water storage ponds

The above non-financial factors are scored on a subjective scoring range of 1 to 5 (1= least favorable and 5 = most favorable), based on their relative comparison. Table 7-4 provides the scoring for the non-financial factors.

Table 7-4
Scoring of Non-Financial Factors

Factor	Score		
	Option 1	Option 2(a) FV Hub	Option 2(b) La Crete Hub
Regulatory Approvals	3	3	3
Operational Resource	2	4	4
Intake Pump Station Operational Risks	3	3	4
Raw Water Source	3	3	3
Operational Flexibility	4	2	2
Capital Funding Utilization	4	3	3
Land Availability	3	2	1
Total Score	**22**	**18**	**20**

8 Conclusions and Recommendations

8.1 CONCLUSIONS

This study evaluated three different water supply options for the supply areas within the Mackenzie County:

Option 1 provides the best capital value. It allows optimization of the capital investment (staged utilization). However, the following issues/disadvantages need to be considered with this option:

- Upgrades and/or expansion of the La Crete WTP are immediately required;
- Long term raw water availability for La Crete (may need new river intake in the future); and
- Need for raw water storage at La Crete (future).

Option 2(b) is second best capital value overall. Facility is closer to the demand center in the long run.

Issues/Disadvantages:
- Raw water availability for La Crete – new river intake(immediate);
- Raw water storage (immediate); and
- WTP upgrades/expansion (immediate).

Option 2(a) is the least capital value overall. This provides the ability to use existing intake and raw water storage for short /medium term.

Issues/Disadvantages:
- Fort Vermilion WTP Expansion (immediate).

Based on the range of non-financial factors evaluated in Section 7.3, Option 1 has the best ranking overall.

In that respect, Option 1 is the best option at this stage as it provides an opportunity to continue the operation of existing facilities and potentially switch over to Option 2(b), if required in future.

The study identified the following issues that require further investigation/attention:

8.1.1 Fort Vermilion

The existing WTP and the intake transfer pump station are located in the close proximity of the Peace River. Associated Engineering reviewed the Alberta Flood Hazard map (refer to Figure 3-1) for this location. At this stage, it appears that the WTP and the raw water storage reservoirs are not located in the flood areas. However, the intake transfer pump station appears to be close to the flood hazard area. The transfer pump station has electrical components (heater, lights, etc.) that would be flooded, if the river level rises above the level of the electrical equipment. It is understood that the Operators close the inlet valves to the intake transfer pump station manually when river level rises.

In addition, flooding may happen in and around the surrounding areas thus limiting access. The County should periodically review the flood hazard map for any changes and consider strengthening flood defences around the intake transfer pump station.

8.1.2 La Crete

The existing wells are classified as Ground Water Under Direct Influence (GWUDI) wells by AEP due its close proximity to surface water. It is also reported that one of the ground water wells is drawing sand. Water treatment systems, supplied by GWUDI wells, are required to be provided with a treatment system that can achieve a minimum 3-log removal credit for *Giardia* and *Cryptosporidium*, and 4-log removal credits for Virus. The current treatment scheme (green sand filters and ion-exchange softeners followed by chlorination) is typically not considered to provide any log removal credit for *Cryptosporidium*.

One option will be to install an Ultra Violet (UV) disinfection system downstream of the existing softeners to provide the required log removal credits for *Giardia* and *Cryptosporidium*. Alternatively, the County can complete additional studies to certify the existing ground water wells as “high quality ground water wells”, in which case, no further treatment will be necessary.

The above issue was disused with Mr. George Neurohr, from Alberta Environment and Sustainable Resource Development (AEP), during the review meeting on February 27, 2015. Mr. Neurohr indicated the following:

- The County has applied for a renewal of the operating licence (EPEA), and the AEP is reviewing the application.
- After the review, AEP will advise the County of any additional level of treatment system (such as an Ultra Violet disinfection) required.

The existing ground water wells, at La Crete, are not adequate enough for meeting the long term raw water demands for both Option 1 (separate system), and Option 2(b): Regional System. Depending on the actual growth in the region, the wells are likely to run out of capacity in 10-20 years’ time. In order to secure a long term raw water supply, the County may need to migrate to a surface water source, which will require construction of a river intake structure in the Peace River.

Alternatively, the County can evaluate if additional wells can be constructed to provide additional capacity. However, it should be noted that this will require additional hydro geological investigations, field well testing, etc., to identify a suitable well (which may or may not be feasible). In addition, the cost of a new well development and the associated infrastructure (power supply, access road etc.) needs to be considered. Potential costs of a new well development can range from $100K to $300K. However, there are no guarantees that a new well, with a sufficient capacity of good quality water and within a suitable distance from the existing transmission pipeline, is available.

The hydraulic capacity of the existing WTP is operating close to the immediate water demands (under peak day demand conditions), and may require upgrades/expansion or additional treatment in the near future.

Any upgrades/expansion requirements for the La Crete WTP should consider implications of potential future surface water from Peace River. The existing treatment scheme (green sand filter and softeners) will not be suitable for treating surface water. An alternative treatment system (such as a conventional treatment system) will be required. Some of the existing system components, such as the distribution pumps and the chemical systems (chlorination), can be re-utilized.

8.2 RECOMMENDATIONS

8.2.1 Short Term

- Continue with Option 1 – Operate two separate systems.
- Fort Vermilion:
  - No major capital upgrade is required. Some operational improvements/minor upgrades may be implemented.
  - Evaluate the risk due to flooding and re-assess risk rating as necessary. Consider implementing flood defenses around the intake pump chamber.
- La Crete:
  - As a short term basis, AE recommends completing the on-site testing of the existing filters, to see if the filters can be operated at a higher flow rate. This might delay the upgrade of the existing La Crete WTP.
  - Subject to direction from AEP, the County may be required to address issues related to the GWUDI status: Options include reclassification of wells as high quality water or additional treatment (UV).
  - Existing WTP is operating close to the hydraulic capacity under Peak Day Demand conditions. Any upgrades/expansion requirements for the La Crete WTP should consider implications of potential future surface water from Peace River.
  - County develop a strategy for securing long term raw water supply. Options include constructing a new river intake structure in the Peace River, or evaluate if additional wells can be constructed to provide additional capacity.
- Utilize the existing 150 mm transfer pipeline between Fort Vermilion and La Crete. Consider construction of a new truckfill halfway between Fort Vermilion and La Crete to alleviate routing maintenance issues (flushing of the pipeline segments) and to provide water to rural customers.

8.2.2 Long Term

- Infrastructure planning for future growth needs is a continuous process. Therefore, the County should review the growth/demand needs of the community on a continuous basis (every 5-10 year interval) and revise the planning goals as required.
- Continue to monitor the risk from the river potentially flooding the water supply assets at Fort Vermilion (WTP and intake pump chamber). Any elevated risk due to flooding will require revaluation of the water supply options and may require implementation of Option 2(b).

Closure

This report was prepared for the Mackenzie County to complete a detailed comprehensive study to develop a strategy for meeting the water supply needs of the area, including an investigation of the feasibility of mixing water from the two existing water treatment plants, located in Fort Vermilion and La Crete.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Engineering Alberta Ltd.

PROFESSIONAL ENGINEER ALBERTA
ALAN Y. LUI
June 04, 2015

Alan Lui, P.Eng.
Project Manager

PROFESSIONAL ENGINEER ALBERTA
RAJ SUBRAMANIAN
June 04, 2015

Raj Subramanian, P.Eng.
Project Engineer

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF

Signature: ______________________

Date: June 4, 2015

APEGA Permit to Practice P 3979

Appendix A – Water Quality Technical Memorandum

Owner:	Mackenzie County	***File No.:***	2014.3320.00.E.03.00
Project:	Comprehensive Water Supply, Treatment and Distribution Study	***Date:***	April 24, 2015
		Revision:	0

Subject: Treated Water Blending Feasibility

1 Introduction

Mackenzie County (County) has initiated as comprehensive water supply options assessment that included either La Crete WTP or Fort Vermillion WTP or both WTPs supplying the Mackenzie County regional system. Associated Engineering (AE) has determined potential operating scenarios for a staged Mackenzie County water system that comprised of mixing 20%, 33%, 50%, 66% and 80% of the La Crete WTP produced water with Fort Vermillion WTP treated water.

2 Treated Water Summary

The Guidelines for the Canadian Drinking Water Quality (GCDWQ) are established by the Federal-Provincial-Territorial Committee on Drinking Water and published by Health Canada. The GCDWQ guidelines are grouped into two categories:

- **Maximum Acceptable Concentrations (MAC)** limits have been established for certain substances that are known or suspected to caused adverse effects on health on the basis of lifetime consumption.
- **Aesthetic Objectives (AO)** limits apply to certain substances or characteristics of drinking water that can affect its acceptance by consumers or interfere with practices for supplying good water.

Table 1 and Table 2 summarize the water quality data from the La Crete WTP and Fort Vermilion WTP, respectively, from the annual water quality test reports from 2009 to 2014. The GCDWQ limits for selected water quality parameters are also included in those tables.

None of the listed water quality parameters in Table 1 and Table 2 exceeded the allowable limits of GCDWQ. The average water quality concentration over the five year period was used for the desktop assessment of blending.

Table 1
La Crete Treated Water Quality Summary

Parameter	GCDWQ Limits	MAC or AO	La Crete Treated Water					
			2014-05-28	2012-10-04	2011-12-21	2010-01-11	2009-12-15	Average
pH	6.5 – 8.5	AO	7.9	7.6	7.3	7.3	7.2	7.5
Sodium, mg/L	200	AO	161	132	144	129	108	135
Potassium, mg/L	-	-	2	-	3	3	3	2
Calcium, mg/L	-	-	11.7	20.4	22.3	24.6	26.9	21.2
Magnesium, mg/L	-	-	3.1	5.7	5.85	6.17	7.89	5.7
Iron, mg/L	0.3	AO	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese, mg/L	0.05	AO	<0.001	<0.001	-	-	-	<0.001
Fluoride, mg/L	1.5	MAC	0.3	0.2	0.2	0.3	0.2	0.2
Chloride, mg/L	250	AO	13.8	13.9	19	13.6	16.6	15.4
Sulphate, mg/L	500	AO	30.0	26.4	48.2	27.9	23.9	31.3
Total Alkalinity, mg/L as $CaCO_3$	-	-	340	338	329	331	307	329
Hardness, mg/L as $CaCO_3$	500	AO	42	74	80	87	100	77
Total Dissolved Solids, mg/L	500	AO	401	404	440	403	371	404
Total Organic Carbon, mg/L	-	-	1.1	1.9	1.2	1.4	0.5	1.2

Table 2
Fort Vermillion Treated Water Quality Summary

Parameter	GCDWQ Limits	MAC or AO	Fort Vermillion Treated Water					
			2014-08-20	2013-3-04	2012-04-12	2011-10-27	2010-04-04	Average
pH	6.5 – 8.5	AO	7.8	7.7	8.1	8	8	7.9
Sodium, mg/L	200	AO	5.7	4.39	6.5	7.6	4.5	5.7
Potassium, mg/L	-	-	0.7	0.57	0.9	0.9	<0.6	0.8
Calcium, mg/L	-	-	27.4	37	35.5	37	34.5	34.3
Magnesium, mg/L	-	-	7.7	7.98	8.1	8.7	7.3	8.0
Iron, mg/L	0.3	AO	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01
Manganese, mg/L	0.05	AO	<0.001	0.001	<0.005	<0.005	<0.005	<0.001
Fluoride, mg/L	1.5	MAC	<0.10	0.25	<0.05	<0.05	<0.05	0.10
Chloride, mg/L	250	AO	12.7	10.8	15	21	11	14
Sulphate, mg/L	500	AO	21.6	20.2	25	27	20	23
Total Alkalinity, mg/L as $CaCO_3$	-	-	67	95	99	94	100	91
Hardness, mg/L as $CaCO_3$	500	AO	100	125	120	125	116	117
Total Dissolved Solids, mg/L	500	AO	116	138	150	159	131	139
Total Organic Carbon, mg/L	-	-	1.56	1.25	2	-	2	1.7

3 Desktop Review of Blending

Treated water from a WTP is often in stable equilibrium of chemical constituents. Depending on the chemical balance of the treated water that determines the water stability, it could be corrosive, scale-forming (precipitates calcium) or neutral (preferred). If water is too corrosive, the water may dissolve metals like copper and lead from distribution pipelines which may have health effects for consumers. If water is too scale forming, the scale may reduce the diameter of distribution piping leading to pipe line plugs and can also decrease the life of water appliances such as water heaters. When possible, the best practice is to have the treated water slightly scale forming as the small formation of scale provides a protective coating on distribution pipes.

The stability of the water is influenced by water quality parameters such as alkalinity, pH, calcium, chlorides and sulphates content. The blending of difference source water can have a significant effect on the stability of water and the blended water could become either corrosive or scale-forming.

Although a number of indices have been developed, such indices do not accurately predict the water stability but can only give a probable indication of stability. A common water stability index, Langelier Saturation Index (LSI) was used to evaluate the stability of the blended treated waters from La Crete and Fort Vermillion WTPs at various blending ratios. Common characteristics of LSI are as follows:

- LSI is a measurement of a water tendency to develop calcium carbonate scale (scale-forming) or dissolve calcium (corrosive) based on calcium carbonate equilibrium
- When LSI>0, water is supersaturated with respect to calcium carbonate and scaling may occur
- When LSI<0, water is unsaturated with respect to calcium carbonate and may remove scaling
- When LSI=0, water is consider to be neutral (i.e. neither scale-forming or scale-removing)
- Common operating range of LSI is from - 1 to +1 (narrower range close to zero is often preferred)

A desktop assessment of blending of two waters was conducted by using WaterPro! ® Software. The averages of the last five years of treated water quality data were used in the water modeling software. Table 3 summarizes the results from the desktop blending analysis. Table 3 also presents the LSI values from desktop modelling using the water sample collected on February 27, 2015.

Table 3
Summary of LSI – Desktop Modeling

LSI	Treated Water	Blended Water					Treated Water
	Fort Vermillion	80% Fort Vermillion	67% Fort Vermillion	50% Fort Vermillion	33% Fort Vermillion	20% Fort Vermillion	La Crete
		20% La Crete	33% La Crete	50% La Crete	67% La Crete	80% La Crete	
Based on historical average water quality data	-0.02	-0.15	-0.17	-0.19	-0.20	-0.21	-0.23
Based on February 27, 2015 water quality data	-0.07	0.13	0.20	0.27	0.32	0.34	0.35

The Mackenzie county operators indicated that they have not experienced any issues with scaling or corrosion within the distributions system in both Fort Vermillion and La Crete. Based on the summary of scaling potential indices:

- While the Fort Vermilion water LSI values were consistent but the La Crete treated water stability varied between being corrosive and scale-forming.
- Small changes are noted in the LSI values when a greater percentage of La Crete treated water is added.
- LSI values are within the common operating range
- Since both the La Crete and Fort Vermilion treated waters are reported as non-corrosive by the operators, the blended water is also likely to be non-corrosive.

4 Bench-Scale Blending Tests

4.1 WATER STABILITY

AE collected treated water samples from both WTPs on February 27th and conducted bench-scale blending tests on March 2nd at various blending ratios. AE dis not observe precipitation or visible water quality changes during the tests. Table 4 summarizes selected water quality data and the calculated LSI of the two treated water sources and after blending at different ratios.

Table 4
Summary of Blended Water Quality Data

Water Quality Parameter	Treated Water	Blended Water					Treated Water
	Fort Vermillion	80% Fort Vermillion 20% La Crete	67% Fort Vermillion 33% La Crete	50% Fort Vermillion 50% La Crete	33% Fort Vermillion 67% La Crete	20% Fort Vermillion 80% La Crete	La Crete
Total Dissolved Solids, mg/L	160	370	330	280	250	210	430
pH	7.77	7.98	7.95	7.94	7.98	7.94	7.96
Total Alkalinity, mg/L as $CaCO_3$	99	290	260	210	190	150	340
Calcium (Total), mg/L	40	28	30	33	34	37	25
Chloride, mg/L	16	16	16	16	16	15	17
Sulphate, mg/L	26	29	28	28	27	27	30
Magnesium (Dissolved), mg/L	8.6	7.3	7.4	7.7	7.9	8.1	7.0
Nitrate, mg/L as N	0.079	0.057	0.12	0.066	0.069	0.071	0.049
Calculated LSI	**-0.07**	**0.37**	**0.34**	**0.29**	**0.31**	**0.22**	**0.35**

Based on the summary of scaling potential indices:

- LSI values are within the common operating range
- Since both the La Crete and Fort Vermilion treated waters are reported as non-corrosive by the operators, the blended water is also likely to be non-corrosive.

4.2 SIMULATED DISTRIBUTION SYSTEM ANALYSIS

4.2.1 Residence Time

Regional pipeline increase water age, as water has longer travel time to reach last consumer, which may affect water quality especially by decreasing the disinfectant residual concentration and by increasing the disinfection by-product (DBP) concentration. It should be noted that the residence time in the pipes would decrease as future demands increase the pipe flows and reduce such negative impacts. As regional lines are typically sized for future capacity (25 years), the residence time or water age in the pipelines can be significantly higher during the initial stages. Table 5 summarizes the various residence time that each pipeline based on initial average day flow using proposed pipeline size and alignment. The assumptions for determining initial average pipeline flows were:

- Middle truckfill service 20% of the La Crete rural population and service 20% of the Fort Vermillion rural population at 120 L/c/d
- Buffalo Head truckfill service 20% of the La Crete rural population at 120 L/c/d
- Tompkins Landing truckfill service 20% of the La Crete rural population at 120 L/c/d
- Rocky Lane truckfill service 100% of the Rocky Lane rural population at 120 L/c/d

Table 5
Summary of Regional Pipelines Residence Time

Pipeline		Pipeline Diameter	Pipeline Length	Pipeline Volume	Community Demands	Residence Time
Start	End	(mm)	(km)	(m^3)	(m^3/day)	(days)
La Crete/Fort Vermillion	Middle Truckfill[1]	150	23	406	180.0	4.6
La Crete	Fort Vermillion	300	47	3322	556	6
Fort Vermillion	La Crete	550	47	11166	1757	6.4
La Crete	Buffalo Head Truckfill	200	14.5	456	143.5	3.2
La Crete	Tompkins Landing Truckfill	200	21.5	675	143.5	4.8
Fort Vermillion	Rocky Lane Truckfill	150	29.5	521	121.8	4.3

[1] Residence time assumes truckfill located in the middle of pipeline and truckfill alternating every other day from either La Crete or Fort Vermillion

The various regional pipelines have a residence time between 3.2 and 6.4 days at initial average day demand. Based on AE's past experience with regional line, these resident times will allow for a free chlorine disinfectant as long as free chlorine boosting occurs prior to entering the service reservoir.

4.2.2 DBP Formation Potential Simulation

AE conducted chlorine decay and 7 day disinfection by-product formation Potential on a 50:50 blend of La Crete and Fort Vermillion treated water. The tests were conducted at 12°C using the following two scenarios:

- Blending the water using the existing chlorine residual
- Blending water with additional sodium hypochlorite to boost the total chlorine residual to 3.0 mg/L.

Figure 1 summarizes the chlorine decay from both the blending of existing chlorine residual from the treated water collecting from the WTP and the boosting of the residual to 3.0 mg/L of the blended water. The chlorine residual decay test occurred over 7 days maintained a residual above the required 0.1 mg/L for both scenarios.

Figure 1
Summary of Chlorine Decay

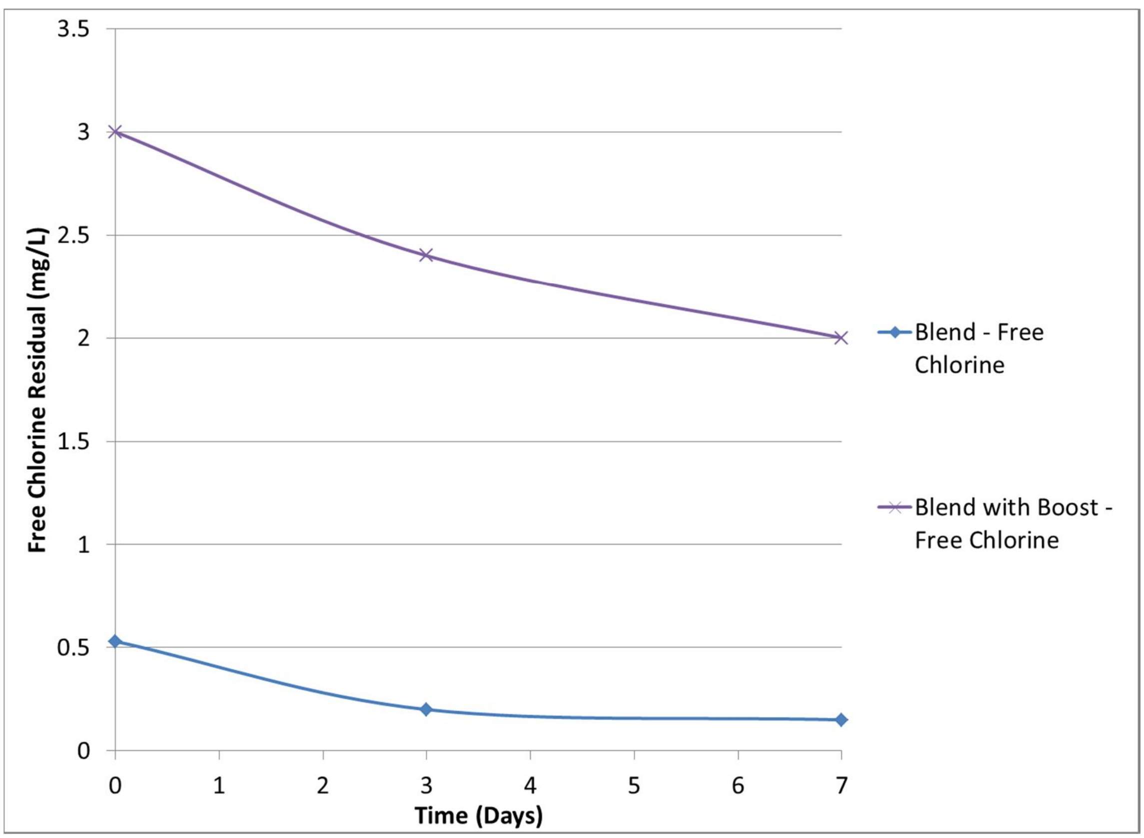
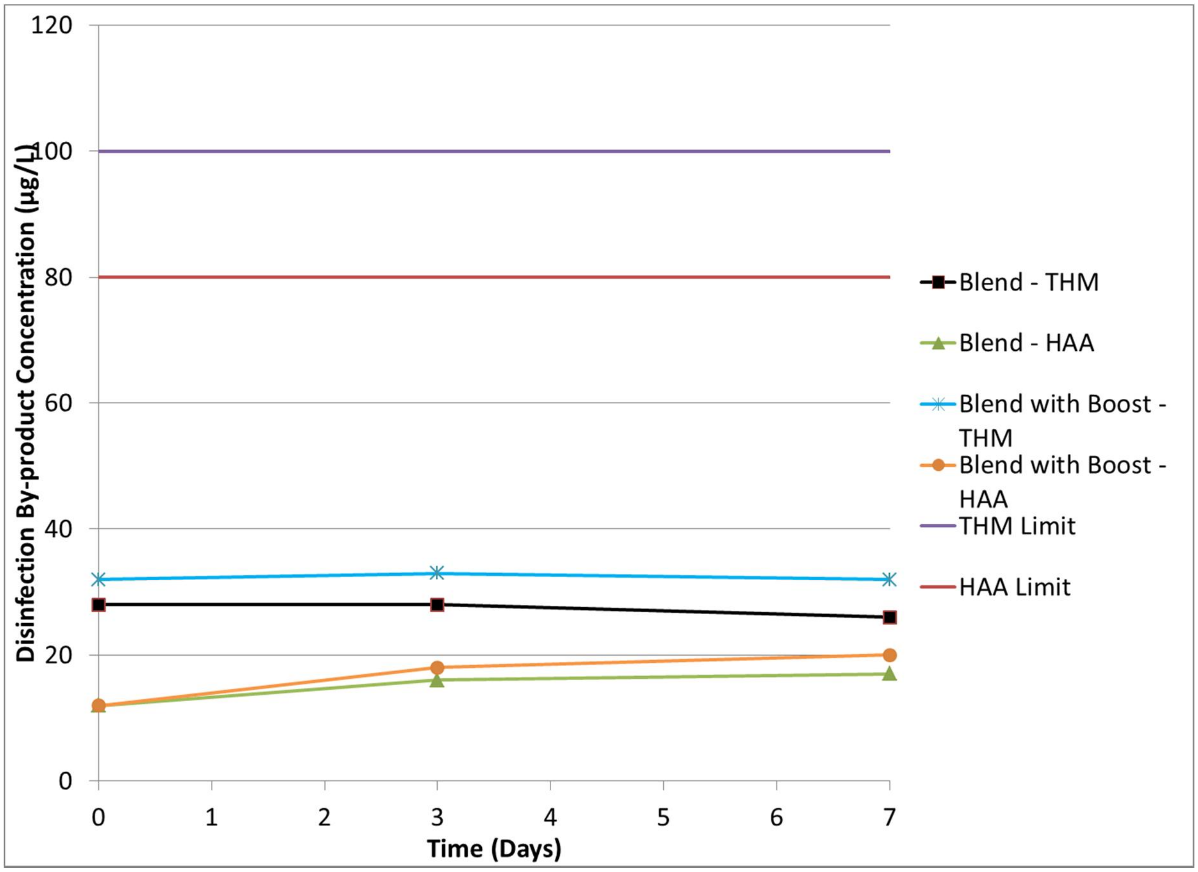


Figure 2 summarizes the DBP formation potential simulation results. The DBP formation potential simulation indicates that both the THM and HAA formed after 7 days of reaction were below the regulatory limits of 100 and 80 µg/L, respectively. The THM concentration was elevated in the testing sample with chlorine boost but was still below the GCDWQ THM limits.

Table 6
Summary of Simulated Distribution System and Chlorine Decay



5 Summary

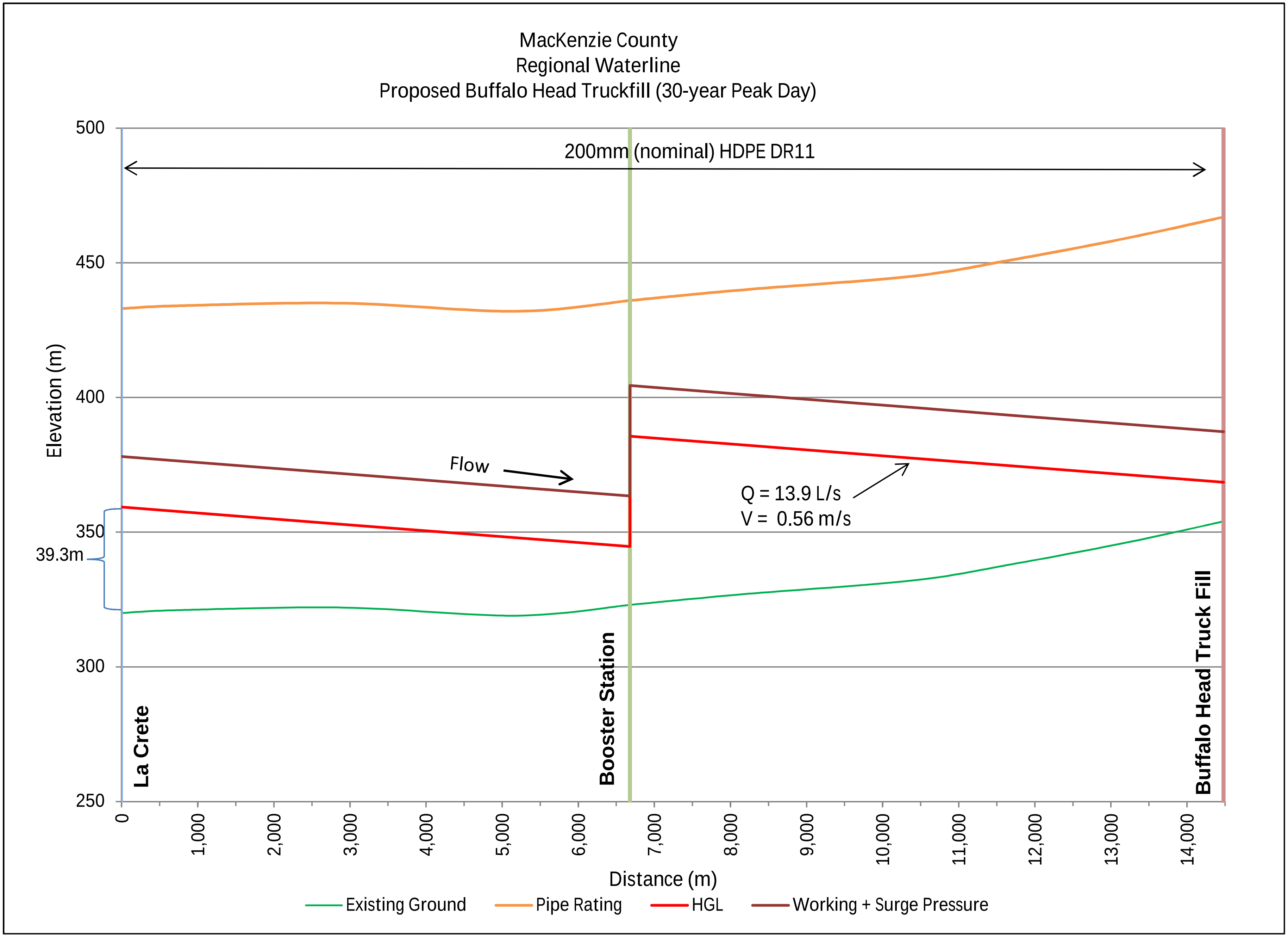
5.1 WATER STABILITY

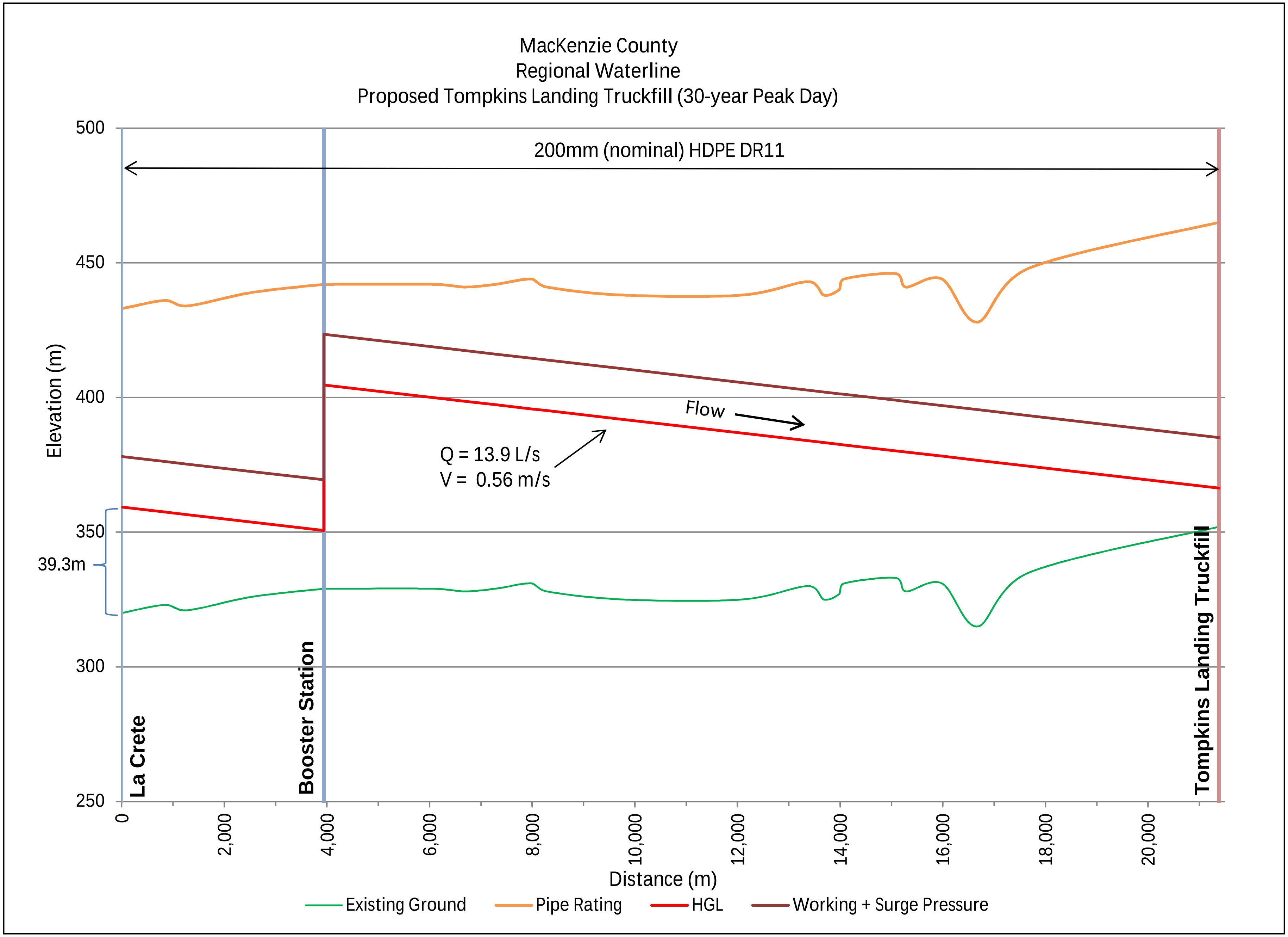
The distribution system operation in both La Crete and Fort Vermillion reportedly do not experience issues with corrosion or scaling. The desktop and bench-scale scaling or corrosion potential prediction do not exhibit dramatic changes when blending La Crete and Fort Vermillion treated waters indicating that the blending treated water likely will not significantly change current conditions for scaling or corrosion seen in either distribution system.

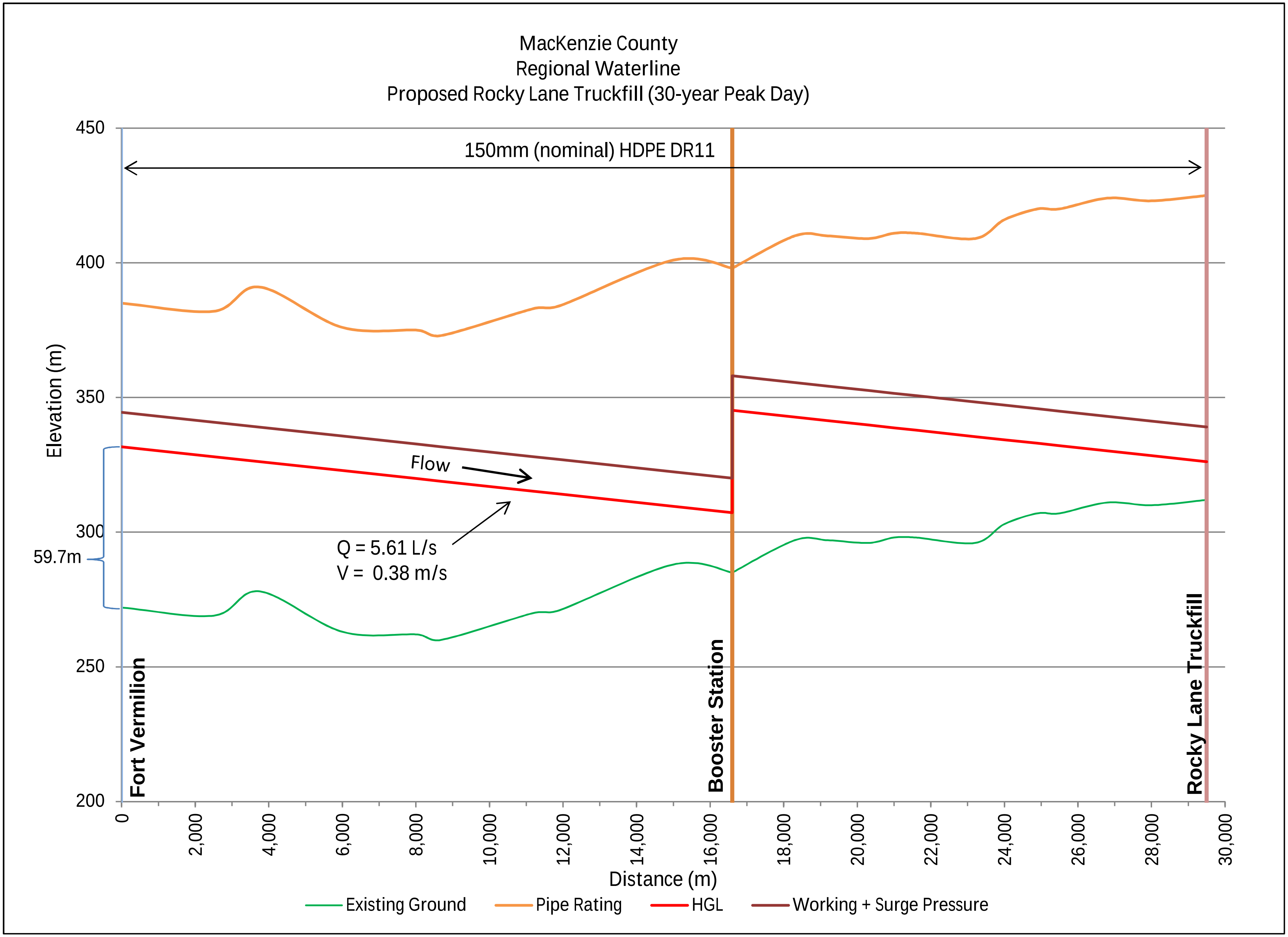
5.2 SIMULATED DISTRIBUTION SYSTEM ANALYSIS

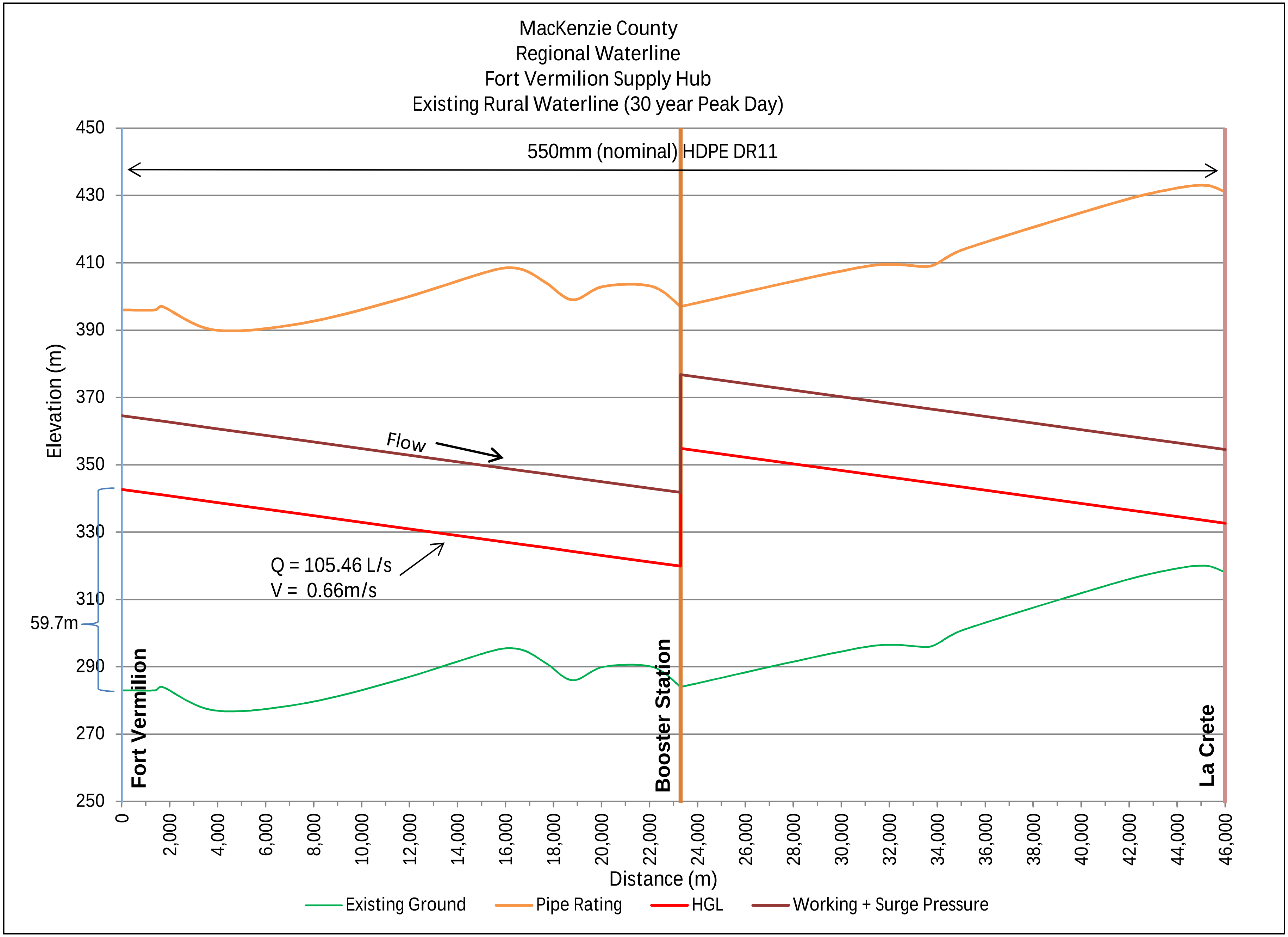
The residence time in the various regional pipelines ranged from 3.2 to 6.4 days. A free chlorine decay simulation and a disinfection by-product formation potential simulation were conducted during the study showed both the current residual and boosted residual could maintain the required free chlorine residual in the regional pipelines for seven days. The disinfection by-product formation potential simulation indicated that current level of free chlorine residual would not cause THM or HAA levels to exceed regulatory guidelines (GCDWQ limits). The disinfection by-product formation potential simulation with the boosted chlorine residual caused the THM concentration to increase but the increase in THM levels did not cause THM or HAA to approach regulatory guidelines limits.

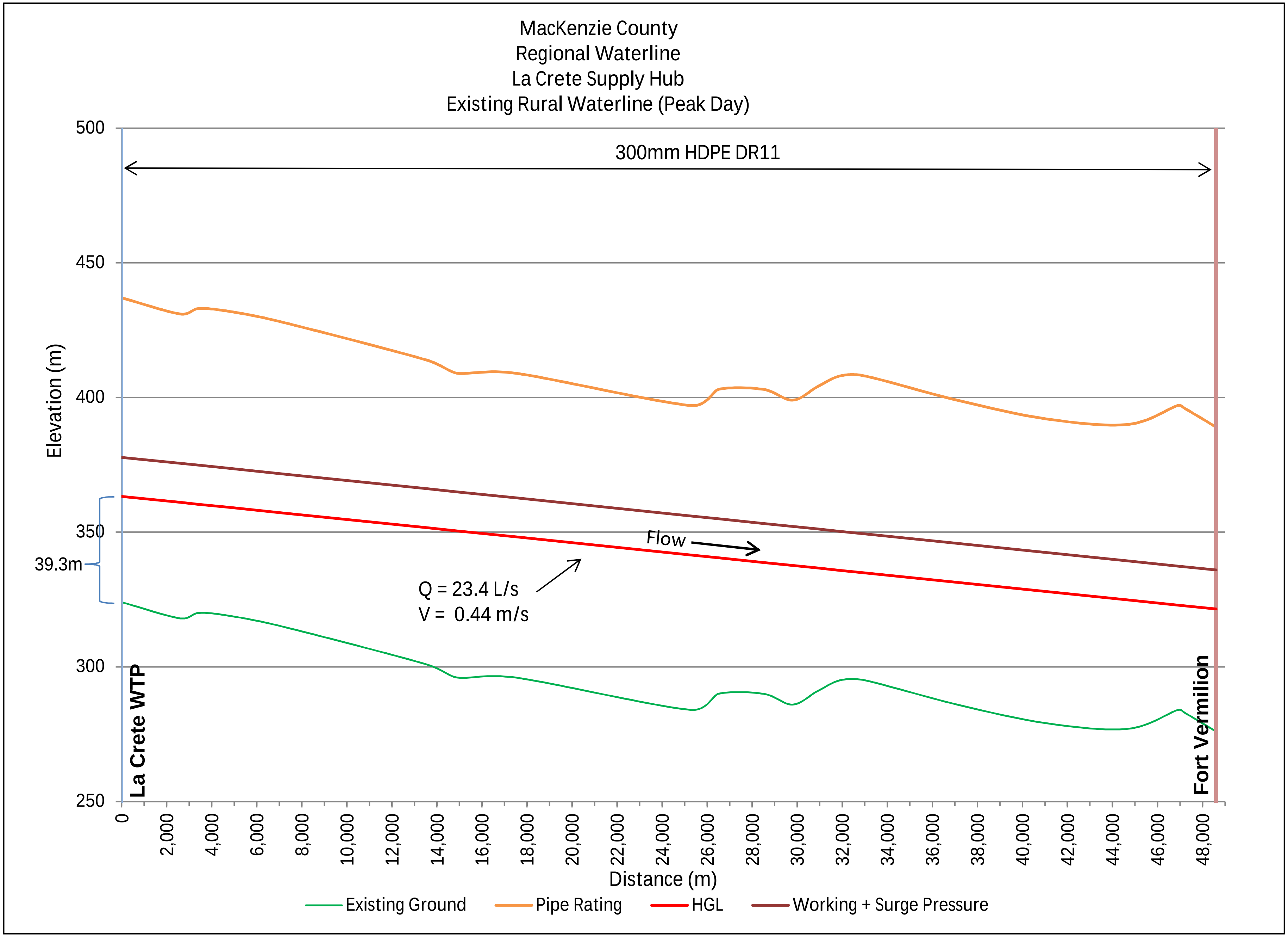
Appendix B – Conceptual Hydraulic Grade Lines


MacKenzie County
Regional Waterline
Proposed Buffalo Head Truckfill (30-year Peak Day)
200mm (nominal) HDPE DR11
Elevation (m)
500
450
400
350
300
250
39.3m
Flow
Q = 13.9 L/s
V = 0.56 m/s
La Crete
Booster Station
Buffalo Head Truck Fill
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
Distance (m)
Existing Ground
Pipe Rating
HGL
Working + Surge Pressure


MacKenzie County
Regional Waterline
Proposed Tompkins Landing Truckfill (30-year Peak Day)
200mm (nominal) HDPE DR11
Elevation (m)
500
450
400
350
300
250
39.3m
Flow
Q = 13.9 L/s
V = 0.56 m/s
La Crete
Booster Station
Tompkins Landing Truckfill
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
Distance (m)
Existing Ground
Pipe Rating
HGL
Working + Surge Pressure


MacKenzie County
Regional Waterline
Proposed Rocky Lane Truckfill (30-year Peak Day)
150mm (nominal) HDPE DR11
Elevation (m)
450
400
350
300
250
200
59.7m
Flow
Q = 5.61 L/s
V = 0.38 m/s
Fort Vermilion
Booster Station
Rocky Lane Truckfill
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
Distance (m)
Existing Ground
Pipe Rating
HGL
Working + Surge Pressure


MacKenzie County
Regional Waterline
Fort Vermilion Supply Hub
Existing Rural Waterline (30 year Peak Day)
550mm (nominal) HDPE DR11
Elevation (m)
450
430
410
390
370
350
330
310
290
270
250
59.7m
Flow
Q = 105.46 L/s
V = 0.66m/s
Fort Vermilion
Booster Station
La Crete
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
Distance (m)
Existing Ground
Pipe Rating
HGL
Working + Surge Pressure


MacKenzie County
Regional Waterline
La Crete Supply Hub
Existing Rural Waterline (Peak Day)
300mm HDPE DR11
Elevation (m)
500
450
400
350
300
250
39.3m
Q = 23.4 L/s
V = 0.44 m/s
Flow
La Crete WTP
Fort Vermilion
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
48,000
Distance (m)
Existing Ground
Pipe Rating
HGL
Working + Surge Pressure