

TECHNICAL MEMORANDUM A.1.3

Regional Municipality of Wood Buffalo

Influent Waste Streams



February 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE/PURPOSE

The main objectives of Technical Memorandum A.1.3, Influent Waste Streams, are to:

- Define the service area for the wastewater treatment facility for the next 25 years.
- Confirm existing RMWB urban population and future population projections
- Define and confirm existing influent waste stream flows and loads.
- Develop influent waste stream flow projections for next 25 years.
- Develop influent waste stream load projections for next 25 years.
- Comment on existing mud pit (hydro-vac type) waste management practices.

2 MAIN FINDINGS

The main findings of this work are summarized as follows:

- **Piped Service Area:** The ultimate service area totals over 13,000 hectares as defined by the proposed Urban Development Sub-Region (UDSR). This includes 14 sub-areas totalling approximately 7,600 hectares in the north catchment and 12 sub-areas totalling approximately 5,600 hectares in the south catchment.
- **Population Projections:** The 2013 equivalent population in the UDSR is estimated at 85,100 persons. Based on a range of annual population growth rates relative to the current population (low: 3%, medium: 4%, and high: 5%) the population could increase significantly over the next 25 years (at low growth reaching 148,900 persons, at medium growth reaching 170,200 persons, and at high growth reaching 191,500 persons). The ultimate UDSR service population is estimated at 352,000 persons, approximately, providing room for growth well beyond the next 25 years.
- **Influent Waste Stream Flows and Loads:**
Flows: Average per capita piped wastewater flows currently measure about 300 litres per capita per day (L/c/d). This number appears more appropriate for the Fort McMurray Wastewater Treatment Facility (WWTF) planning rather than the Engineering Service Standards (ESS), which is more appropriate for linear infrastructure design. Septage currently accounts for approximately 10% of the total flow being treated at the Fort McMurray WWTF. The total piped plus septage flows are approaching 30 Megalitres per day (MLD or ML/d) average flow. Projected 25-year flows are 47, 54, and 61 MLD at low, medium, and high growth rates, respectively. These projections assume that 40% of the septage hauled to Fort McMurray will be diverted to Anzac and/or Conklin WWTFs commencing in 2015.

Loads: The Fort McMurray WWTF currently treats septage indirectly as lagoons provide pre-treatment. With construction of a new septage handling facility, the septage can be treated directly in the WWTF. Initially, this will increase biochemical oxygen demand (BOD) loads by an estimated 20% and the total suspended solids (TSS) loads by more than 40%. However, the likely diversion of an estimated 40% of the septage loads generated south of Fort McMurray to the future Anzac or Conklin WWTFs commencing in 2015 will significantly reduce the direct septage load impact on the Fort McMurray WWTF. With a possible future South Regional WWTF, the flows and loads treated at the Fort McMurray WWTF could be reduced by about 15% in the near term (5-10 years) and by about 35% in the longer term (20-25 years).

Mud Pit Wastes: Hydro-vac type wastes are managed separately at the Fort McMurray WWTF. Decanted water from the mud pit is returned to the WWTF via the lagoons and occasional return pumping. The return flows are averaging less than 1% of the hydraulic loading on the facility; however, peak loadings could be as high as an estimated 10%. Solids from the mud pit are extracted and dried naturally on site. The current mud pit and drying areas do not provide as sustainable solution.

3 RECOMMENDATIONS

The main recommendations are summarized as follows:

- Verify influent flows.
- Base WWTF planning on actual per capita flows rather than the ESS standards.
- Confirm septage characteristics and restrict loads if necessary to enable proper WWTF operation. Evaluate direct septage load impacts versus indirect impacts with the septage lagoon providing a buffer.
- Develop a sustainable solution for managing mud pit wastes. This work should include confirmation of total solids concentrations (discharged, mud pit, and dried), confirmation of decant return flows and the possible need to attenuate these, identification and review of sustainable options, and a conceptual design report.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	v
List of Figures	vi
1 Introduction	1-1
2 Piped Wastewater	2-1
2.1 Piped Wastewater Service Area	2-1
2.2 Population Projections	2-2
2.3 Piped Wastewater Flows	2-14
2.4 Piped Wastewater Characteristics	2-15
2.5 Piped Wastewater Flow Projections	2-15
3 Septage	3-1
3.1 Service Area	3-1
3.2 Septage Quantities	3-3
3.3 Septage Characteristics	3-3
3.4 Septage Loads	3-9
3.5 Total Hauled Wastewater Projections	3-9
3.6 Hauled Wastewater Projections Following Diversions	3-10
3.7 Septage Summary	3-10
4 Hydro-Vac Type Waste	4-1
4.1 Hydro-Vac Type Waste Service Area	4-1
4.2 Hydro-Vac Waste Quantities	4-1
4.3 Hydro-Vac Waste Characteristics	4-2
4.4 Hydro-Vac Waste Loads	4-4
4.5 Hydro-Vac Waste Projections	4-4
4.6 Hydro-Vac Waste Management	4-4
4.7 Hydro-Vac Waste – Next Steps	4-5
5 Combined Piped and Septage Wastes	5-1
5.1 Total Liquid Waste Projections	5-1
5.2 Waste Load Projections	5-1

6	Summary	6-1
6.1	Conclusions	6-1
6.2	Recommendations	6-2

Closure

Appendix A – Septage Survey - March 4-8, 2013

List of Tables

		PAGE NO.
Table 2-1	North and South Gross Catchment Areas	2-1
Table 2-2	Historical Municipal Census Populations	2-2
Table 2-3	2010 Municipal Census Data	2-9
Table 2-4	Ultimate Population Projections for UDSR	2-10
Table 2-5	Ultimate Equivalent Population Projections for UDSR	2-10
Table 2-6	North and South Population Splits	2-13
Table 2-7	25 Year UDSR Population Growth Range	2-13
Table 2-8	Summary of FMWWTF Effluent Flow Data, MLD	2-14
Table 2-9	Summary of FMWWTF Effluent Flow Factors	2-14
Table 2-10	2012 FMWWTF Average Influent Loads	2-15
Table 2-11	Ultimate Average Wastewater Generation North and South Catchment	2-16
Table 2-12	25 Year Average Wastewater Generation Range (MLD)	2-17
Table 3-1	Municipality Camp Database Summary	3-3
Table 3-2	Estimated Septage Loads in 2012	3-9
Table 3-3	Average Projected Hauled Septage Volumes (ML/d) to FMWWTF	3-9
Table 4-1	Mud Pit Waste Quantities	4-1
Table 4-2	Limited Laboratory Results for Mud Pit and Other Wastes	4-3

List of Figures

	PAGE NO.
Figure 1-1 Overall Site Plan	1-3
Figure 2-1 Existing Development Area	2-3
Figure 2-2 North Catchment Area	2-5
Figure 2-3 South Catchment Area	2-7
Figure 2-4 Population Projection - USDR	2-12
Figure 3-1 Location of Open Camps	3-5
Figure 3-2 Potential Stand-Alone North Septage Treatment Facility Service Area	3-7
Figure 5-1 Fort McMurray WWTF Average Day Flow Projections	5-1
Figure 5-2 Fort McMurray WWTF Average Day BOD Load Projections	5-2
Figure 5-3 Fort McMurray WWTF Average Day TSS Load Projections	5-2

1 Introduction

This Technical Memorandum amalgamates the work proposed for Tasks A.1.3 and A.1.4 in the Project Plan.

The scope of work for this technical memorandum includes:

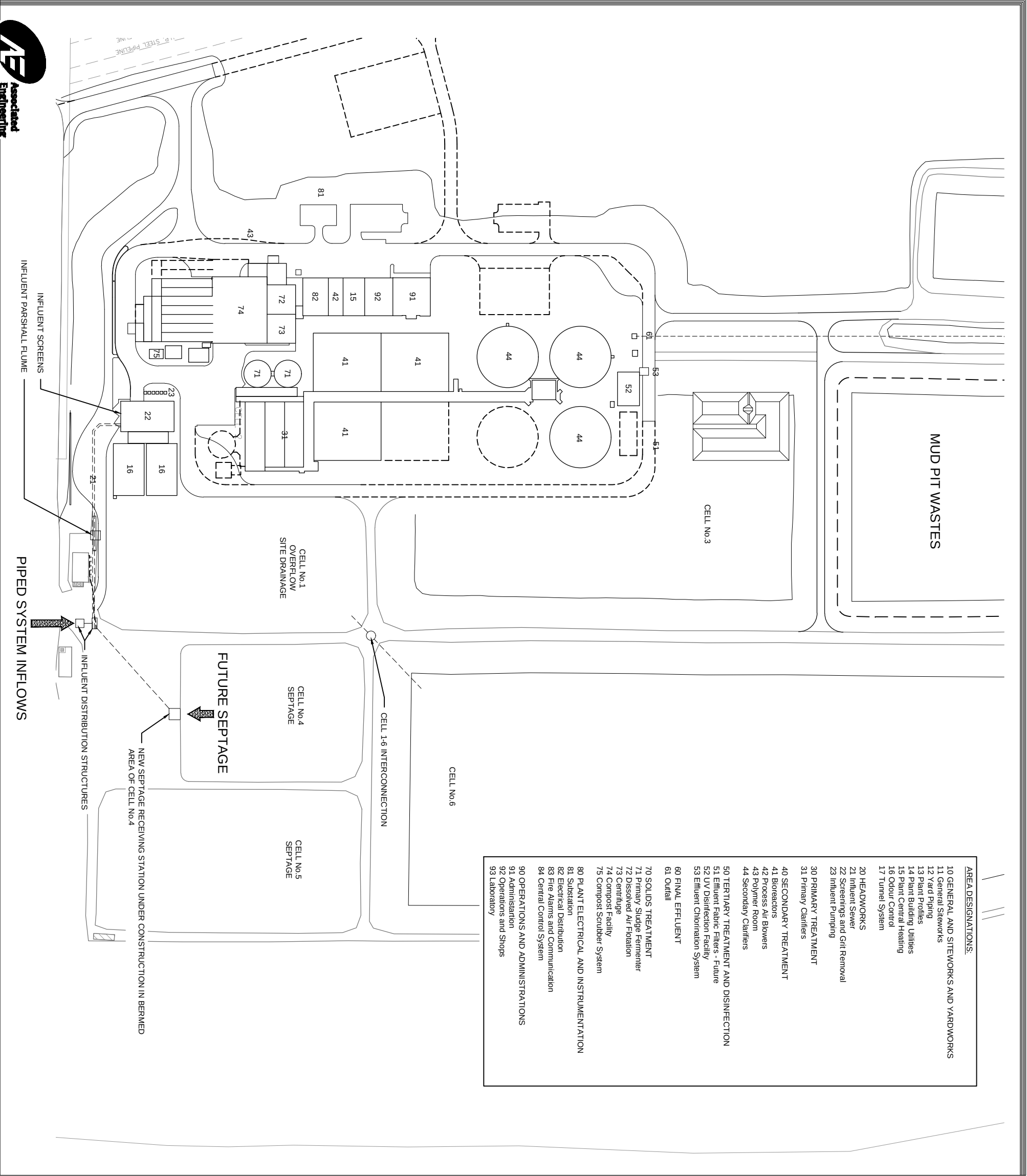
- Define the service area for the wastewater treatment facility for the next 25 years.
- Confirm existing RMWB urban population and future population projections
- Define and confirm existing influent waste stream flows and loads.
- Develop influent waste stream flow projections for next 25 years.
- Develop influent waste stream load projections for next 25 years.
- Comment on existing hydro-vac waste management practices.
- Summarize all findings and recommendations in a Technical Memorandum.

The main waste streams at the Fort McMurray Wastewater Treatment Facility (FMWWTF) include:

- Piped wastewater from the Fort McMurray urban service area entering the FMWWTF from two main flow distribution chambers.
- Septage hauled to septage receiving system: (a) currently to lagoons with occasional return-flow pumping to the distribution chamber; and (b) in the near future directly or indirectly to a pump station that will discharge to the main distribution chamber.
- Hydro-vac and other high solids content wastes hauled to a mud pit.

Figure 1-1 provides an overall site plan with the waste stream sources highlighted.





REGIONAL MUNICIPALITY
OF WOOD BUFFALO

WASTEWATER MASTER PLAN

FORT MCMURRAY

WASTEWATER TREATMENT FACILITY

WASTE STREAMS

NOTE:
BACKGROUND DRAWING BASED ON EARTH
TECH DRAWING (G00 001 REV B)

SCALE: 1:2500

FEBRUARY, 2014

FIGURE 1-1

2 Piped Wastewater

2.1 PIPED WASTEWATER SERVICE AREA

The ultimate service area is defined by the proposed Urban Development Sub-Region (UDSR) which was created by the Oil Sands Secretariat and AESRD. Figure 2-1 illustrates the proposed UDSR boundary as well as the existing and future development areas for the region. The developments within the UDSR are highlighted as two different catchment areas, the north, and the south. The north and south areas have been pre-defined in previous work completed. The two catchments have been defined for water and wastewater infrastructure planning. Figures 2-2 and 2-3 illustrate the existing and future development areas for the proposed north and south catchments, respectively. A summary of the ultimate residential (R) and commercial/industrial (C/I) developments associated with each of the catchments is provided in Table 2-1.

**Table 2-1
North and South Gross Catchment Areas**

North Development Area	Gross Area (ha)	South Development Area	Gross Area (ha)
R: Lower Townsite	439	R: Prairie Creek	25
R: Waterways	86	R: Hangingstone	1,553
R: Draper Valley	293	R: Horse River	678
R: Abasand	176	C/I: Airport East Industrial Lands+ Lynton	760
R: Beacon Hill	100	C/I: Southlands Area 1A	470
R: Gregoire (mixed use)	108	C/I: Southlands Area 1B	530
R: Saline Creek	860	C/I: Southlands Area 2	320
R: Sapræe Creek/Spruce Valley	552	C/I: Southlands Area 4	218
R: Timberlea	1,001	C/I: Airport West Industrial	70
R: Thickwood	771	C/I: Airport Lands	668
R: Parson's Creek	837	C/I: Mackenzie	295
R: West Growth	1,061	C/I: Gateway + Quarry Ridge	38
R: Forest Heights	924		
C/I: Highway 63 Corridor	322		

Within the north and south catchments, there are some areas that may swing between the two catchments. Depending upon staging of development, the areas may be moved to the north or south catchment. The areas which may switch between the two catchments include Airport West Industrial and Airport Lands. Mackenzie, Prairie Creek, Gateway, and Quarry Ridge and are listed in the south catchment area even though they are currently situated in the north catchment. These areas are listed in the south, assuming that flows will be diverted to ensure a stable base flow to the future South Regional Wastewater Treatment Facility (SRWWTF) at start-up.

2.2 POPULATION PROJECTIONS

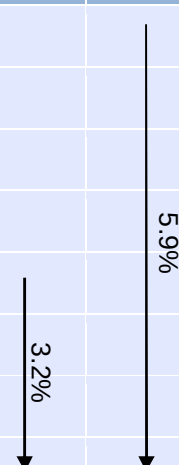
The analyses of populations are based on assumptions as per the Technical Memorandum, entitled, “*Urban Development Sub-region Population Projection*”.

Population projections in the Municipality are challenging considering the significant impact the oil sands industrial development can have on population growth. Estimating growth within the Municipality is important as it is directly correlated to determining the infrastructure required.

To assist with predicting the future growth in the Municipality, AE reviewed the 10 year historical Municipal Census data for the UDSR. Table 2-2 summarizes the census data reviewed. The 5 and 10 year annual growth rates for the urban service area are 3.2% and 5.9%, respectively.

Table 2-2
Historical Municipal Census Populations*

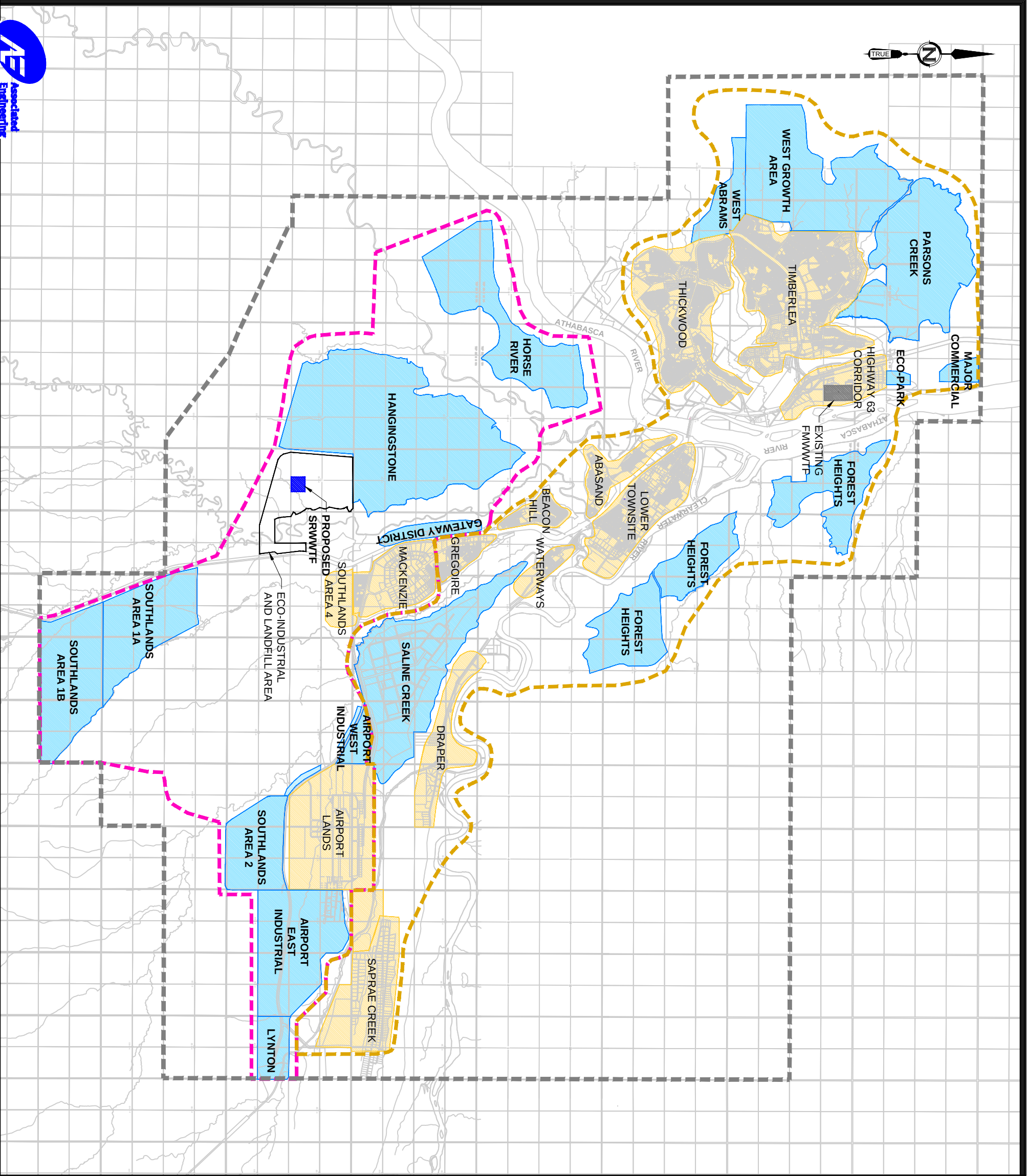
Year	Population	5 Year	10 Year
2002	47,757		
2004	56,111		
2005	60,983		
2006	61,366		
2007	65,400		
2008	72,363		
2010	76,797		
2012	76,009		



* The urban service area defined in the census does not include Draper Valley or Sapræ Creek.

The 2010 Municipal Census outlines population for the various development areas within the UDSR as shown in Table 2-3.

The Municipal Census data in Table 2-3 indicates that the Municipality's population was nearly identical in 2010 and 2012, as a result of the world economic slowdown. For planning purposes, AE has assumed the populations in each of the developments shown in Table 2-3 remained the same between 2010 and 2013.



WASTEWATER MASTER PLAN

OVERALL UDSR

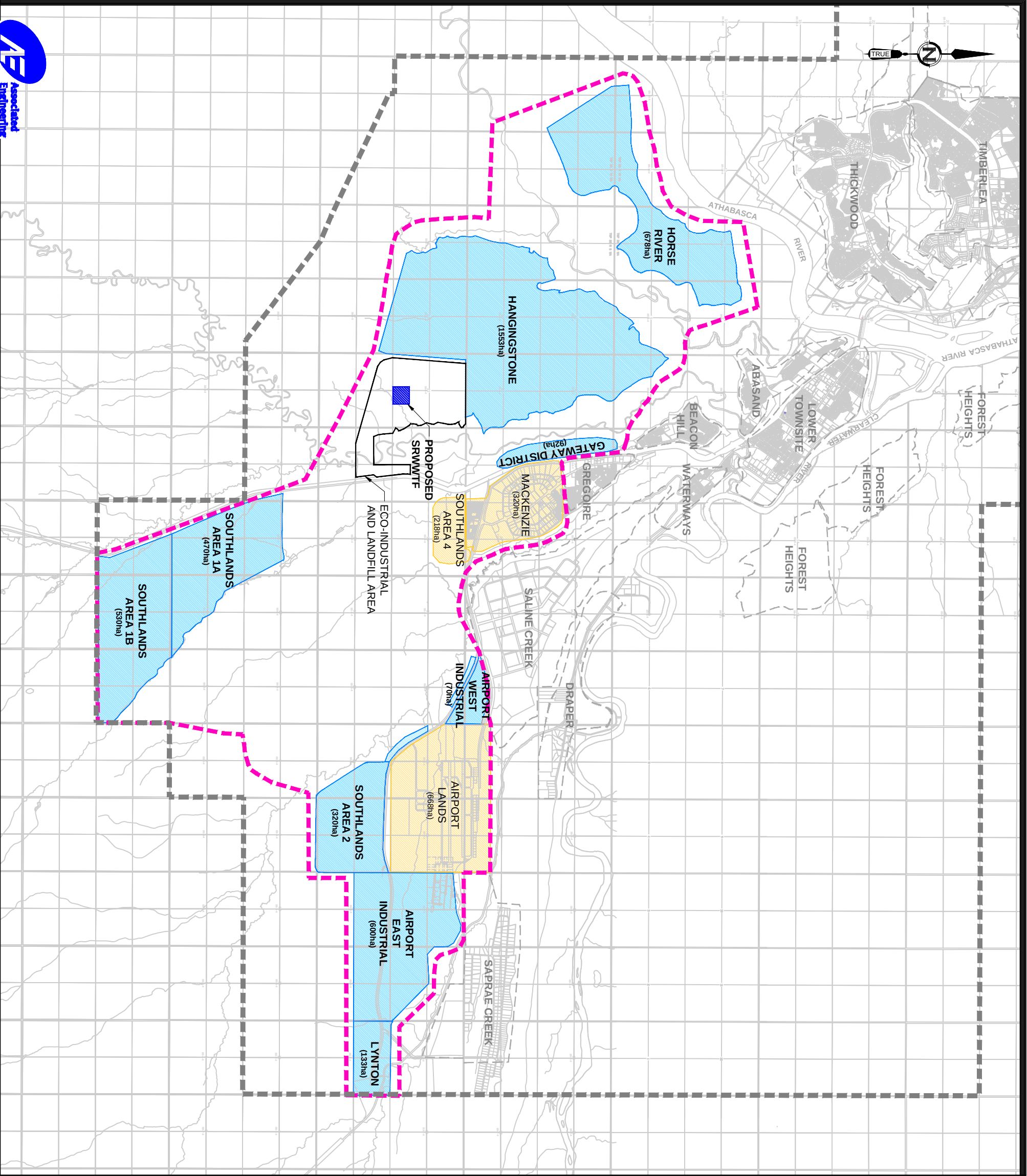
- LEGEND:**
- WMWP SOUTH CATCHMENT BOUNDARY
 - WMWP NORTH CATCHMENT BOUNDARY
 - PROPOSED URBAN DEVELOPMENT SUB-REGION

- DEVELOPMENT AREAS:**
- EXISTING DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS

SCALE: 1:100,000

FEBRUARY, 2014

FIGURE 2-1



WASTEWATER MASTER PLAN

SOUTH CATCHMENT AREA

LEGEND:

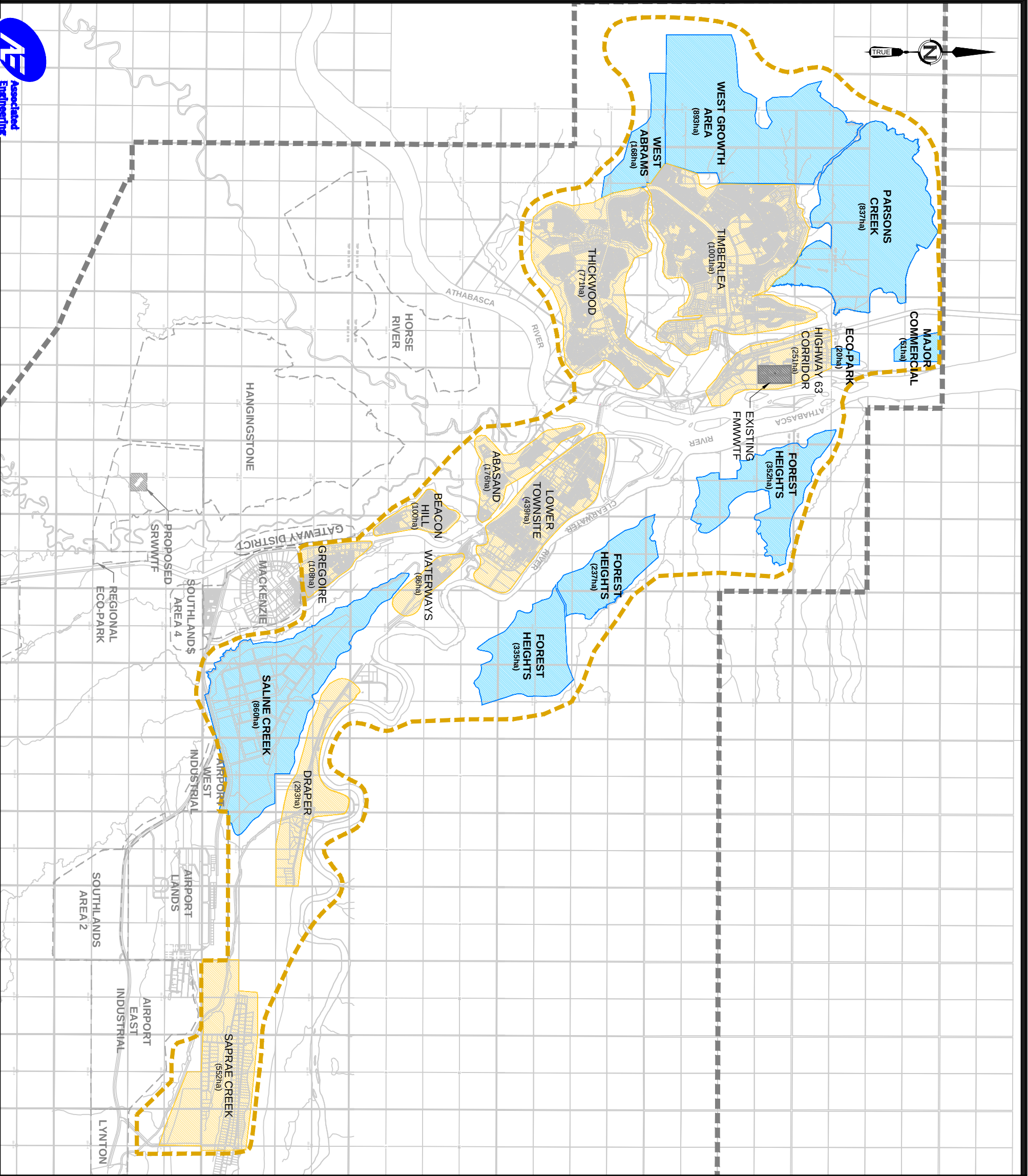
- WMWP SOUTH CATCHMENT BOUNDARY
- WMWP NORTH CATCHMENT BOUNDARY
- PROPOSED URBAN DEVELOPMENT SUB-REGION

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS

SCALE: 1:85,000

FEBRUARY, 2014



WASTEWATER MASTER PLAN

NORTH CATCHMENT AREA

- LEGEND:**
- WWMP NORTH CATCHMENT BOUNDARY
 - PROPOSED URBAN DEVELOPMENT SUB-REGION

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS

SCALE: 1:85,000

FEBRUARY, 2014

FIGURE 2-2

Table 2-3
2010 Municipal Census Data

Existing Development Area	2010 Census Populations
Lower Townsite	12,111
Waterways	686
Abasand	5,445
Beacon Hill	2,489
Gregoire (mixed use)	4,600
Saline Creek	—
Timberlea	30,594
Thickwood	18,784
Parson's Creek	—
Shadow Population	2,088
Total	76,797

2.2.1 Ultimate Population Projections

The ultimate population projection of the proposed UDSR is calculated based upon full development of the areas identified in the north and south catchment areas. The full development of these areas has been determined based on summarization of various past studies, the review of gross developable areas within the region, and the Municipality's Engineering Servicing Standards.

The studies reviewed and summarized include the following:

- Fringe Area Development Assessment, Urban Service Area – March, 2007
- Water Master Plan (WMP) – November, 2011
- Airport Servicing Study – December, 2011
- Mackenzie Diversion Project – ongoing, May, 2013
- Development Charge Update – ongoing, May, 2013

AE and the Municipality held a workshop on March 8, 2013 to discuss the future development of the proposed UDSR. During this workshop, discussion revolved around developable areas in the south and future population projections. For new development areas, three important definitions were confirmed:

- **Gross Area (GA):** Total land area, including both developable and non-developable lands.
- **Gross Developable Area (GDA):** Developable land area only, both non-populated and populated land, including roadways, storm water management, park space, etc.
- **Net Residential Area (NRA):** Populated land area only, residential area.

These three definitions are cardinal for projecting populations in new developments. Depending upon the stage of development planning, different parameters are used to project the future population of the area. As discussed and agreed upon at the workshop, the population projection parameters, shown in Table 2-4, will be applied to future areas when an area structure plan is not available.

Table 2-4
Ultimate Population Projections for UDSR

Development Area	Residential Population Estimate	Commercial/Industrial Population Estimate
GA	Further review required	Further review required
GDA	50 people/ha	37 people/ha
NRA	90 people/ha	50 people/ha

Table 2-5 summarizes the ultimate population projections for each of the development areas in the north and south catchments. The projected ultimate equivalent populations of the north and south catchments are 241,500 and 109,650, respectively, for an ultimate proposed UDSR population of 351,150 equivalent people.

Table 2-5
Ultimate Equivalent Population Projections for UDSR

North Catchment	Population	Notes/Comments
Residential		
Lower Townsite	48,000	WMP & Development Charge Update
Waterways	2,700	WMP & Development Charge Update
Draper Valley	400	WMP & Development Charge Update
Abasand	6,000	WMP & Development Charge Update
Beacon Hill	2,600	WMP & Development Charge Update
Gregoire (mixed use)	7,400	Development Charge Update
Saline Creek	20,000	WMP & Development Charge Update
Saprae Creek/Spruce Valley	5,000	WMP & Development Charge Update
Timberlea	42,000	WMP & Development Charge Update
Thickwood	19,200	WMP & Development Charge Update
Parson's Creek	26,000	WMP & Development Charge Update
West Growth	31,000	WMP & Development Charge Update
Forest Heights	24,000	WMP & Development Charge Update
Total Residential	234,300	
Commercial/Industrial		
Highway 63 Corridor	7,200	WMP
Total Commercial/Industrial	7,200	
Total North Catchment	241,500	

South Catchment	Population	Notes/Comments
Residential		
Prairie Creek	1,250	Calculation from Gross Developable Area
Hangingstone	42,000	WMP
Horse	15,000	WMP
Total Residential	58,250	
Commercial/Industrial		
Airport East Industrial Lands+ Lynton	6,200	WMP & 30% Developable: March 8 Workshop
Southlands Area 1A	5,200	30% Developable: March 8 Workshop
Southlands Area 1B	5,900	30% Developable: March 8 Workshop
Southlands Area 2	6,800	WMP & Development Charge Update
Southlands Area 4	4,500	WMP & Development Charge Update
Airport West Industrial	2,500	Airport San Servicing
Airport Lands	6,050	Airport San Servicing
Mackenzie	6,750	WMP & Development Charge Update
Gateway + Quarry Ridge	7,500	WMP & Development Charge Update
Total Commercial/Industrial	51,400	
Total South Catchment	109,650	
TOTAL UDSR	351,150	

2.2.2 Twenty-Five Year Population Projections

The Municipality's equivalent population is currently estimated to be 85,100 people; the ultimate population for the proposed UDSR is estimated to be 351,150 equivalent people once all regions are fully developed. The time frame for the Municipality to reach the ultimate population is unknown. Typically, municipalities plan to implement infrastructure required to satisfy 25 year projections for the development areas. This may result in full development of some areas and only partial development of other areas. To plan for 25 year wastewater generation rates, AE has estimated the north and south equivalent populations for the next 25 years.

The 25 year population of the Municipality is difficult to estimate due to many uncertainties in the economic growth of the region. In June, 2011, the Municipality completed a Population and Employment Projection Model to provide various projection of the future growth of the region depending upon different production capacities in the oil sands industry.

This model determined three different growth rates for the UDSR:

- Low 2.1% annual increase
- Medium 3.2% annual increase
- High 4.1% annual increase

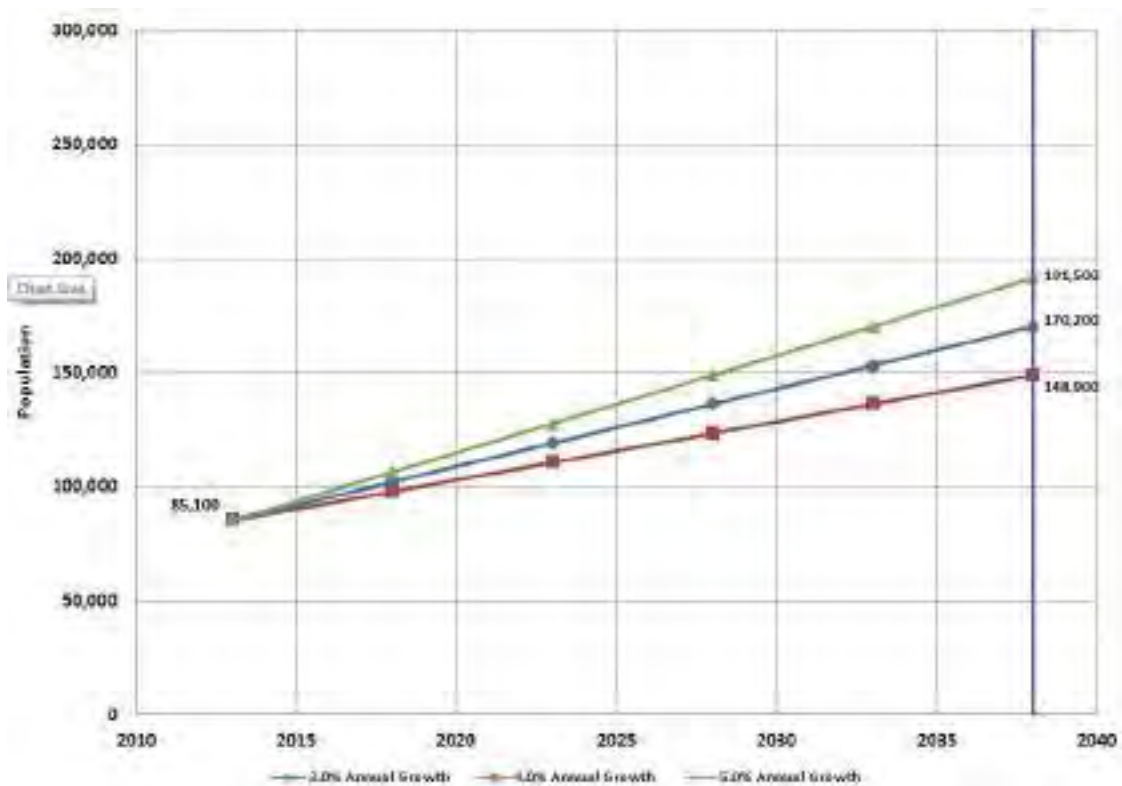
Regional Municipality of Wood Buffalo

The population projections from the Population and Employment Projection Model were discussed during the March 8th workshop and the Municipality expressed that the population projection range is too low. The Municipality determined that the 4.1% growth rate is more accurately reflective of a low growth rate based upon historical population increases. Past municipal census data indicates a range of 3.2% to 5.9% annual population growth between 5 and 10 years. With this, AE proposes the following range of population projection rates to the UDSR:

- Low 3.0% annual increase
- Medium 4.0% annual increase
- High 5.0% annual increase

Figure 2-4 illustrates the range of populations in the region is between 148,900 and 191,500 equivalent people in the UDSR within 25 years.

Figure 2-4
Population Projection - UDSR



To determine the growth in the north and south catchments, AE went through the exercise of estimating development in each of the development areas. This exercise was based on discussions that took place during the March 8th workshop about areas that are under development and/or likely to develop next, including Southlands 1A and Hangingstone.

2-12

After going through the exercise AE determined typical population splits between the north and south catchment areas. The ultimate population split between the north and south is 69% to 31%, respectively. Table 2-6 summarizes the projected population split between north and south catchments in 5 year steps.

Table 2-6
North and South Population Splits

Catchment	2013	2018	2023	2028	2033	2038
North	100%	85%	75%	65%	65%	65%
South	0%	15%	25%	35%	35%	35%

The values in Table 2-7 indicate that it will take 15 to 20 years for the population dispersion in the UDSR to reflect a split similar to the ultimate populations. These projections may shift based on changes in development goals in the north and south respectively. Table 2-7 summarizes the population projections for the north and south catchments based upon the splits in Table 2-6.

Table 2-7
25 Year UDSR Population Growth Range

Catchment	2013	2018	2023	2028	2033	2038
3.0%						
UDSR	85,100	97,900	110,600	123,400	136,200	148,900
North	85,100	83,215	82,950	80,210	88,530	96,785
South	—	14,685	27,650	43,190	47,670	52,115
4.0%						
UDSR	85,100	102,100	119,100	136,200	153,200	170,200
North	85,100	86,785	89,325	88,530	99,580	110,630
South	—	15,315	29,775	47,670	53,620	59,570
5.0%						
UDSR	85,100	106,400	127,700	148,900	170,200	191,500
North	85,100	90,440	95,775	96,785	110,630	124,475
South	—	15,960	31,925	52,115	59,570	67,025

2.3 PIPED WASTEWATER FLOWS

Table 2-8 summarizes 2010-2012 piped wastewater flow data and piped wastewater flow rates, based on effluent Parshall flume readings at the FMWWTF. Table 2-9 summarizes the flow factors relative to average day flows.

Table 2-8
Summary of FMWWTF Effluent Flow Data, MLD^a

Parameter	2010	2011	2012
Min Hour	0.07	0.04	2.46
Min Day	12.94	9.88	16.74
Min Week	19.43	19.47	22.03
Min Month	20.80	20.70	21.92
Avg Day	24.18	23.02	24.83
Max Month	26.05	25.76	28.59 ^b
Max Week	31.84	28.12	28.59 ^b
Max Day	39.25	32.11	48.70
Peak Hour	62.27	71.84	64.46

Table 2-9
Summary of FMWWTF Effluent Flow Factors
(relative to yearly averages)^a

Parameter	2010	2011	2012
Min Hour	0.00	0.00	0.10
Min Day	0.53	0.43	0.67
Min Week	0.80	0.85	0.89
Min Month	0.86	0.90	0.88
Avg Day	1.00	1.00	1.00
Max Month	1.08	1.12	1.15 ^b
Max Week	1.32	1.22	1.15 ^b
Max Day	1.62	1.39	1.96
Peak Hour	2.58	3.12	2.60

^a Influent flow factors may have wider variation due to no dampening of the flows through the WWTF.

^b Max month and max week data for 2012 was incomplete; therefore, the indicated max month and week flow factors for 2012 may have been higher than indicated.

2.4 PIPED WASTEWATER CHARACTERISTICS

Table 2-10 summarizes average 2012 influent concentrations for various parameters. The loading peaks could not be ascertained as this would have required significantly more sample analyses.

Table 2-10
2012 FMWWTF Average Influent Loads

Parameter	Concentration mg/L*	Load kg/d
BOD	207	5,283
TSS	280	7,181
Total Phosphorus	3.6	91
OPO ₄ -P	1.8	47
NH ₃ -N	29.8	726
COD	482	12,657
pH	7.6	n/a

* Except pH

2.5 PIPED WASTEWATER FLOW PROJECTIONS

The Municipality's Engineering Servicing Standards (ESS) stipulate a per capita generation rate of 360 L/c/d to determine the anticipated average day wastewater flow from development areas. Although this is considered reasonable for individual development areas, it would appear to be overly conservative for the combined areas. For example, in 2012 the FMWWTF treated an average flow in the order of 25 MLD. This represents a per capita flow in the order of 300 L/c/d, some 60 L/c/d less than the ESS.

To estimate the sizing of wastewater treatment infrastructure, AE started with the 2012 piped flow data and utilized the same low, medium, and high projection rates as for the population projections (3%, 4%, and 5%). However, to estimate the average day wastewater generation rates for individual areas within the UDSR, a per capita generation rate of 360 L/c/d is applied to the projected populations, as per the ESS. Once the average day flow is estimated the peak day, peak hour, peak week, peak month, and inflow/infiltration values are applied to sizing various components of the wastewater infrastructure.

2.5.1 Ultimate Piped Average Day Wastewater Generation

The ultimate piped wastewater generation for the UDSR is estimated by applying the per capita generation rate to the ultimate population projections for the region. Table 2-11 summarizes the anticipated wastewater generation from each of the development areas once fully developed.

Table 2-11
Ultimate Average Wastewater Generation North and South Catchment

North Catchment	L/s	MLD
Residential		
Lower Townsite	200	17.3
Waterways	11	1.0
Draper Valley	2	0.1
Abasand	25	2.2
Beacon Hill	11	0.9
Gregoire (mixed use)	31	2.7
Saline Creek	83	7.2
Saprae Creek/Spruce Valley	21	1.8
Timberlea	175	15.1
Thickwood	80	6.9
Parson's Creek	108	9.4
West Growth	129	11.2
Forest Heights	100	8.6
Total Residential	976	84.4
Commercial/Industrial		
Highway 63 Corridor	30	2.6
Total Commercial/Industrial	30	2.6
Total North Catchment*	1,006	87
South Catchment	L/s	MLD
Residential		
Prairie Creek	5	0.6
Hangingstone	175	15
Horse	62	5.4
Total Residential	242	21
Commercial/Industrial		
Airport East Industrial Lands + Lynton	26	2.2
Southlands Area 1A	22	1.9
Southlands Area 1B	25	2.0
Southlands Area 2	28	2.4
Southlands Area 4	19	1.6
Airport West Industrial	10	0.9
Airport Lands	25	2.1
Mackenzie	28	2.3
Gateway + Quarry Ridge	31	2.6
Total Commercial/Industrial	214	18
Total South Catchment*	456	39
TOTAL UDSR*	1,462	126

*The totals for treatment may be reduced in the order of 17% to account for an overall average 300 L/c/d for the overall area versus 360 L/c/d for the individual areas.

2.5.2 25 Year Average Day Wastewater Generation

Table 2-12 summarizes the estimated wastewater volumes requiring treatment in the UDSR over the 25 years.

Table 2-12
25 Year Average Wastewater Generation Range (MLD*)

Catchment	2013	2018	2023	2028	2033	2038
3.0%						
UDSR	25.8	29.5	33.3	37.0	40.8	44.5
North	25.8	25.1	24.9	24.1	26.5	28.9
South	—	4.4	8.3	13.0	14.3	15.6
4.0%						
UDSR	26.0	31.0	36.0	41.0	46.0	51.0
North	26.0	26.4	27.0	26.7	29.9	33.2
South	—	4.7	9.0	14.4	16.1	17.9
5.0%						
UDSR	26.3	32.5	38.8	45.0	51.3	57.5
North	26.3	27.6	29.1	29.3	33.3	37.4
South	—	4.9	9.7	15.8	17.9	20.1

* MLD: mega litres per day.

3 Septage

3.1 SERVICE AREA

3.1.1 Septage Truck Survey

The Municipality conducted a day-time survey of septage truck size and origin entering the site between March 4 and 8, 2013, normally between the hours of 8:30 a.m. to 4:30 p.m. each day. Refer to Appendix A for details. The surveyed trucks averaged about 1,300 m³ hauled septage volumes daily. The data were reviewed with respect to truck origin as follows:

- North Township 90 and north
- South Township 86 and south
- Local Within 20 km of the FMWWTF

The origin/volume of the septage trucks was determined as follows:

	<u>North</u>	<u>South</u>	<u>Local</u>
• Number of trucks	51.8%	42.6%	5.7%
• Volume of trucks	55.2%	43.1%	1.7%

The distribution of trucks is important because, in future, the Municipality plans to divert the “South” septage haulers to the Anzac wastewater treatment facility, which is currently under construction, or to the Conklin wastewater treatment facility, which is planned for construction starting in 2014. If the “South” trucks are diverted to Anzac or Conklin in future, then up to 57% of the hauled septage (including local haulage) could keep going to the FMWWTF, i.e. the remaining 43% would be diverted.

Of the total hauled loads, approximately 65% were identified as camp wastes, 20% industrial wastes, <10% domestic wastes, and <5% for the remainder (1% sludge, 1% lagoon, 1% car wash, and <1% Municipality's industrial waste).

AE confirmed that both the Anzac and Conklin wastewater treatment facilities have been designed to accommodate the septage loads that could be diverted from the FMWWTF¹. The 2012 Anzac projections ranged from 65 to 89 average truckloads per day, and the Conklin estimate for 2011 was 43 truckloads per day.

Looking only at the Anzac projections, and assuming an average truck size of 22 m³, Anzac would initially be able to handle approximately 1,400 to 2,000 m³/d, well in excess of the estimated diversion from the FMWWTF.

¹ Personal communication with Doug McRae, Morrison Hershfield, July 23, 2013.

3.1.2 Camp Database

The Municipality (courtesy of Sara Rivers) provided their database on camp facilities that have been approved. Some of the camps are open and some are closed. The “closed” camps are proposed for future operation and some may be permanently closed. Most of the open camps likely haul their domestic wastewater via truck to the FMWWTF. Some of the camps have their own wastewater treatment facilities and their haulage may be limited only to excess biological sludge. As well, there are likely a number of non-camp facilities that require truck haulage; therefore, these are not represented in the camp database.

In the future, the camps located south of Fort McMurray (Township 86 and further south) will likely haul their wastewater either to the proposed Anzac WWTF or to Conklin WWTF which are planned for construction in the near future. Therefore, the septage loads discharged to the FMWWTF should see a corresponding decrease at that time. Only the camps located north or within the local area of Fort McMurray would continue to haul septage to the FMWWTF.

Table 3-1 summarizes the camp location and size information extracted from the database. The status of several of the camps (open or closed) was not indicated for 47 of the 140 camps in the database. Since the camp occupancy rates are not known, the associated septage volumes cannot be estimated.

The Municipality's camp database, where much of the hauled septage originates, suggests that the north should have a higher ratio of wastewater generation, based on the number of beds in the camps: 72% North (FMWWTF) and 28% South (Anzac and Conklin).

For purposes of this WWMP, roughly a 60%/40% North/South split is assumed. This provides a slightly higher North-South split than determined during the five-day survey (57% / 43%), and a somewhat lower split than estimated based on the camp database (72% / 28%).

In addition, it should be recognized some of the local area haulage, representing a small portion of the “North” haulage, may be delivered to the SRWWTF, when it is constructed in the future.

Figure 3-1 shows the location of open camps within the Municipality's camp database, and the suggested Township divisions for future flow diversions from the FMWWTF to Anzac/Conklin. Figure 3-2 shows a potential stand-alone north septage treatment facility service area that could handle an estimated 50% of the septage. This is discussed further in Section 3.6.

**Table 3-1
Municipality Camp Database Summary**

Location / Status	Number of Camps	Total Number of Beds	Avg Number of Beds per Camp
North (Twp. 87 and North)			
All	76	62,717	825
Open	16	20,603	1,288
Future	50	42,114	842
South (Twp. 86 and South)			
All	64	26,547	415
Open	19	8,025	422
Future	43	18,522	431

3.2 SEPTAGE QUANTITIES

Our review of the Municipality's 2012 septage haul data showed the following septage volumes were hauled to the FMWWTF septage lagoons:

- Average Day 2,310 m³
- Peak Day 3,720 m³
- Peak Hour 10,900 m³

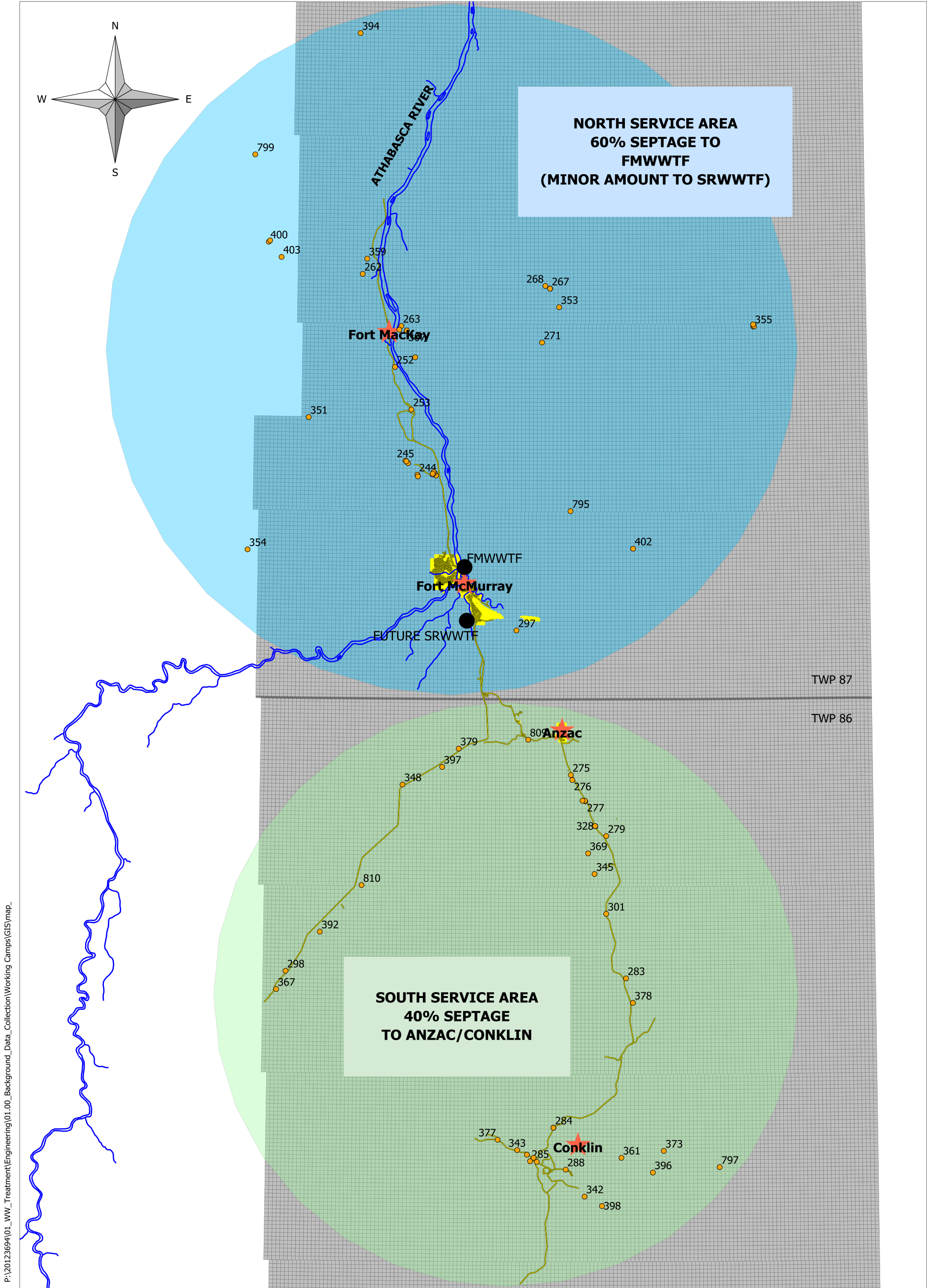
3.3 SEPTAGE CHARACTERISTICS

AE's 2009 septage study reported the following average concentrations in the septage hauled to Fort McMurray's septage lagoons:

- BOD 694 mg/L
- COD 2200 mg/L
- TSS 1679 mg/L
- TKN 148 mg/L
- Total P 41 mg/L

The concentrations were markedly higher than for the piped wastewater.





WASTEWATER MASTER PLAN

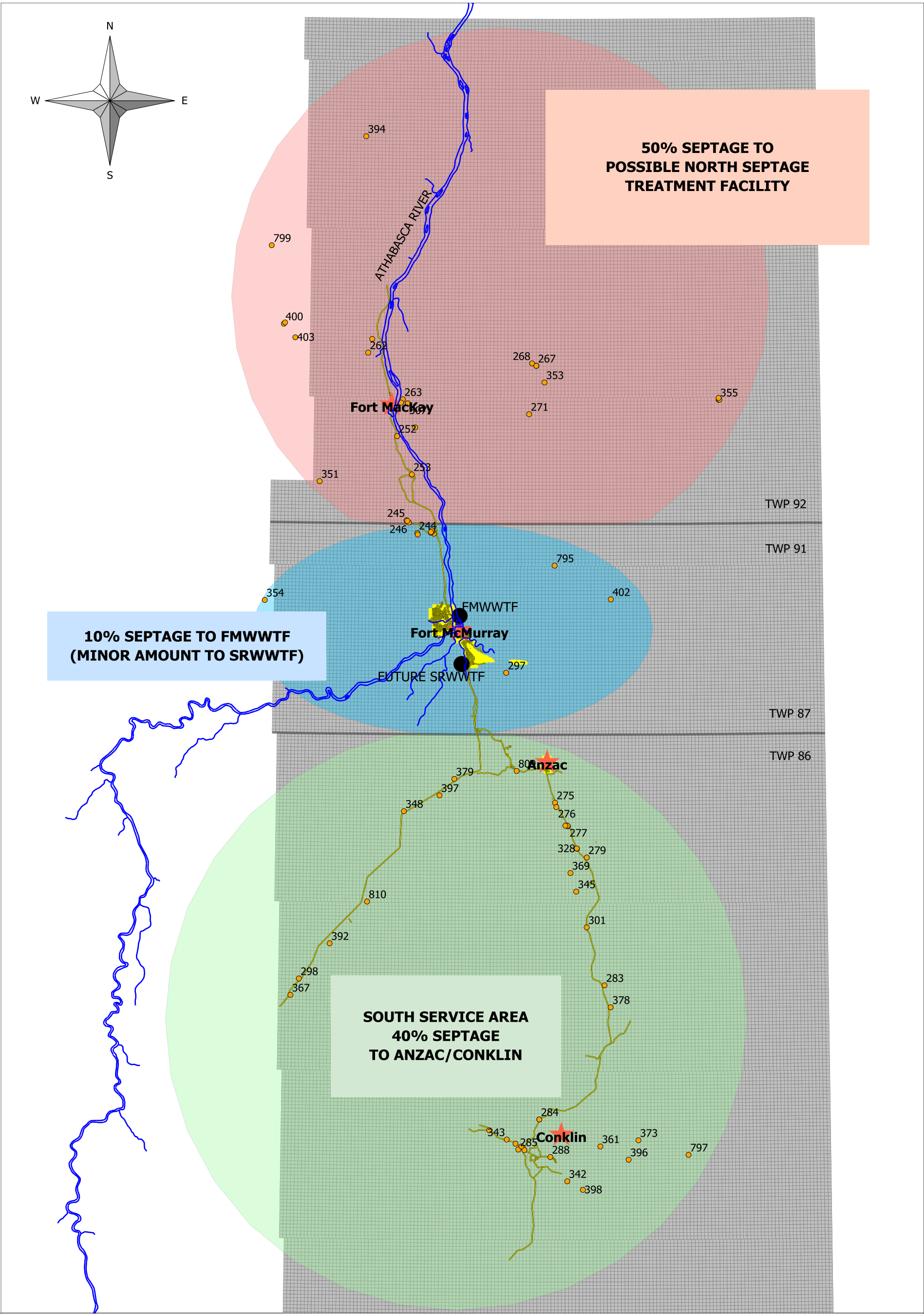
NORTH AND SOUTH SEPTAGE SERVICE AREAS
WITH ANZAC/CONKLIN WWTFs OPERATIONAL

NOTE: CAMP SITES (NOT CLOSED)
ARE BASED ON RMWB'S
CAMP DATABASE AND ARE
INDICATED AS •###

FEBRUARY, 2014

FIGURE 3-1

P:\20123694\01_WW_Treatment\Engineering\01.00_Background_Data_Collection\Working Camps\GIS\map_RMWB Jr.map:[Component]



WASTEWATER MASTER PLAN

POSSIBLE SEPTAGE SERVICE AREAS WITH A NEW NORTHERN SEPTAGE TREATMENT FACILITY IN THE VICINITY OF FORT MACKAY

NOTE: CAMP SITES (NOT CLOSED) ARE BASED ON RMWB'S CAMP DATABASE AND ARE INDICATED AS •###

FEBRUARY, 2014

FIGURE 3-2

3.4 SEPTAGE LOADS

Based on the 2012 septage hydraulic loads and the average 2009 constituent concentrations, the estimated loads in the 2012 septage are shown in Table 3-2:

Table 3-2
Estimated Septage Loads in 2012

Parameter	Average Day (kg/d)	Peak Day (kg/d)	Peak Hour (kg/d)
BOD	1,600	2,600	
COD	5,100	8,200	
TSS	3,900	6,200	18,300
TKN	340	550	
Total P	95	150	

Peak hour loading is shown only for TSS. The TSS impact would be mostly felt in the headworks (screens and grit removal facilities). The indicated loading estimates assume direct discharge of the septage to the WWTF at the average constituent concentrations, as determined in the 2009 septage study along with the hydraulic variation noted in 2012.

3.5 TOTAL HAULED WASTEWATER PROJECTIONS

The septage haulage to the FMWWTF in 2012 averaged 2,310 m³/d (2.31 ML/d). For purposes of this report, we assumed a 60% / 40% split between the north and south, that the north facility will receive 60% of the total hauled septage commencing about 2015, and that the hauled wastewater will increase at rates mirroring the piped system population/flow increases.

With the southern hauled septage being diverted to Anzac or Conklin around 2015, the north facility would see an initial reduction in septage volumes, followed by gradual increases back to the initial levels and beyond.

With these assumptions, the average projected hauled septage volumes (ML/d) to the FMWWTF are shown in Table 3-3.

Table 3-3
Average Projected Hauled Septage Volumes (ML/d) to FMWWTF

Year	Low (3%)	Medium (4%)	High (5%)
2013	2.38	2.40	2.43
2018	1.64	1.72	1.80
2023	1.84	2.00	2.15
2028	2.05	2.27	2.49

Year	Low (3%)	Medium (4%)	High (5%)
2033	2.26	2.55	2.84
2038	2.47	2.83	3.19

3.6 HAULED WASTEWATER PROJECTIONS FOLLOWING DIVERSIONS

Section 3.1 showed that the projected total septage volumes hauled to the FMWWTF will be reduced by an estimated 40%, once the Anzac and/or Conklin WWTFs are constructed.

If septage volume increases from northern regions place increased demands on the FMWWTF, then perhaps a stand-alone septage treatment facility in the north could be considered at that time. Fort Mackay appears to be centrally located to the northern septage generators; therefore, a stand-alone septage treatment facility may have merit in that area. Assuming such a facility served camps and other facilities located in Township 92 and north (about half the distance between Fort Mackay and the FMWWTF), then another 50% of the septage loads potentially could be diverted, leaving the FMWWTF and the future SRWWTF to handle no more than 10% of the projected septage loads.

3.7 SEPTAGE SUMMARY

- The Municipality's recent five-day survey of the septage haulers discharging loads at the Fort McMurray septage lagoons showed that approximately 55% of the total hauled volume was from the north, 43% was from the south, and 2% was local (within 20 kms of Fort McMurray).
- Based on the Municipality's camp database, it appears that the northern haulage could be higher, approximately 72% North (FMWWTF), leaving 28% for the South (Anzac and Conklin).
- For purposes of this wastewater master plan, roughly a 60% North/ 40% South split is assumed.
- 2012 septage haul data showed the following septage volumes were hauled to the FMWWTF septage lagoons: Average Day: 2,310 m³, Peak Day: 3,720 m³, Peak Hour: 10,900 m³.
- AE's 2009 septage study showed that septage concentrations were significantly higher than for normal piped wastewater.
- Assuming that septage volumes increase linearly at 5% annually (medium growth projection), and 40% of the septage is diverted to Anzac or Conklin by 2015, the FMWWTF would see an initial reduction in septage volumes, followed by gradual increases back to the current levels by about 2028, and continue to increase by a further 30% by about 2038.

If septage volume increases from northern regions place increased demands on the FMWWTF, then perhaps a stand-alone septage treatment facility in the north could be considered at that time.

4 Hydro-Vac Type Waste

4.1 HYDRO-VAC TYPE WASTE SERVICE AREA

Some of the hauled waste is inert material such as hydro-vac waste not suitable for direct discharge at the wastewater treatment facility. Generation of these wastes is likely more related to construction activity than to camp facilities, so it is not included in the camp database. Refer to Section 4.3 for further discussion of the hydro-vac type wastes. Data on the origin of hydro-vac type wastes was not available.

Sources of hydro-vac wastes may include industrial cleaning, waste removal, day-lighting, trenching, post hole digging, and spill clean-up. Therefore, hydro-vac wastes can potentially have significant contaminant concentrations depending on the waste source.

Hydro-vac and other liquid wastes with high inert solids contents are hauled to the Municipality's mud pit (approx. 30,000 m² area) located at the FMWWTF. Assuming the pit is filled to a 4.0 m depth, it potentially could store up to 120,000 m³ of waste before waste removal for drying, and/or ultimate disposal is required.

The Municipality is concerned that the present operation of the mud pit is not sustainable.

4.2 HYDRO-VAC WASTE QUANTITIES

The Municipality provided comments and available data on the mud pit, during a February 20, 2013 site visit. Table 4-1 summarizes available 2011 and 2012 data on wastes hauled to the mud pit. Data for previous years were not available.

The data were quite variable. For 2012, the Municipality's records show that approximately 90,000 m³ of wastes were deposited in the 120,000 m³ containment area. Since much of the pit cannot be accessed from the bank for a clean-out, it is not surprising that the pit had to be cleaned on two occasions in 2012.

Table 4-1
Mud Pit Waste Quantities

Month	2011		2012	
	Trucks #	Volume m ³	Trucks #	Volume m ³
January	226	3,048	486	6,159
February	244	3,273	535	7,128
March	290	3,542	509	6,892
April	377	5,159	305	4,174
May	317	4,193	324	4,331

Month	2011		2012	
	Trucks #	Volume m ³	Trucks #	Volume m ³
June	326	4,109	461	5,954
July	382	4,999	544	7,165
August	457	6,009	796	10,680
September	359	4,636	808	11,237
October	491	6,343	966	12,801
November	275	3,789	587	7,926
December	175	2,050	490	6,253
Year Totals	3,919	51,150	6,811	90,700

4.3 HYDRO-VAC WASTE CHARACTERISTICS

Table 4-2 summarizes limited laboratory results on sludge characteristics for the mud pit; also some data on septage solids pumped from the septage lagoon and dewatered in “geobags” is included for comparison purposes.

Unfortunately, the total solids concentrations of the mud pit wastes were not available. Assuming that this waste averages 6% solids concentration as it is deposited, and it thickens to 18% in the mud pit (i.e., a threefold concentration increase), the estimated volume of water that could be decanted and returned to the plant would be about 60,000 m³ in 2012. The Municipality indicated that return pumping to the plant lasted about three weeks, so this potentially could account for a 3,000 m³/d influent flow increase to the plant (about 12% of the current plant flow) during return pumping.

In future, the return pumping rate and timing may have to be adjusted to avoid over-stressing the FMWWTF.

The ultimate disposal location for the mud pit wastes would likely be the landfill. The wastes would need to be dried sufficiently to pass the paint filter test. The landfill would need to advise if the constituent concentrations meet their acceptance criteria.

Table 4-2
Limited Laboratory Results for Mud Pit and Other Wastes*

Date	Sample Location/Type	Total Petroleum Hydrocarbons		Benzene	Toluene	Ethylbenzene	Xylene (total)	Lead	pH	Flashpoint
		µg/g	µg/g							µg/g
Mud Pit										
16-Apr-12	Wet Side Mud Pit	1030		<0.17	<1.0	<0.20	<1.0	0.146	8.00	>75
16-Apr-12	Dry Side Mud Pit	556		<0.17	<1.0	<0.20	<1.0	0.030	8.48	>75
Mud Pit Haulers										
16-Apr-12	Hauler 1	116		<0.17	<1.0	<0.20	<1.0	0.094	8.02	>75
16-Apr-12	Hauler 2	564		<0.17	<1.0	<0.20	<1.0	0.079	8.36	>75
16-Apr-12	Hauler 3	239		<0.17	<1.0	<0.20	<1.0	0.070	7.99	>75
14-Apr-12	Hauler 4	1720		<0.17	<1.0	<0.20	<1.0	<0.005	8.50	>75
Other										
27-Mar-12	Geobags & RMWB	7880		<0.17	<1.0	<0.20	<1.0	13.16	7.34	>75
27-Mar-12	Geobags & RMWB	6680		<0.17	<1.0	<0.20	<1.0	9.36	6.95	>75
27-Mar-12	Geobags & RMWB	9480		<0.17	<1.0	<0.20	<1.0	14.56	6.91	>75

* Acceptable limits depend on disposal location and the associated acceptance criteria.

4.4 HYDRO-VAC WASTE LOADS

Solids loadings to the mud pit cannot be accurately estimated at this time because solids concentration data are not available. Based on the above assumed concentrations, the 2012 solids loading estimates are follows:

As deposited:

- Total volume 90,000 m³
- Solids concentration 6 wt%
- Dry solids 5,400 tonnes (approx.)

Following settlement/concentration in mud pit:

- Total volume 30,000 m³
- Solids concentration 18 wt%
- Wet solids weight 33,000 tonnes
(Assuming 1.10 bulk specific gravity)

Following removal and natural drying:

- Total volume 15,000 m³
(Assuming approx. 50% volume reduction after drying)
- Area required 3 hectares
(Assuming 500 mm dried depth accumulation yearly)

4.5 HYDRO-VAC WASTE PROJECTIONS

The 2012 haulage volumes to the mud pit almost doubled between 2011 and 2012. This may be a reflection of increased construction activity. Certainly, this magnitude of yearly increase cannot be expected to continue into the future. Future haulage volumes will also likely reflect the level of construction activity in the region.

4.6 HYDRO-VAC WASTE MANAGEMENT

4.6.1 Fort McMurray Wastewater Treatment Facility Mud Pit

The Municipality's Peter Jenkins indicated about \$300K was spent for desludging the mud pit in 2012. The Municipality brings in a contractor with an excavator which has about a 9 m reach from the bank of the mud pit. Solids in the middle of the mud pit cannot be reached by the excavator. Typically the mud pit fills completely each year so solids removal is required annually. The excavator loads dump trucks which deposit the concentrated slurry in the drying area adjacent/east of the mud pit. Excess water is also periodically pumped from the mud pit to lagoon Cell 6, then Cell 1, and returned for treatment in the plant.

Peter estimates that the drying area has space for only about 2 more years of solids; therefore, a longer term solution is required.

4.6.2 Waste Management Practices in Other Jurisdictions

To provide a preliminary understanding of other options that may be available for the Municipality to consider, we offer the following information:

Kennedale Yard, City of Edmonton: The City of Edmonton formerly operated a facility that would receive hydro-vac wastes as well as debris from cleaning out sewage lift stations. The facility served only City of Edmonton vehicles. The facility included a dump ramp where a truck could dump its load onto a sloped concrete pad which was heated during winter operation. Heating was achieved by a boiler, heat exchangers, and a glycol recirculation system throughout the concrete pad. The free water drained from the waste to a sump connected to a sanitary sewer. The remaining solids were moved to another area of the heated concrete pad with a bobcat to dry. The solids were periodically loaded into a truck for disposal at the City's landfill.

The City no longer uses this facility. One factor in the City's decision to close the facility may have been the City's concern about operator health risks when moving the mixed (sewage-contaminated) material with a bobcat. Another factor may have been high operating costs for the pad heating system.

The waste is now hauled to the Riley landfill.

Riley Landfill: AE contacted the Riley Landfill personnel who indicated:

- “Sludges go into our sludge pit to be solidified prior to landfilling which removes the free liquid allowing us to be able to landfill.”
- The Riley Landfill has two sludge pits, one for receiving the waste, the other for mixing the hydro-vac waste with wood chips and peat moss to solidify it all year round, regardless of extreme weather conditions. The solidified waste is then landfilled.
- Most hydro-vac service companies either reuse the waste on the client's land or transport it to facilities similar to those at the Riley Landfill. Although most hydro-vac waste is Class 2, the majority of their clients prefer to transport their waste to a facility like Riley's that can deal with Class 1 and 2 waste.

4.7 HYDRO-VAC WASTE – NEXT STEPS

The following summarizes suggested next steps for addressing the hydro-vac waste management issues at the FMWWTF:

1. Waste Characterization:
 - **Hydro-Vac Wastes:** Obtain 7 representative samples of wastes being deposited at the mud pit. Analyze the samples for % total solids concentration, metals scan, as well as previously analyzed constituents (Total Petroleum Hydrocarbons, Benzene, Toluene, Ethylbenzene, Xylene, pH, Flashpoint).

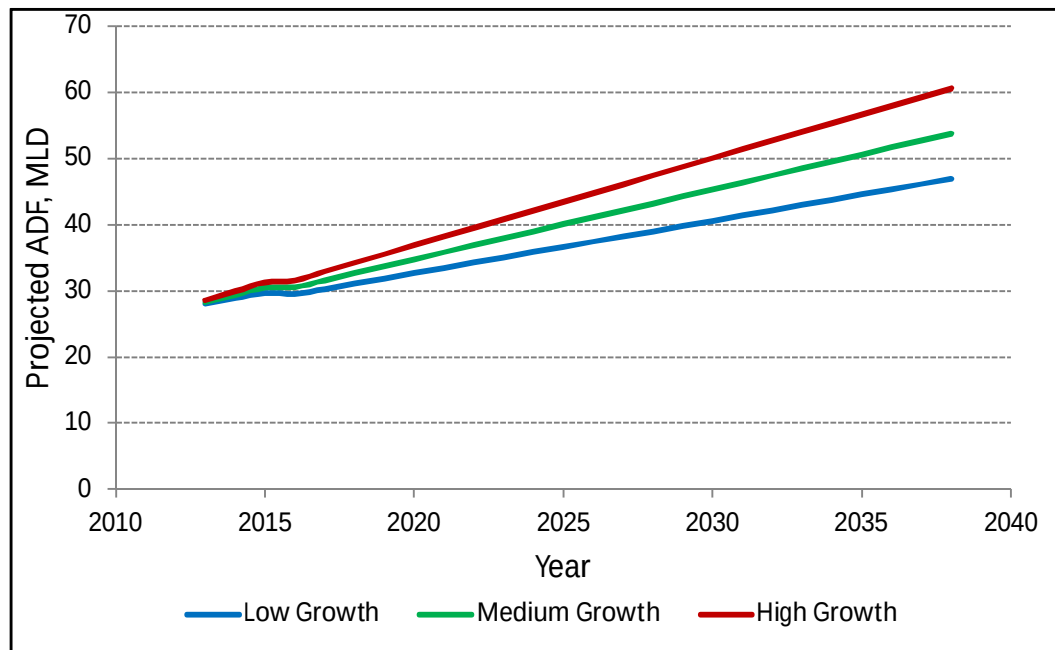
- **Mud Pit Wastes:** Repeat the above analyses for 7 samples of wastes being removed from the mud pit (following decanting of excess water).
 - **Dried Hydro-Vac Wastes:** Obtain another 7 samples of the hydro-vac wastes following natural drying. Repeat these analyses, plus a paint filter test.
 - **Decant Water Quality:** During decanting of the mud pit, obtain 3 representative samples of the decant water to determine its acceptability for subsequent return to the main FMWWTF for final treatment. Analyses tentatively to include: BOD, COD, TSS, pH, metals scan, TPH, and BTEX.
2. Disposed Options
- **Landfill Acceptance:** Provide data on dried hydro-vac waste to landfill operator for feedback on the acceptability of the material at the landfill.
 - **Facility Tours:** View firsthand the hydro-vac waste management practices at other Alberta facilities that accept hydro-vac wastes (Riley landfill and one other facility to be confirmed).
3. Conceptual Design
- **Conceptual Design Report:** Prepare a report summarizing the results of the above investigations with recommendations to address short-term and longer term hydro-vac waste management approaches at FMWWTF or at the landfill site.

5 Combined Piped and Septage Wastes

5.1 TOTAL LIQUID WASTE PROJECTIONS

Figure 5-1 shows the average day total piped and trucked septage projections for the Fort McMurray area, assuming that 40% of the septage is diverted to Anzac starting in 2015.

Figure 5-1
Fort McMurray WWTF Average Day Flow Projections



5.2 WASTE LOAD PROJECTIONS

Figure 5-2 shows the average day influent BOD load projections for Fort McMurray, along with the estimated impact of direct septage handling and low, medium, and high growth rates. Figure 5-3 shows the same types of projections for Total Suspended Solids (TSS).

Figure 5-2
Fort McMurray WWTF Average Day BOD Load Projections

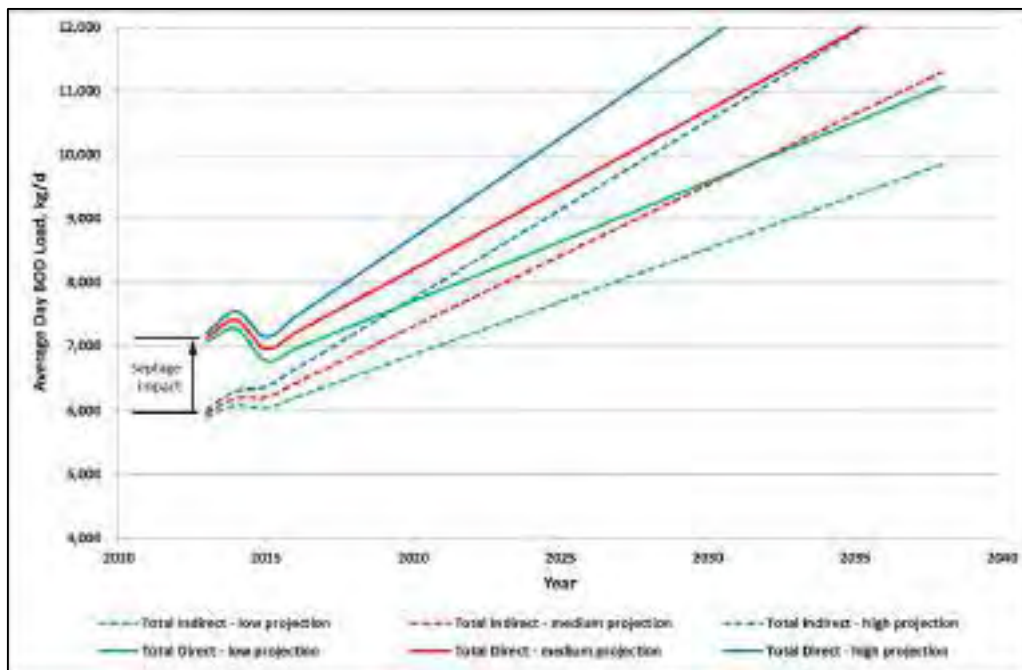
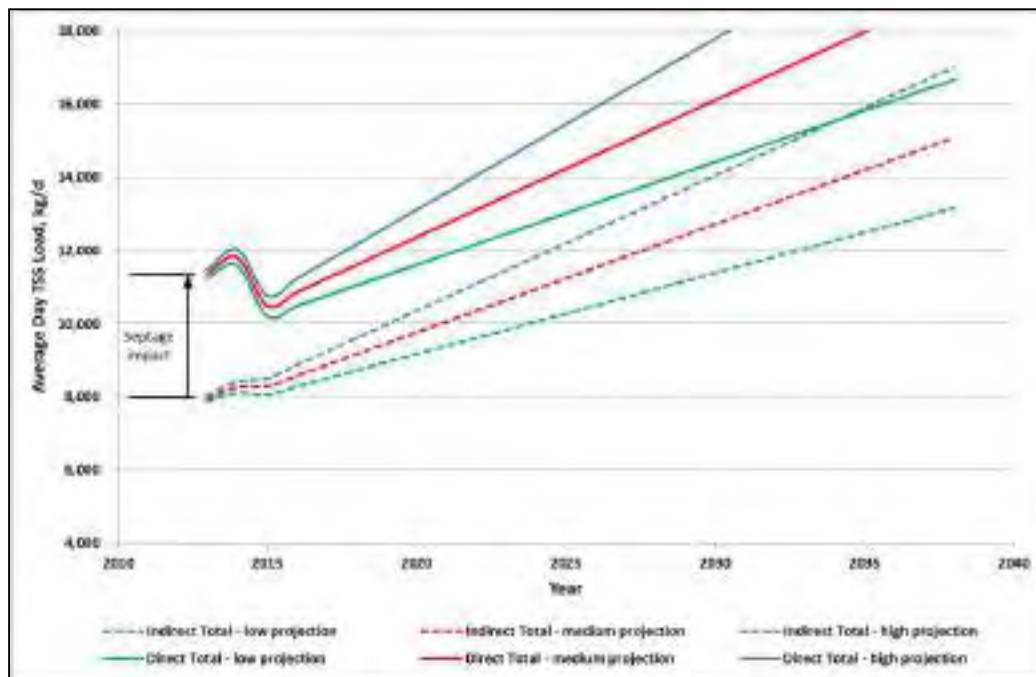


Figure 5-3
Fort McMurray WWTF Average Day TSS Load Projections



6 Summary

6.1 CONCLUSIONS

6.1.1 Piped System

1. **Piped Service Area:** Figure 2-1 illustrates the piped service areas for the north and south catchments.
2. **Population Projections:** The 2013 equivalent population in the Urban Development Sub-Region (UDSR) is estimated at 85,100 persons. The ultimate service population is estimated at approximately 352,000 persons (rounded up), split with 242,000 in the north catchment and 110,000 in the south.
3. **Population Growth Rates:** The range of population growth rates for planning purposes is Low – 3.0% annual linear increase; Medium – 4.0% annual linear increase; High - 5.0% annual linear increase.
4. **Piped Wastewater Flows:** The 2012 effluent flow monitoring data for the FMWWTF shows that the average day flow was around 25 MLD, including an estimated 3 MLD decanted water from the septage lagoons. The estimated flow based on ESS per capita wastewater generation plus septage decant is approximately 33 MLD, or about 30% greater. Therefore, there is either an error in the reported effluent flow data, or the ESS per capita generation values are too conservative for the existing developments.
5. **Wastewater Characteristics:** The 2012 piped influent wastewater concentrations were significantly weaker than the 2009 septage study concentrations. For example piped BOD averaged 207 mg/L whereas the septage BOD averaged 694 mg/L. Very little data is available on hydro-vac waste characteristics; therefore, more sampling and analysis would be desirable.
6. **SRWWTF Impact:** With a possible future SRWWTF, the flows and loads to the FMWWTF could be reduced by an estimated 15%. In the longer term (2038), the SRWWTF may handle an estimated 35% of the piped wastewater.
7. **Flow Peaks:** Based on 2010-2012 effluent flow data, the Maximum Day Flow: Average Day Flow ratio was approximately 2:1 and the treated effluent Peak Hour Flow: Average Day Flow ratio was approximately 3.1:1. Actual influent flow peaks may have been greater.

6.1.2 Septage

1. **Septage Service Area:** The FMWWTF currently receives septage from a wide area both north and south of the City. In the future, the Anzac and Conklin WWTFs will serve the south septage haulers. The FMWWTF will serve the north and some local septage haulers. A possible future SRWWTF could serve the remainder of the local septage haulers.
2. **Wastewater Loads:** Currently, the septage lagoons provide a buffer between the septage discharge and the main treatment facility. However, when the septage is blended directly with the piped wastewater in the near future, it appears that the loads will be much greater (e.g., perhaps 20% higher for BOD and more than 40% higher for TSS).

3. **Short-term Reduced Wastewater Volumes and Loads:** Once the Anzac and Conklin WWTFs are operational, the septage haul to the FMWWTF will initially be reduced by approximately 40%.
4. **Stand-alone North Septage Facility:** The construction of a stand-alone septage treatment facility in the vicinity of Fort McKay could reduce the septage loads on the FMWWTF by a further 50% (an estimated 10% of the total septage loads would then be treated at the FMWWTF).

6.1.3 Hydro-Vac Type Wastes

1. **Mud Pit Service Area:** The mud pit at the FMWWTF primarily services hydro-vac waste haulers. The service area currently is not known.
2. **Hydro-Vac Wastewater Quantities:** The estimated 2012 hydro-vac type wastewater volume totaled 90,700 m³. Assuming that the decanted portion of the wastes is approximately two-thirds of the deposited wastes, the return flow to the plant would be insignificant (<1% of plant flow), but the peak loading may be over 10% of the plant flow during return pumping.
3. **Hydro-Vac Waste Management:** The current mud pit and drying areas do not provide a sustainable solution.

6.2 RECOMMENDATIONS

6.2.1 Piped Wastewater

1. **Influent Flows:** Influent flows should be verified. The accuracy of the upgraded influent flow measurements should be compared relative to the effluent flow measurement on a daily basis. Also, additional checks should be made, e.g., influent wet well draw down tests and/or tank filling tests.
2. **Flow Projections:** Depending on the findings with respect to influent flows, future projections of wastewater flows should fully consider baseline per capita flow contributions which appear to be about 300 L/c/d, significantly less than the 360 L/c/d ESS value. Use of the ESS value should be restricted to individual new developments.

6.2.2 Septage

1. **Septage Characteristics:** More up-to-date septage characterization work should be undertaken in view of the significant loading contribution from septage. There may be a need to restrict high load septage haulers or require them to discharge to the septage lagoon to provide a treatment buffer if necessary.
2. **Impact of Direct Discharge:** The septage characterization work should also evaluate and compare direct septage discharges versus indirect discharge via the septage pond.
3. **Return Pumping:** The Operations Plan should recognize the additional hydraulic and constituent loads that are placed on the FMWWTF during return pumping from Cell 1.

6.2.3 Hydro-Vac Type Wastes

1. **Mud Pit Wastes:** Further study should be undertaken with the objective of developing a sustainable plan for managing these wastes. This should include:
 - Confirmation of Total Solids concentrations of the wastes being discharged, stored in the mud pit, and following drying;
 - Confirmation of the decant loads and the possible need to attenuate the return flows to the FMWWTF;
 - Review of sustainable options (e.g. landfilling and tour of other Alberta facilities); and
 - Preparation of a conceptual design report.

TECHNICAL MEMORANDUM A.1.3

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to define the service area for the wastewater treatment facility; confirm the existing and future population projections; define and confirm the existing influent waste stream flows and loads; develop influent waste stream flow and load projections; and review the existing mud pit waste management practices.

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.



Edith Asselin, M.Eng., P.Eng., LEED AP
Project Manager



Patrick W. Given, P.Eng.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF
Signature: 
Date: <u>FEB. 10 2014</u>
APEGA Permit to Practice P 3979

Appendix A – Septage Survey - March 4-8, 2013

RMWB FORT McMURRAY HAULED WASTE SURVEY

Date 2013 mm.dd.yy	Time^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin^b	Direction^c Nor S	Distance^d km	Waste Type^e	Comments^h
03.04.13	7:30	313	25	Ft. McKay	N	5	Domestic	
03.04.13	7:54	802	22	Brook Wood	S	40	Domestic	
03.04.13	8:00	859	18	Conklin	S	200	Camp	
03.04.13	8:01	871	12	Saprae Creek	S	19	Camp	
03.04.13	8:02	0.19	10	Carillion Hangingstone	S	29	Industrial	
03.04.13		0.19	10	Carillion Ft. McMurray	S	10	Industrial	
03.04.13		0.19	10	Cheechem Enbridge	S	35	Industrial	
03.04.13	8:03	522	30	Conklin	S	150	Industrial	
03.04.13	8:05	864	32	Meg (Conklin)	S	160	Industrial	
03.04.13	8:10	768	34	Suncor	N	20	Industrial	
03.04.13	8:12	814	34	Beaver Creek	S	25	Sludge	
03.04.13	8:15	264	22	Noralta Lodge	N	25	Domestic	
03.04.13	8:30	805	18	Voyager Hudson Lodge	N	27	Domestic	
03.04.13	9:43	781	34	Noralta Lodge	N	25	Camp	
03.04.13	10:50	694	10	Kirby Drilling	S	150	Camp	
03.04.13	10:54	0.98	20	Meg (Conklin)	S	300	Camp	
03.04.13	11:09	520	30	Suncor	N	40	Camp	
03.04.13	11:12	842	7	Bear Cat (Conklin)	S	200	Camp	
03.04.13	11:15	294	25	Connoco Phillips	S	190	Camp	
03.04.13	11:21	872	18	CNRL Kirby	S	115	Camp	
03.04.13	11:22	776	12	Suncor (Fort Hills)	N	80	Industrial	
03.04.13	11:23	264	25	Noralta Lodge	N	25	Camp	
03.04.13	11:25	539	13	Ft. McKay Industrial Park	N	40	Camp	
03.04.13	11:26	781	34	Noralta Lodge	N	25	Camp	
03.04.13	11:44	523	12	Jaco Camp	S	30	Camp	
03.04.13	11:50	157	25	Lewyk Park	N	20	Camp	
03.04.13	11:51	910	30	MRM Albion	N	58	Domestic	
03.04.13	12:51	34	28	Surmont Lodge	S	80	Camp	
03.04.13	12:52	0.27	25	Fire Bag	N	110	Camp	
03.04.13	12:53	824	10	Wilsons	N	1	Camp	
03.04.13	12:59	904	10	Great Divide Algar Camp	S	80	Camp	
03.04.13	13:06	0.19	10	Ruth Lake Mckay River	N	45	Camp	
03.04.13	13:07	139	13	Opco Lodge	N	150	Camp	
03.04.13	13:15	306	18	Thompson Brothers Camp	S	227	Camp	
03.04.13	13:22	859	18	Conklin	S	160	Camp	
03.04.13	13:23	313	25	Ft. McKay	N	25	Domestic	
03.04.13	13:31	377	10	Marianna Lake	S	85	Domestic	
03.04.13	13:32	897	34	Kearl Lake	N	160	Industrial	
03.04.13	13:36	900	24	Noralta Lodge	N	25	Camp	
03.04.13	13:38	869	5.5	Suncor	S	50	Camp	
03.04.13	13:40	911	28	Conklin	S	130	Camp	
03.04.13	13:49	912	20	Black Diamond	S	90	Camp	
03.04.13	13:50	913	25	MRM	N	58	Industrial	
03.04.13	14:03	264	23	Noralta Lodge	N	25	Camp	
03.04.13	14:08	851	1	A-1 Portables	Local	5	Car Wash	Clears Portables across town
03.04.13	14:11	522	30	Conklin	S	50	Camp	
03.04.13	14:12	803	25	Barge Landing	N	70	Camp	
03.04.13	14:13	871	12	Mckay River	N	50	Industrial	
03.04.13	14:14	824	10	Wilson Ameco	N	1	Camp	
03.04.13	14:19	781	25	Noralta Lodge	N	25	Camp	
03.04.13	14:24	427	8	E. Construction Office	N	1	Domestic	
03.04.13	14:25	894	12	Kearl Lake	S	150	Camp	
03.04.13	14:54	883	7	Telephone Lake	N	170	Camp	
03.04.13	14:55	338	17	Devon Jackfish	S	150	Camp	
03.04.13	15:04	0.9.0	24	Weldco Sewer	N	70	Industrial	10 different spots
03.04.13	15:05	905	30	Beaver Lodge	N	45	Sludge	
03.04.13	15:06	520	30	Suncor	N	30	Camp	
03.04.13	15:07	875	22	Creeburn Lodge	N	80	Camp	
03.04.13	15:10	0.68	11	Hwy 63 S	S	60	Camp	
03.04.13		0.68	11	Tower Rd Campground	Local	3	Camp	

Date 2013 mm.dd.yy	Time ^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin ^b	Direction ^c Nor S	Distance ^d km	Waste Type ^e	Comments ^h
03.04.13	15:12	864	30	Meg Energy	S	160	Camp	
03.04.13	15:15	377	10	A-1 Portables	N	10	Car Wash	Clears Portables across town
03.04.13	15:32	888	32	Devon JackFish	S	156	Camp	
03.04.13	15:39	909	23	Oil Sands Lodge	N	80	Camp	
03.04.13	15:50	701	10	Meg Energy	S	120	Camp	
03.04.13	15:56	900	24	Noralta Lodge	N	25	Camp	
03.04.13	16:02	768	34	Suncor	N	20	Industrial	
03.04.13	16:03	344	28	D Upper Conklin	S	160	Camp	
03.04.13	16:18	543	30	Lake Side	N	50	Camp	
03.04.13	16:20	904	11	Algar Neat Divine	S	80	Camp	
03.04.13	16:24	264	23	Noralta Lodge	N	23	Camp	
03.05.13	8:15	523	12	Brook Wood	S	50	Commercial	
03.05.13	8:19	786	15	Ledcor OJ Pipeline	S	20	Commercial	A-1 Portables
03.05.13	8:24	894	15	Sherby Camp	S	200	Commercial	
03.05.13	8:33	878	22	Barge Landing	N	55	Commercial	Camp
03.05.13	8:35	781	34	Noralta Lodge	N	25	Camp	
03.05.13	8:37	522	30	Conklin	S	150	Commercial	
03.05.13	8:42	514	13	SMS	N	30	Commercial	
03.05.13	8:51	389	2	Nexen	S	65	Commercial	
03.05.13	8:53	803	25	Barge Landing	N	65	Commercial	
03.05.13	8:54	885	27	IPF	S	200	Industrial	
03.05.13	8:57	805	18	Hudson Lodge	N	54	Camp	
03.05.13	8:59	871	12	Saprae Creek	S	20	Domestic	
03.05.13	9:03	900	24	Noralta Lodge	N	25	Camp	
03.05.13	9:05	802	22	Brook Wood	S	46	Commercial	
03.05.13	9:28	814	34	Beaver Lodge	N	25	Commercial	
03.05.13	9:33	0.54	15	Lesherer	S	206	Camp	
03.05.13	9:35	888	31	Devon Jackfish	S	156	Camp	
03.05.13	9:45	786	6	Inland	S	1	Commercial	
03.05.13	10:02	832	30	Meg Energy	S	150	Industrial	
03.05.13	10:03	912	20	Black Diamond	S	90	Commercial	
03.05.13	10:06	781	34	Noralta Lodge	N	25	Camp	
03.05.13	10:28	824	8	Tyco	N	1	Commercial	
03.05.13	10:34	370	8	Landfill	S	12	Commercial	
03.05.13	10:35	311	30	Conklin	S	200	Commercial	
03.05.13	10:37	455	10	Telephone Lake	N	240	Camp	
03.05.13	10:38	872	17	CNRL Kirby	N	135	Camp	
03.05.13	10:55	520	30	Epcor	N	30	Camp	
03.05.13	10:57	803	25	Barge Landing	N	65	Camp	
03.05.13	11:03	831	15	Kirby	S	149	Camp	
03.05.13	11:14	306	18	Poplar Creek	N	31	Camp	
03.05.13	11:18	900	24	Noralta Lodge	N	25	Camp	
03.05.13	11:23	0.68	8	Conklin	S	160	Camp	
03.05.13	11:31	523	12	Dover	N	50	Camp	
03.05.13	11:39	514	12	Williams Energy	N	30	Industrial	
03.05.13	11:42	776	11	Suncor (Fort Hills)	N	80	Industrial	
03.05.13	11:46	612	30	Shell	N	120	Industrial	
03.05.13	11:50	694	2	Site Energy	S	160	Industrial	
03.05.13	11:57	764	1	Husky Oil	N	110	Commercial	
03.05.13	12:11	856	10	BB	S	70	Camp	
03.05.13	12:13	313	25	Ft. McKay	N	70	Lagoon	Hauling from a RMWB Lagoon
03.05.13	12:18	418	12	Ruth Lake	N	40	Camp	
03.05.13	12:23	331	13	Horizon	N	40	Camp	
03.05.13	12:28	404	6	Tyran	N	60	Camp	
03.05.13	12:29	768	34	Suncor	N	40	Industrial	
03.05.13	12:38	324	2	Taiganova	N	1	Commercial	
03.05.13	12:45	139	13	Opco Lodge	N	82	Camp	
03.05.13	12:56	875	22	Barge Landing	N	55	Camp	
03.05.13	12:58	404	25	Fire Bag	N	110	Camp	
03.05.13	13:00	164	1	Premier Towing	S	10	Industrial	
03.05.13	14:55	913	20	Shell	N	75	Industrial	
03.05.13	15:00	871	12	McKay River	N	40	Industrial	

Date 2013 mm.dd.yy	Time ^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin ^b	Direction ^c Nor S	Distance ^d km	Waste Type ^e	Comments ^h
03.05.13	15:04	875	22	Barge Lodge	N	55	Camp	
03.05.13	15:15	370	8	Landfill	S	26	Industrial	
03.05.13	15:17	612	30	Shell Jackpine	N	80	Industrial	
03.05.13	15:26	0.34	26	Surmont Lodge	S	150	Camp	
03.05.13	15:33	551	25	Husky	N	100	Camp	
03.05.13	15:36	803	25	Barge Landing	N	65	Camp	
03.05.13	15:38	369	23	Noralta Lodge	N	25	Camp	
03.05.13	15:40	909	23	Oil Sands Lodge	N	65	Camp	
03.05.13	15:43	313	25	RMWB Septic Lagoon	N	70	Lagoon	
03.05.13	15:46	832	20	Meg	S	150	Camp	
03.05.13	15:48	701	10	Meg	S	150	Camp	
03.05.13	15:51	872	18	Elite Camp	S	150	Camp	
03.05.13	15:54	694	10	North Gate	S	227	Camp	
03.05.13	16:00	331	10	Horizon North	N	40	Camp	
03.05.13	16:07	871	3	Water Treatment Bird	S	4	Industrial	
03.06.13	8:02	803	25	Barge Landing	N	65	Camp	
03.06.13	8:03	875	22	Barge Landing	N	65	Camp	
03.06.13	8:04	900	24	Noralta Lodge	N	25	Camp	
03.06.13	8:10	915	24	Noralta Lodge	N	27	Camp	
03.06.13	8:13	843	28	Conklin	S	163	Camp	
03.06.13	8:19	802	22	Brook Wood	S	40	Camp	
03.06.13	8:24	851	1	Around Town	Local		Domestic	Clears Portables across town
03.06.13	8:30	340	28	Conklin	S	160	Camp	
03.06.13	8:33	389	2	Jaco Camp	S	40	Domestic	
03.06.13	8:41	805	18	Voyager Lodge	N	27	Camp	
03.06.13	8:45	369	23	Noralta Lodge	N	25	Camp	
03.06.13	8:48	824	10	Sun Trucking	N	26	Camp	
03.06.13	8:49	776	11	L Roberts Shop	N	40	Commercial	
03.06.13	8:50	864	32	Meg Energy	S	160	Camp	
03.06.13	8:56	885	27	Conklin	S	200	Camp	
03.06.13	9:07	0.98	20	Meg Energy	S	200	Camp	
03.06.13	9:08	0.34	26	Surmont Lodge	S	78	Camp	
03.06.13	9:10	344	30	Conklin	S	150	Camp	
03.06.13	9:11	909	22	Oil Sands Lodge	N	93	Camp	
03.06.13	9:34	842	4	Mcdonald Island	S	4	Industrial	
03.06.13	10:25	918	32	Devon Jackfish	S	156	Camp	
03.06.13	10:35	747	11	Suncor (Fort Hills)	N	80	Industrial	
03.06.13	10:45	872	18	Elite Camp	S	150	Camp	
03.06.13	10:50	157	26	Lewyt Park	N	24	Domestic	
03.06.13	11:16	520	30	Suncor	N	30	Camp	
03.06.13	11:19	899	6	AOC Dover	N	150	Camp	
03.06.13	11:20	824	10	Gear Center	S	7	Industrial	
03.06.13	11:21	860	13	Ft. McKay Industrial	N	40	Commercial	
03.06.13	11:22	694/420	9	Nabourns 59	S	149	Camp	
03.06.13	11:40	524	0.25	Around Town	Local		Domestic	A-1 Portables
03.06.13	11:42	831	20	Western Camp	S	240	Camp	
03.06.13	11:46	913	25	MRM	N	80	Industrial	
03.06.13	11:50	912	20	Black Diamond	S	90	Camp	
03.06.13	11:51	313	25	Fort McKay	N	70	Domestic	
03.06.13	11:55	802	22	Brook Wood	S	45	Camp	
03.06.13	14:01	157	12	Lewyt Park	N	24	Camp	
03.06.13	14:02	340	28	Conklin	S	150	Camp	
03.06.13	14:08	919	34	Kearl Lake	N	120	Camp	
03.06.13	14:10	803	25	Barge Landing	N	65	Camp	
03.06.13	14:21	864	32	Meg Energy	S	160	Camp	
03.06.13	14:23	768	34	Suncor	N	30	Commercial	
03.06.13	14:26	871	6	Ft. McKay Industrial Park	N	60	Industrial	
03.06.13	14:29	313	25	Ft. McKay	N	70	Domestic	
03.06.13	14:30	404	25	Fire Bag	N	110	Industrial	
03.06.13	14:32	842	12	Tower Rd Campground	Local	5	Domestic	
03.06.13	14:41	520	30	Suncor	N	30	Camp	
03.06.13	14:53	551	20	IRG Baseline	N	45	Camp	

Date 2013 mm.dd.yy	Time ^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin ^b	Direction ^c Nor S	Distance ^d km	Waste Type ^e	Comments ^h
03.06.13	15:09	306	20	Marianna Lake	S	261	Camp	
03.06.13	15:15	0.34	26	Surmont Lodge	S	78	Camp	
03.06.13	15:17	915	24	Noralta Lodge	N	25	Camp	
03.06.13	15:18	802	22	Brook Wood	S	45	Camp	
03.06.13	15:19	369	23	Noralta Lodge	N	25	Camp	
03.06.13	15:21	799	13	Sleep Bank	N	100	Camp	
03.06.13	15:22	338	18	Devon Jackfish	S	160	Camp	
03.06.13	15:23	912	20	Black Diamond	S	90	Camp	
03.06.13	15:23	888	32	Devon Jackfish	S	150	Camp	
03.06.13	15:24	913	25	MRM Industrial	N	85	Industrial	
03.06.13	15:25	824	10	Valard Camp	N	100	Camp	
03.06.13	15:52	691/077	6	Conklin Community	S	200	Domestic	
03.06.13	15:54	909	22	Oil Sands Lodge	N	43	Camp	
03.06.13	16:00	311	27	Conklin	S	350	Camp	
03.06.13	16:02	900	24	Noralta Lodge	N	27	Camp	
03.06.13	16:04	904	10	Great Divide Camp	S	80	Camp	
03.07.13	8:25	514	13	SMS	N	30	Industrial	
03.07.13	8:40	0.34	26	Surmont Lodge	S	80	Camp	
03.07.13	8:46	911	27	BNL Yard	S	140	Industrial	
03.07.13	8:48	885	27	Conklin (ITF Camp)	S	200	Camp	
03.07.13	8:50	802	22	Brook Wood	S	45	Camp	
03.07.13	9:11	768	31	Suncor	N	45	Industrial	
03.07.13	9:13	915	24	Noralta Lodge	N	25	Camp	
03.07.13	9:15	880	10	Conklin	S	130	Industrial	
03.07.13	9:17	864	30	Meg	S	130	Industrial	
03.07.13	9:19	370	6	South East Pump House	S	45	RMWB Industrial	
03.07.13	9:26	588	32	Devon Jackfish	S	150	Camp	
03.07.13	9:28	918	32	Devon Jackfish	S	150	Camp	
03.07.13	9:29	871	10	Suncor Petro Canada	N	60	Industrial	
03.07.13	9:38	824	10	Black Diamond	S	80	Camp	
03.07.13	9:43	369	23	Noralta Lodge	N	25	Camp	
03.07.13	9:44	832	30	Meg Energy	S	160	Camp	
03.07.13	9:46	900	24	Noralta Lodge	N	25	Camp	
03.07.13	9:48	340	28	Dipper	S	160	Camp	
03.07.13	9:50	909	20	Oil Sands Lodge	N	30	Camp	
03.07.13	9:51	344	25	Pll	S	152	Camp	
03.07.13	9:53	894	18	Kirby	S	120	Camp	
03.07.13	10:44	311	27	Cenovus	S	120	Camp	
03.07.13	10:47	551	25	Dipper	S	160	Camp	
03.07.13	10:49	805	18	Suncor (Voyager)	N	25	Camp	
03.07.13	10:52	0.54	15	Nexen	S	60	Camp	
03.07.13	11:03	903	30	Jack Pine Shell	N	75	Industrial	
03.07.13	11:18	520	30	Epcor	N	25	Camp	
03.07.13	11:22	747	12	Fort Hills	N	80	Industrial	
03.07.13	11:24	915	24	Noralta Lodge	N	25	Camp	
03.07.13	11:31	894	18	BNL Yard	S	130	Camp	
03.07.13	11:47	103	6	Barakat	S	150	Industrial	
03.07.13	13:36	903	26	Liebher	N	70	Industrial	
03.07.13	13:40	915	24	Noralta Lodge	N	25	Camp	
03.07.13	14:00	514	13	Williams Energy	N	30	Industrial	
03.07.13	14:09	847	28	Wood Hills	S	140	Camp	
03.07.13	14:28	912	22	Black Diamond	S	90	Camp	
03.07.13	14:31	918	32	Jack Fish	S	156	Camp	
03.07.13	14:33	0.34	26	Surmont Lodge	S	80	Camp	
03.07.13	14:43	524	2	Mckay River	N	100	Industrial	
03.07.13	14:45	869	6	Suncor	S	40	Camp	
03.07.13	14:47	540	5	Predator 16	N	80	Camp	
03.07.13	14:50	864	20	Meg Energy	S	140	Camp	
03.07.13	14:52	803	25	Barge Landing	N	65	Camp	
03.07.13	14:55	0.54	15	Nexen	S	60	Camp	
03.07.13	15:10	880	10	Cenova	S	130	Industrial	
03.07.13	15:18	514	13	SMS	N	30	Industrial	

Date 2013 mm.dd.yy	Time ^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin ^b	Direction ^c Nor S	Distance ^d km	Waste Type ^e	Comments ^h
03.07.13	15:20	905	22	Suncor	N	25	Camp	
03.07.13	15:22	871	10	Ft. McKay Industrial Park	N	45	Industrial	
03.07.13	15:25	799	12	Cenova	N	180	Camp	
03.07.13	15:27	520	30	Epcor	N	25	Camp	
03.07.13	15:29	340	28	PTI	S	160	Camp	
03.07.13	15:30	0.93	15	CN Rail	S	60	Camp	
03.07.13	15:32	875	42	Barge Landing	N	55	Camp	
03.07.13	15:33	338	22	Jack Fish	S	150	Camp	
03.07.13	15:35	832	30	Meg	S	115	Camp	
03.07.13	15:36	915	24	Noralta Lodge	N	25	Camp	
03.07.13	15:37	768	33	Suncor	N	35	Industrial	
03.07.13	15:38	842	12	Prairie North	N	60	Camp	
03.07.13	15:43	824	10	Black Diamond	S	80	Camp	
03.07.13	15:47	551	20	Suncor	N	654	Camp	
03.07.13	16:01	909	20	Oil Sands Lodge	N	35	Camp	
03.07.13	16:03	139	12	Horizon North Camp	N	80	Camp	
03.08.13	8:25	905	34	Beaver Lodge	N	45	Industrial	
03.08.13	8:27	909	20	Oil Sands Lodge	N	35	Camp	
03.08.13	8:29	344	25	Conklin	S	150	Domestic	
03.08.13	8:31	802	22	Brook Wood	S	45	Camp	
03.08.13	8:35	915	24	Noralta Lodge	N	25	Camp	
03.08.13	8:37	885	27	South Conklin	S	200	Camp	
03.08.13	8:38	864	20	Meg Energy	S	140	Camp	
03.08.13	8:39	832	32	Meg Energy	S	197	Camp	
03.08.13	8:40	0.34	26	Surmont Lodge	S	80	Camp	
03.08.13	8:42	900	24	Noralta Lodge	N	25	Camp	
03.08.13	8:43	340	28	Conklin	S	150	Camp	
03.08.13	8:47	612	30	Mran	N	85	Industrial	
03.08.13	9:00	914	31	Nexen	S	60	Industrial	
03.08.13	9:13	768	35	Suncor	N	25	Industrial	
03.08.13	9:14	369	23	Noralta Lodge	N	25	Camp	
03.08.13	9:15	805	18	Voyager	N	25	Camp	
03.08.13	9:16	880	10	Conklin	S	130	Camp	
03.08.13	9:17	469	8	Sand Tiger	S	50	Camp	
03.08.13	9:33	0.27	25	Beaver Lodge	N	40	Industrial	
03.08.13	9:44	0.19	10	LRG Camp	N	50	Camp	
03.08.13	9:49	916	32	Devon Jackfish	S	156	Camp	
03.08.13	9:52	139	12	Dover	N	80	Camp	
03.08.13	9:55	539	13	Ft. McKay	N	40	Industrial	
03.08.13	9:57	803	25	Barge	N	65	Camp	
03.08.13	9:58	875	22	Barge	N	65	Camp	
03.08.13	9:59	912	20	Black Diamond	S	90	Camp	
03.08.13	10:01	311	27	Conklin	S	300	Camp	
03.08.13	10:18	859	16	CNRL Kirby	S	200	Camp	
03.08.13	10:20	520	30	Suncor	N	30	Industrial	
03.08.13	10:28	856	10	BB Come	N	50	Camp	
03.08.13	10:30	871	6	Suncor	N	30	Industrial	
03.08.13	10:36	747	11	Ft. Hills	N	80	Industrial	
03.08.13	10:41	694	10	Conklin	S	180	Camp	
03.08.13	10:49	107	25	Lewyt Park	N	28	Domestic	
03.08.13	10:50	103	3	Dover	N	60	Industrial	
03.08.13	11:26	900	24	Noralta Lodge	N	27	Camp	
03.08.13	11:35	0.31	20	North Gate	S	217	Camp	
03.08.13	11:40	845	1	All Over	Local		Domestic	Clears Portables across town
03.08.13	11:44	389	2	Surmont 2	S	60	Domestic	
03.08.13	11:45	869	2	Suncor	s	40	Camp	
03.08.13	12:00	909	20	Oil Sands Lodge	N	35	Camp	
03.08.13	12:05	612	30	Albian Sands	S	80	Industrial	
03.08.13	12:15	3767	10	All Over	Local		Domestic	A-1 Portables
03.08.13	12:18	802	22	Brook Wood	S	45	Camp	
03.08.13	12:24	540	5	Ft. Mckay	N	140	Domestic	
03.08.13	12:35	842	12	Conklin	S	170	Camp	

Date 2013 mm.dd.yy	Time ^a hh:mm	Truck ID RFID#	Truck Size m ³	Waste Origin ^b	Direction ^c Nor S	Distance ^d km	Waste Type ^e	Comments ^h
03.08.13	12:42	833	26	Conklin	S	150	Camp	
03.08.13	12:45	331	14	Horizon North	N	40	Domestic	
03.08.13	12:48	875	22	Barge	N	65	Camp	
03.08.13	12:56	768	35	Suncor	N	25	Industrial	
03.08.13	12:57	369	23	Noralta Lodge	N	25	Camp	
03.08.13	13:00	793	25	Fire Bag	N	110	Industrial	
03.08.13	13:05	843	28	Conklin	S	170	Camp	
03.08.13	13:08	103	12	Saprae Creek	S	20	Industrial	
03.08.13	13:28	914	32	Nexen	S	60	Industrial	
03.08.13	13:42	157	11	Lewyt Park	N	28	Domestic	
03.08.13	13:48	294	25	RMWB Septic Lagoon	N	70	Domestic	
03.08.13	14:11	344	25	Conklin	S	152	Domestic	
03.08.13	14:21	832	32	Meg	S	172	Camp	
03.08.13	14:23	900	24	Noralta Lodge	N	25	Camp	
03.08.13	14:25	0.19	10	Enbridge Cheechum	S	140	Industrial	
03.08.13	14:32	912	20	Black Diamond	S	90	Camp	
03.08.13	14:34	909	15	Oil Sands Lodge	N	35	Camp	
03.08.13	14:39	864	22	Meg Energy	S	120	Camp	
03.08.13	14:45	306	20	Poplar Creek	N	31	Camp	
03.08.13	14:46	803	25	Barge	N	65	Camp	
03.08.13	14:47	805	18	Voyager	N	27	Camp	
03.08.13	14:49	875	22	Barge	N	65	Camp	
03.08.13	14:58	340	28	Conklin	S	160	Domestic	
03.08.13	15:04	0.34	26	Surmont	S	80	Camp	
03.08.13	15:10	139	12	Dover	N	80	Camp	
03.08.13	15:14	369	23	Noralta Lodge	N	25	Camp	
03.08.13	15:16	859	18	Elite Camp	S	150	Camp	
03.08.13	15:18	905	30	Beaver Lodge	N	40	Industrial	
03.08.13	15:25	694	10	North Gate	N	100	Camp	
03.08.13	15:35	455	20	Telephone Lake	N	240	Camp	
03.08.13	15:41	880	10	Conklin	S	130	Camp	
03.08.13	15:45	338	20	Conklin	S	150	Camp	
03.08.13	15:48	831	20	North Gate	N	120	Camp	
03.08.13	15:58	103	12	Prairie North	S	60	Camp	
03.08.13	16:10	919	34	Beaver Lodge	N	49	Industrial	

Summary

Date	# Truck - Local	# Trucks - N	# Trucks - S	Volume - Local	Volume - N	Volume - S	Total Count	Total Volume
03.04.13	2	36	32	12	803	589	70	1,404
03.05.13	-	39	27	-	769	406	66	1,175
03.06.13	3	32	28	13	667	591	63	1,271
03.07.13	-	30	32	-	604	678	62	1,282
03.08.13	<u>2</u>	<u>43</u>	<u>36</u>	<u>11</u>	<u>877</u>	<u>743</u>	<u>81</u>	<u>1,631</u>
Total	7	180	155	36	3,720	3,007	342	6,763

TECHNICAL MEMORANDUM A.1.5

Regional Municipality of Wood Buffalo

Urban Development Sub-Region Population Projection



September 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE

The main objective of the Technical Memorandum A1.5, Population Projections, is to clearly define:

- Future growth areas;
- Ultimate population projection for the full development of the growth areas;
- Annual population growth rates for the region; and
- 25 year population projection.

Population projections are vital for the wastewater master plan in order to check the capacity of the existing infrastructure and to plan for future wastewater infrastructure necessary for residential and commercial/industrial populations.

2 MAIN FINDINGS

To determine future growth areas and populations for the urban development sub-region (UDSR), Associated Engineering (AE) reviewed several historical and recent documents, including:

- 2010 and 2012 Municipal Census Data
- Fringe Area Development Assessment, Urban Service Area – March, 2007
- Water Master Plan (WMP) – November, 2011
- Airport Servicing Study – December, 2011
- Mackenzie Diversion Project – ongoing, May, 2013
- Development Charge Update – ongoing, May, 2013
- Regional Structure Action Strategy (RSAS) Population Forecasts – ongoing, October, 2013

The 2013 equivalent population for the UDSR, inclusive of residential and commercial/industrial population, is estimated to be 85,100 people, based upon 2012 census data and documents reviewed. The ultimate population for the UDSR, after full development of the development areas, is estimated to be 351,150 people.

To determine the population of the region in the next 25 years, AE evaluated the historical population growth range. Based upon historical growth trends in the region, 3.0%, 4.0%, and 5.0% linear annual population growth increases were applied to the 2013 equivalent population. In 25 years the equivalent population of the UDSR is estimated to range between 148,900 and 191,500. AE compared this range to the recent population forecast completed by the RSAS group and determined that the growth ranges were of similar magnitude.

AE reviewed the ultimate and 25 year equivalent population projections with the Municipality during the Workshop on November 18, 2013. During this workshop, the Municipality agreed to adopt the projections completed for the remaining wastewater master plan work.

3 RECOMMENDATIONS

AE recommends for the population projections outlined in this Technical Memo to be adopted for the analysis necessary in the wastewater master plan.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	iv
List of Figures	v
1 Introduction	1
2 Ultimate Service Areas	1
3 Population Projections	9
3.1 Actual Population	9
3.2 Ultimate Population Projections	10
3.3 25 Year Equivalent Population Projections	13
4 Recommendation	22
Closure	
Appendix A – Development Population Growth	

List of Tables

	PAGE NO.
Table 2-1 North and South Ultimate Catchment Areas	1
Table 3-1 Historical Municipal Census Populations*	9
Table 3-2 2012 Municipal Census Data within the UDSR	10
Table 3-3 Ultimate Population Projections for UDSR	11
Table 3-4 Ultimate Population Projections for UDSR	12
Table 3-5 North and South Population Splits	16
Table 3-6 25 Year UDSR Population Growth Range	19

List of Figures

		PAGE NO.
Figure 2-1	UDSR Population Projection Catchment Areas	3
Figure 2-2	UDSR Population Projection North Catchment Area	5
Figure 2-3	UDSR Population Projection South Catchment Area	7
Figure 3-1	UDSR Population Projections	14
Figure 3-2	UDSR Population Projection Development Areas	17
Figure 3-3	WWMP vs. RSAS Residential Population Projections	21

1 Introduction

Associated Engineering is working on several long term planning projects with the Regional Municipality of Wood Buffalo (the Municipality). To properly project future infrastructure needs, it is important to have a clear understanding of the future growth areas and populations within the region. With this, AE has created a brief technical memorandum (Tech Memo) outlining:

- Future growth areas;
- Ultimate population projections for full development of growth areas;
- Annual population growth rates; and
- 25 year population projections.

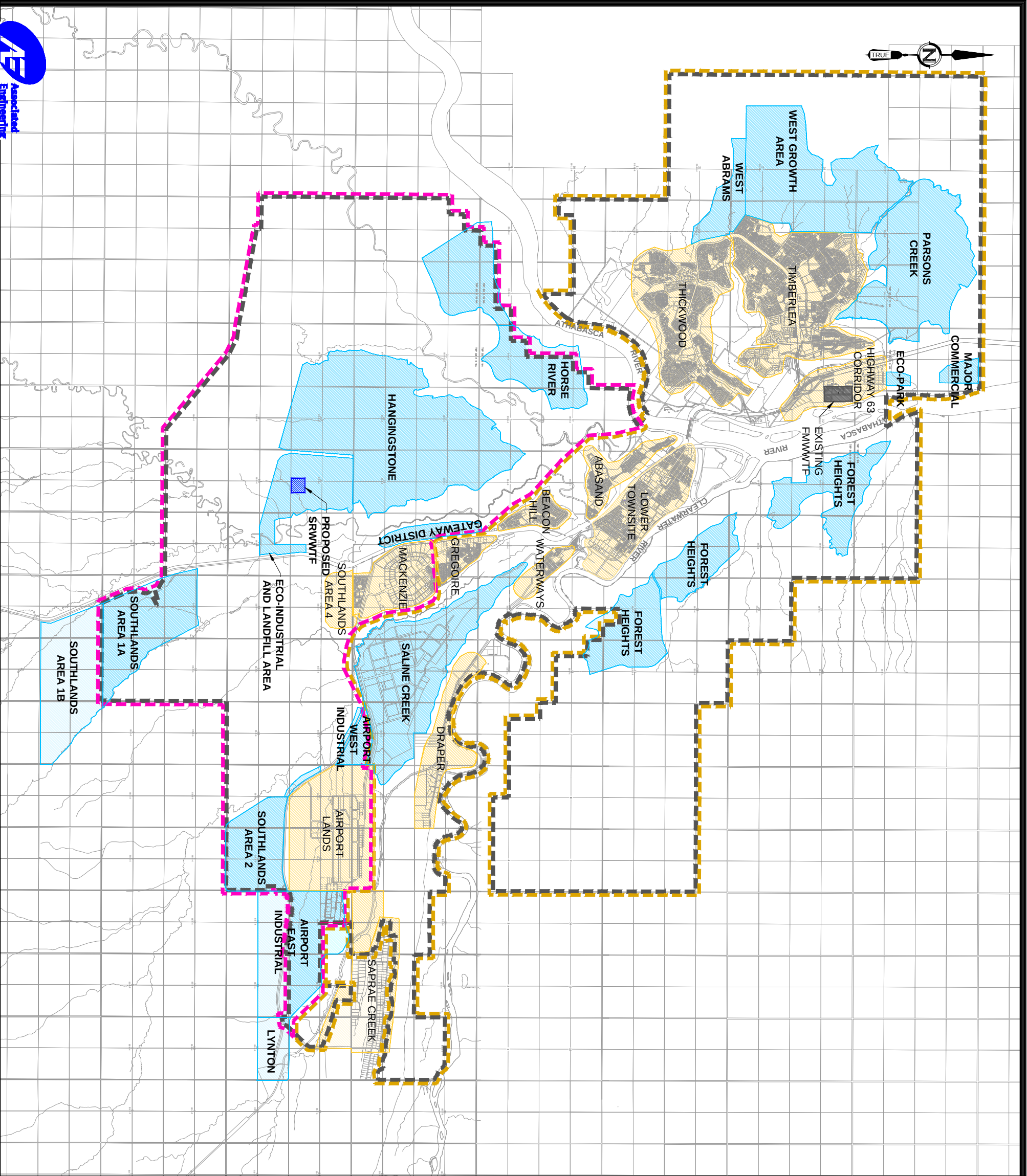
2 Ultimate Service Areas

The ultimate service area is defined by the proposed Urban Development Sub-Region (UDSR), which was created by the Oil Sands Secretariat and Alberta Environment and Sustainable Resource Development (AESRD). Figure 2-1 illustrates the proposed UDSR boundary, as well as the existing and future development areas for the region. The developments, within the UDSR, are highlighted as two different catchment areas: north and south. The north and south areas have been pre-defined in previous work completed. The two catchments have been defined for water and wastewater infrastructure planning. Figures 2-2 and 2-3 illustrate the existing and future development areas for the proposed north and south catchments, respectively. A summary of the ultimate residential (R) and commercial/industrial (C/I) developments associated with each of the catchments is provided in Table 2-1.

Table 2-1
North and South Ultimate Catchment Areas

North Development Area	Gross Area (ha)	South Development Area	Gross Area (ha)
R: Lower Townsite	439	R: Prairie Creek	25
R: Waterways	86	R: Hangingstone	1,553
R: Draper Valley	293	R: Horse River	678
R: Abasand	176	C/I: Airport East Industrial Lands+ Lynton	760
R: Beacon Hill	100	C/I: Southlands Area 1A	470
R: Gregoire (mixed use)	108	C/I: Southlands Area 1B	530
R: Saline Creek	860	C/I: Southlands Area 2	320
R: Sapræ Creek/Spruce Valley	552	C/I: Southlands Area 4	218
R: Timberlea	1,001	C/I: Airport West Industrial	70
R: Thickwood	771	C/I: Airport Lands	668
R: Parson's Creek	837	C/I: Mackenzie	295
R: West Growth	1,061	C/I: Gateway + Quarry Ridge	38
R: Forest Heights	924		
C/I: Highway 63 Corridor	322		

Within the north and south catchments, there are two areas that appear discretionary as to which catchment area they are included. Depending on the staging of their development, these areas may be switched between the north and south catchments. The areas which may be deemed discretionary include the Airport West Industrial and the Airport Lands areas. The Mackenzie, Prairie Creek, Gateway, and Quarry Ridge areas are listed in the south catchment area, even though they are currently situated in the north catchment. These areas are currently listed in the south assuming that flows will be diverted to ensure a stable base flow to the future South Regional Wastewater Treatment Facility (SRWWTF) at start-up.



REGIONAL MUNICIPALITY
OF WOOD BUFFALO

UDSR POPULATION PROJECTION

CATCHMENT AREAS

LEGEND:

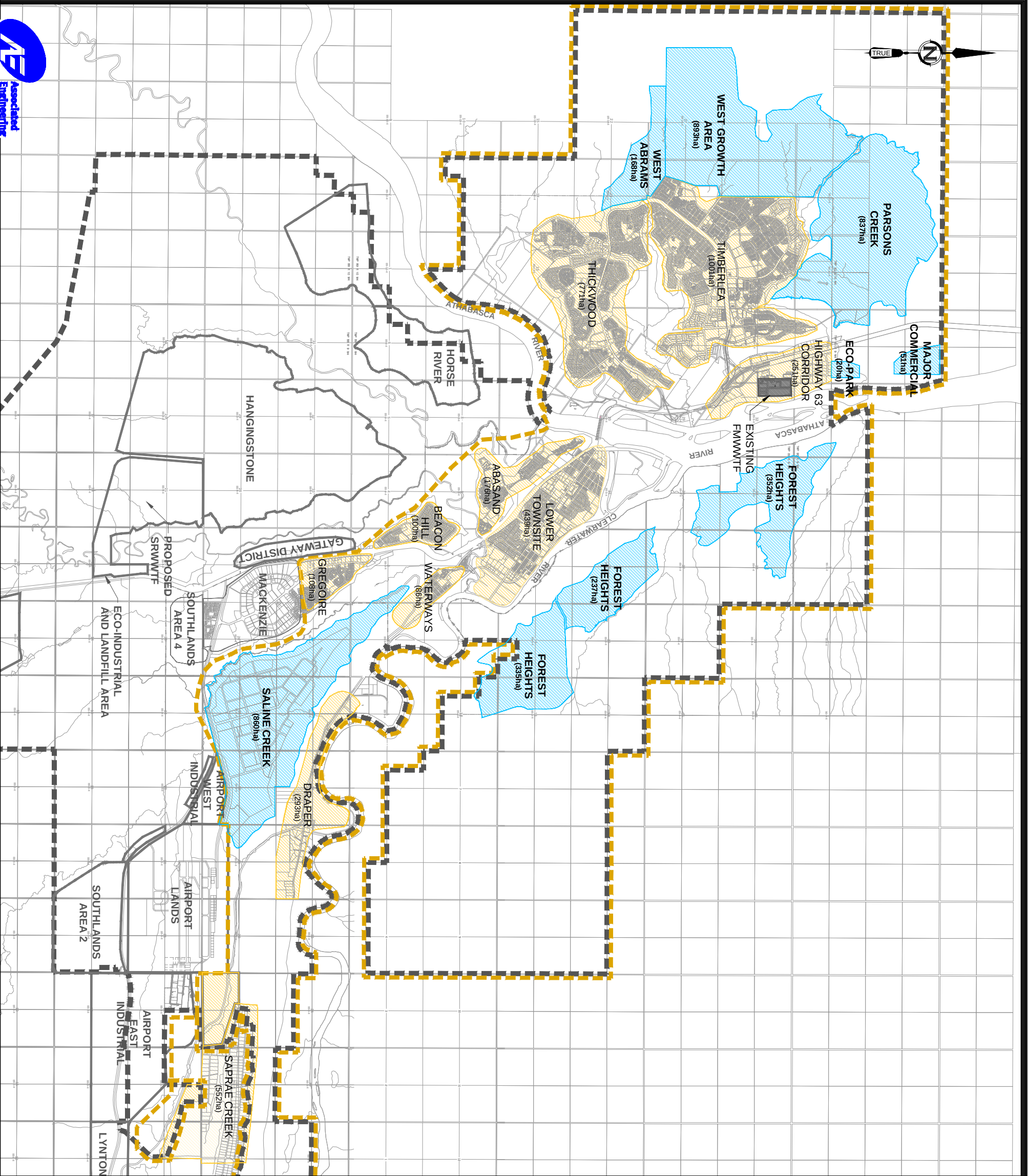
- SOUTH CATCHMENT BOUNDARY
- NORTH CATCHMENT BOUNDARY
- AESRD URBAN DEVELOPMENT
- SUB-REGION (UDSR)

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS OUTSIDE OF UDSDR

SCALE: 1:100,000

JANUARY, 2014



UDSR POPULATION PROJECTION

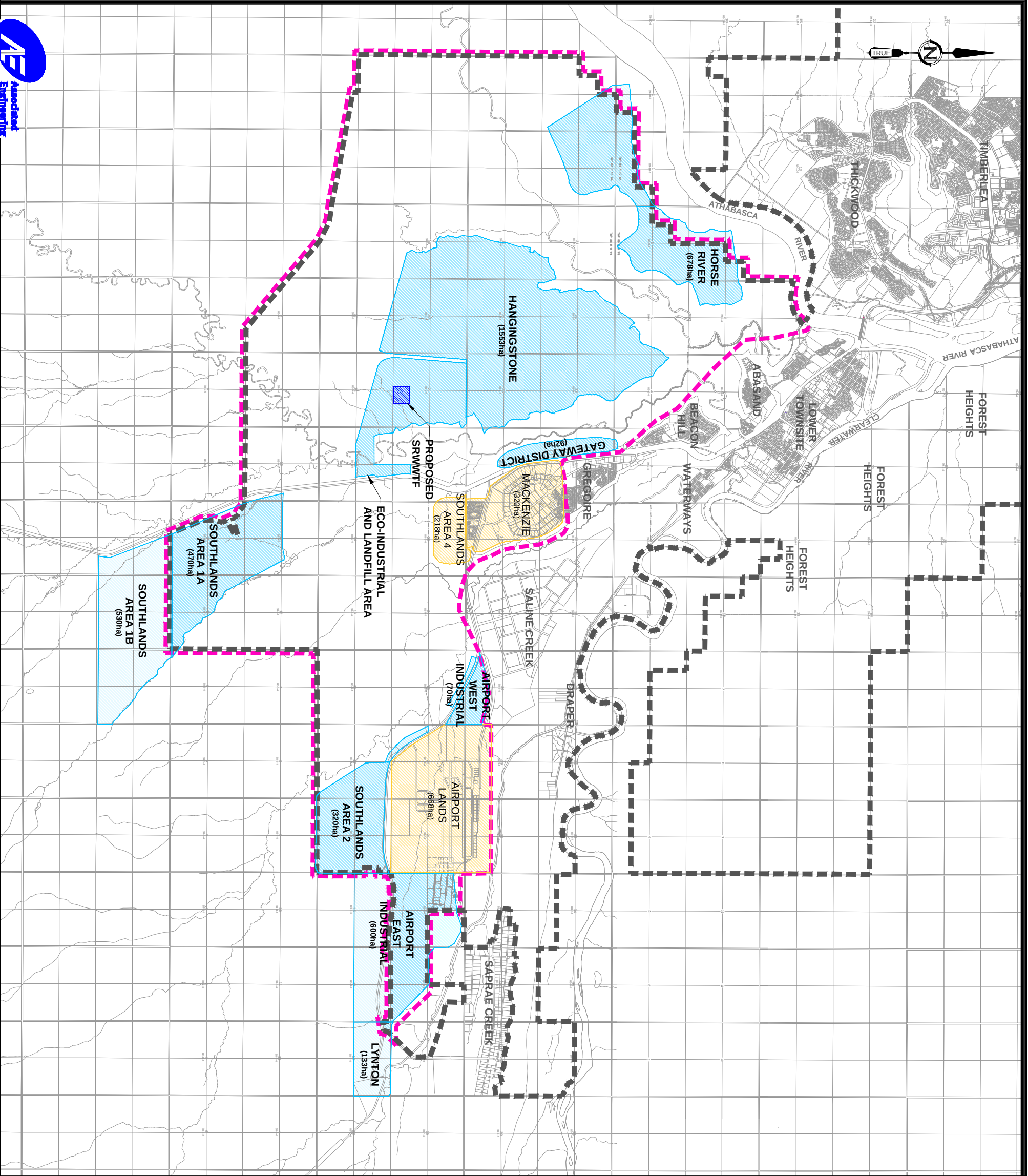
NORTH CATCHMENT AREA

- LEGEND:**
- WMWP NORTH CATCHMENT BOUNDARY
 - AESRD URBAN DEVELOPMENT SUB-REGION (UDSR)
- DEVELOPMENT AREAS:**
- EXISTING DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS

SCALE: 1:85,000

JANUARY, 2014

FIGURE 2-2



UDSR POPULATION PROJECTION

SOUTH CATCHMENT AREA

LEGEND:

- WWMP SOUTH CATCHMENT BOUNDARY
- AESRD URBAN DEVELOPMENT SUB-REGION (UDSR)

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS OUTSIDE OF USDR

SCALE: 1:85,000

JANUARY, 2014

3 Population Projections

3.1 ACTUAL POPULATION

In the Municipality, population projections are difficult to determine, considering the significant impacts the oil sands industrial developments can have on population growth. Estimating growth within the Municipality is important, as it is directly correlated to determining the infrastructure required.

To assist with predicting future growth in the Municipality, AE reviewed the 10 year historical municipal census data for the UDSR. Table 3-1 summarizes the census data reviewed. The 5 and 10 year linear annual growth rates for the urban service area are 3.2% and 5.9%, respectively.

Table 3-1
Historical Municipal Census Populations*

Year	Population	5 Year	10 Year
2002	47,757		
2004	56,111		
2005	60,983		
2006	61,366		
2007	65,400		
2008	72,363		
2010	76,797		
2012	76,009		

* The urban service area defined in the census does not include Draper Valley or Sapræe Creek.

The 2012 municipal census outlines population for the various development areas within the proposed UDSR as shown in Table 3-2.

**Table 3-2
2012 Municipal Census Data within the UDSR**

Existing Development Area	2012 Census Populations
Lower Townsite	10,785
Waterways	726
Draper Valley	197
Abasand	5,239
Beacon Hill	2,193
Gregoire (mixed use)	4,053
Saline Creek	—
Saprae Creek/Spruce Valley	943
Timberlea	33,485
Thickwood	17,548
Parson's Creek	—
Shadow Population	1,980
Prairie Creek	1,050
TOTAL	78,199

The municipal census data in Table 3-1 indicates that the Municipality's residential population was nearly identical in 2010 and 2012, indicating a slightly lower population in 2012. For planning purposes, AE has assumed the residential populations in each of the developments shown in Table 3-2 remained the same between 2012 and 2013.

3.2 ULTIMATE POPULATION PROJECTIONS

The ultimate population projection of the proposed UDSR is calculated based on full development of the areas identified in the north and south catchment areas. The full development of these areas has been determined based on a summarization of various past studies, review of the gross developable areas within the region, and the Municipality's Engineering Servicing Standards. The studies reviewed and summarized the following:

- Fringe Area Development Assessment, Urban Service Area – March, 2007
- Water Master Plan (WMP) – November, 2011
- Airport Servicing Study – December, 2011
- Mackenzie Diversion Project – ongoing, May, 2013
- Development Charge Update – ongoing, May, 2013

AE and the Municipality held a workshop on March 8, 2013, to discuss the future development of the proposed UDSR. During this workshop, discussion revolved around developable areas in the south and the future population projections. For new development areas, three important definitions were confirmed:

Gross Area (GA):	Total land area, includes both developable and non-developable lands
Gross Developable Area (GDA):	Developable land area only, both non-populated and populated land, includes roadways, storm water management, park space etc.
Net Residential Area (NRA):	Populated land area only, residential area

These three definitions are cardinal for projecting populations in new developments. Depending upon the stage of development planning, different parameters are used to project the future population of the area. As discussed and agreed upon at the workshop, the population projection parameters, shown in Table 3-3, will be applied to future areas when an area structure plan is not available:

Table 3-3
Ultimate Population Projections for UDSR

Development Area	Residential Population Estimate	Commercial/Industrial Equivalent Population Estimate
GA	Further review required	Further review required
GDA	50 people/ha	37 people/ha
NRA	90 people/ha	50 people/ha

Municipal and Federal census data reports residential populations only. For infrastructure planning, it is important to evaluate the equivalent population projections for an area. Equivalent populations indicate residential, as well as commercial/industrial population projections. Commercial/industrial population projections are important, as these areas contribute to water demands and wastewater loadings, during periods of operation; therefore, population estimates are even more important, especially when planning water and wastewater systems within communities. When reporting population projections, it is important to distinguish if it is residential or equivalent population.

Table 3-4 summarizes the ultimate residential and equivalent population projections for residential and commercial/industrial development areas in the north and south catchments. The ultimate UDSR residential and equivalent populations are estimated to be 292,550 and 351,150, respectively.

**Table 3-4
Ultimate Population Projections for UDSR**

North Catchment	Residential	Equivalent	Notes/Comments
Residential			
Lower Townsite	48,000	48,000	WMP & Development Charge Update
Waterways	2,700	2,700	WMP & Development Charge Update
Draper Valley	400	400	WMP & Development Charge Update
Abasand	6,000	6,000	WMP & Development Charge Update
Beacon Hill	2,600	2,600	WMP & Development Charge Update
Gregoire (mixed use)	7,400	7,400	Development Charge Update
Saline Creek	20,000	20,000	WMP & Development Charge Update
Saprae Creek/Spruce Valley	5,000	5,000	WMP & Development Charge Update
Timberlea	42,000	42,000	WMP & Development Charge Update
Thickwood	19,200	19,200	WMP & Development Charge Update
Parson's Creek	26,000	26,000	WMP & Development Charge Update
West Growth	31,000	31,000	WMP & Development Charge Update
Forest Heights	24,000	24,000	WMP & Development Charge Update
Total Residential	234,300	234,300	
Commercial/Industrial			
Highway 63 Corridor		7,200	WMP
Total Commercial/Industrial		7,200	
Total North Catchment	234,300	241,500	
South Catchment	Residential	Equivalent	Notes/Comments
Commercial/Industrial			
Airport East Industrial Lands+ Lynton		6,200	WMP & 30% Developable: March 8 Workshop
Southlands Area 1A		5,200	30% Developable: March 8 Workshop
Southlands Area 1B		5,900	30% Developable: March 8 Workshop
Southlands Area 2		6,800	WMP & Development Charge Update
Southlands Area 4		4,500	WMP & Development Charge Update
Airport West Industrial		2,500	Airport San Servicing
Airport Lands		6,050	Airport San Servicing
Mackenzie		6,750	WMP & Development Charge Update
Gateway + Quarry Ridge (mixed use)		7,500	WMP & Development Charge Update
Total C/I		51,400	

South Catchment	Residential	Equivalent	Notes/Comments
Residential			
Prairie Creek	1,250	1,250	Calculation from Gross Developable Area
Hangingstone	42,000	42,000	WMP
Horse	15,000	15,000	WMP
Total Residential	58,250	58,250	
Total South Catchment	58,250	109,650	
TOTAL UDSR	292,550	351,150	

3.3 25 YEAR EQUIVALENT POPULATION PROJECTIONS

The Municipality's equivalent population is currently estimated to be 85,100 people; the ultimate equivalent population for the UDSR is estimated to be 351,150 people, once all regions of developable land are fully developed. The time frame for the Municipality to reach the ultimate population is unknown. Typically, municipalities plan to implement infrastructure required to satisfy 25 year projections for development areas. This may result in full development of some areas and only partial development of other areas. To plan for the 25 year wastewater generation rates, AE has estimated the north and south equivalent populations for the next 25 years.

The 25 year population of the Municipality is difficult to estimate due to many uncertainties in the economic growth of the region. In June, 2011, the Municipality completed a Population and Employment Projection Model to provide various projections of the future growth of the region, depending upon different production capacities in the oil sands industry. This model determined three different growth rates for the UDSR:

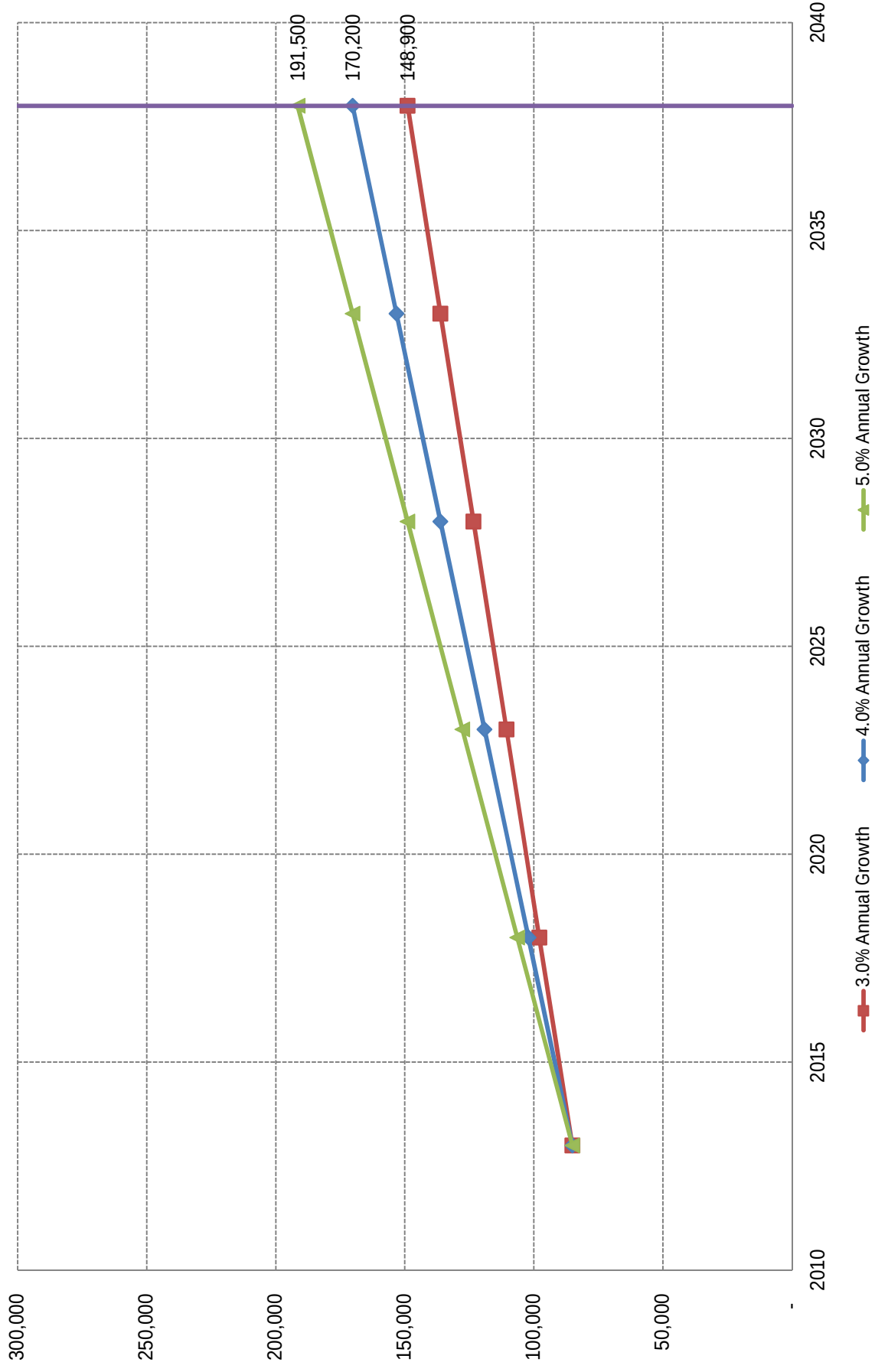
- Low 2.1% annual increase
- Medium 3.2% annual increase
- High 4.1% annual increase

The population projections from the Population and Employment Projection Model were discussed during the March 8th workshop and the Municipality expressed that the population projection range is too low. The Municipality determined that the 4.1% growth rate is more accurately reflective of a low growth rate, based upon historical population increases. Past municipal census data indicates a range of 3.2% to 5.9% annual population growth between 5 and 10 years. With this, AE proposed the following range of population projection rates for the UDSR, the Municipality agreed to these projection rates at the November 18, 2013 workshop:

- Low 3.0% annual increase
- Medium 4.0% annual increase
- High 5.0% annual increase

Figure 3-1 illustrates that the range of equivalent populations in the region is between 148,900 and 191,500 people in the UDSR within 25 years.

Figure 3-1
Population Projections - UDSR



3.3.1 Development Area Population Growth

To determine the growth in the north and south catchments, AE went through the exercise of estimating development in each of the development areas. This exercise was based on discussions that took place during the March, July, and October workshops regarding the areas that are under development and/or are likely to be developed. Tables A-1 through A-3 summarize the development populations AE assumed over the next 25 years, for the over UDSR growth range of between 3% and 5%.

AE has developed a map of the areas likely to be developed. Figure 3-2 illustrates development areas that are undergoing development or likely to develop within the next 5 years (red), as well as developments that are deemed likely to be developed within 5-10 years (purple). The four developments mostly likely to start development within the next 5 years include:

- Eco-Industrial Park, near the existing landfill site;
- Lynton;
- Quarry Ridge; and
- Southlands 1A.

Quarry Ridge and Southlands 1A have been identified as developments that are like to proceed very soon. The Municipality has been working with the developers to create area structure plans and move into the next steps for commercial/industrial developments on these parcels of land. The Municipality has also identified Lynton as an area likely to develop within 5 years as there has been some developer interest in the land.

The Eco-Industrial development, near the existing landfill site, is likely to be developed in the next 5 years to accommodate commercial/industrial land demands, as well as to service eco initiatives identified by the Municipality, including gasification of municipal solid waste. The Eco-Industrial development area has also been identified as the future home of the South Regional Wastewater Treatment Facility (SRWWTF), which will service all of the developments in the south catchment area.

The developments likely to develop within the next 5-10 years include:

- Hangingstone;
- Horse River; and
- Southlands 2.

In the Fringe Study (2007), the Hangingstone development area was identified as a residential development only. The Planning and Development Department of the Municipality has recently reviewed the lands available within the UDSR, and has identified a shortfall in availability of commercial/industrial land. With this, the Hangingstone development is being re-evaluated to also incorporate commercial/industrial properties.

The Municipality and ParioPlan are in the process of evaluating the various development options for the Hangingstone area. Due to the uncertainty of commercial/industrial development in this area, AE has assumed a fully populated residential area for this Tech Memo, ultimately 42,000 people.

The Horse River development area is home to the Riverbend Point residential development. The Area Structure Plan (ASP) for this project was completed by Daon Property Corp. and Scheffer Andrew Ltd., in 2011; however, the Municipality is uncertain that this area will develop within the next 5 years.

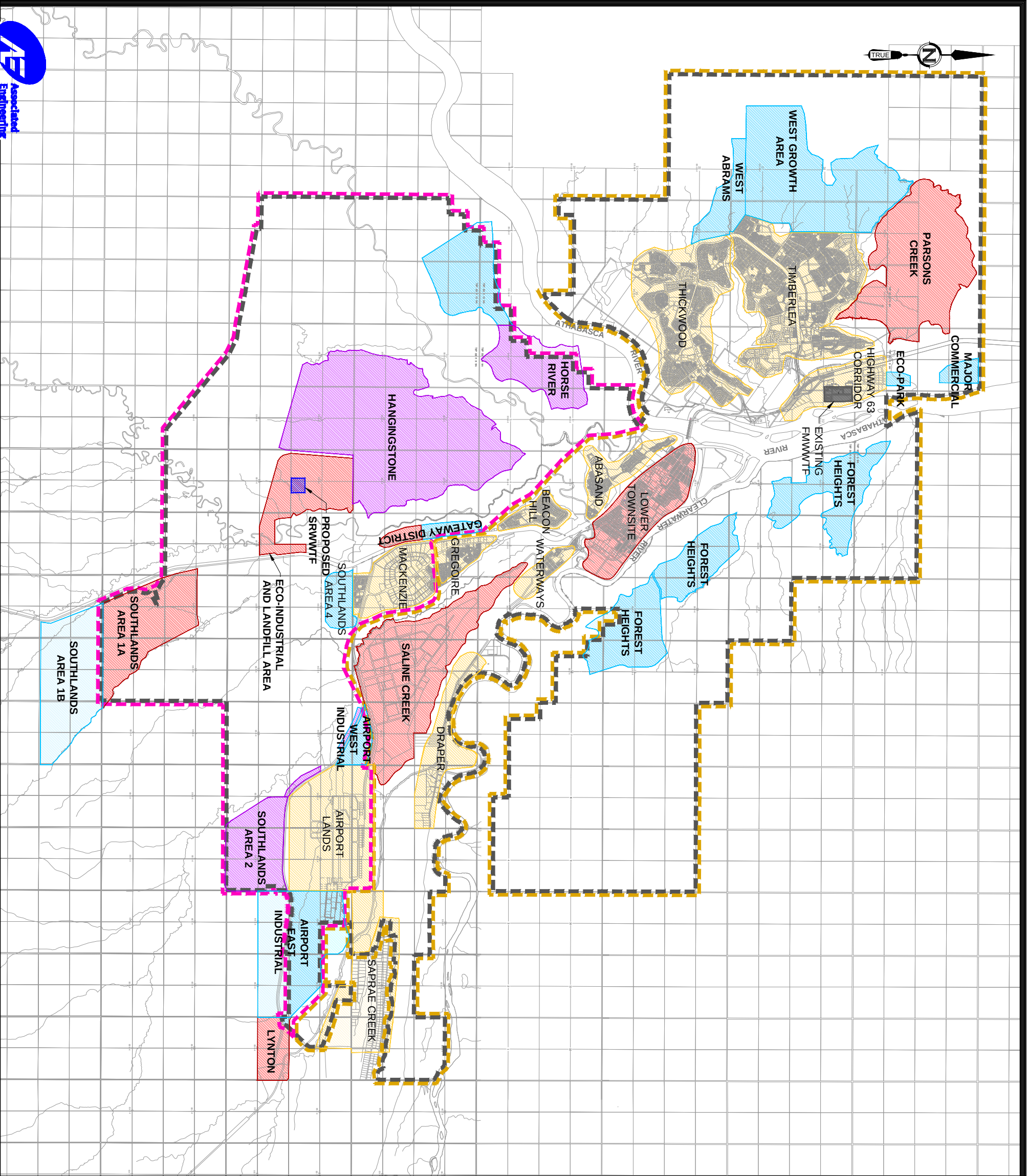
3.3.2 North and South Catchment Populations

After going through this exercise, AE determined typical population splits between the north and south catchment areas. The ultimate population split between the north and south is 69% and 31%, respectively. Table 3-5 summarizes the projected population split between north and south catchments in 5 year steps.

**Table 3-5
North and South Population Splits**

Catchment	2013	2018	2023	2028	2033	2038
North	100%	85%	75%	65%	65%	65%
South	0%	15%	25%	35%	35%	35%

The values in Table 3-5 indicate that it will take 15 to 20 years for the population dispersion in the UDSR to reflect a split similar to the ultimate populations. These projections may shift, based on changes in the development goals in the north and south, respectively. Table 3-6 summarizes the population projections for the north and south catchments, based upon the splits in Table 3-5.



UDSR POPULATION PROJECTION

DEVELOPMENT AREAS

LEGEND:

- SOUTH CATCHMENT BOUNDARY
- NORTH CATCHMENT BOUNDARY
- AESRD URBAN DEVELOPMENT SUB-REGION (UDSR)

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- CURRENTLY UNDERGOING DEVELOPMENT
LIKELY TO DEVELOP WITHIN NEXT (0-5) YEARS
- LIKELY TO DEVELOP WITHIN NEXT
(5-10) YEARS
- FUTURE DEVELOPMENT AREAS (>10 YEARS)
- PROPOSED DEVELOPMENT AREA
OUTSIDE OF UDSR

SCALE: 1:100,000

JANUARY, 2014

Table 3-6
25 Year UDSR Population Growth Range

Catchment	2013	2018	2023	2028	2033	2038
3.0% Growth						
UDSR	85,100	97,900	110,600	123,400	136,200	148,900
North	85,100	83,215	82,950	80,210	88,530	96,785
South	—	14,685	27,650	43,190	47,670	52,115
4.0% Growth						
UDSR	85,100	102,100	119,100	136,200	153,200	170,200
North	85,100	86,785	89,325	88,530	99,580	110,630
South	—	15,315	29,775	47,670	53,620	59,570
5.0% Growth						
UDSR	85,100	106,400	127,700	148,900	170,200	191,500
North	85,100	90,440	95,775	96,785	110,630	124,475
South	—	15,960	31,925	52,115	59,570	67,025

3.3.3 RSAS Population Projections

The Municipality has been working with industrial and provincial government representatives to create a Regional Structure Action Strategy (RSAS). The key principles of the RSAS are to address:

- Land for growth;
- Transportation infrastructure;
- Housing affordability; and
- Quality of life.

One of the first initiatives, to assist with the key principles, was for the RSAS to develop population projections for the Municipality. As part of the recent development work by the RSAS, the RSAS reviewed past population forecasts for the region, including:

- Municipal Census, 2012;
- Fringe Study, 2007;
- Municipal Development Plan, 2011;
- Commercial and Industrial Land Use Study (CILUS), 2010; and
- Comprehensive Regional Infrastructure Sustainability Plan (CRISP), 2010.

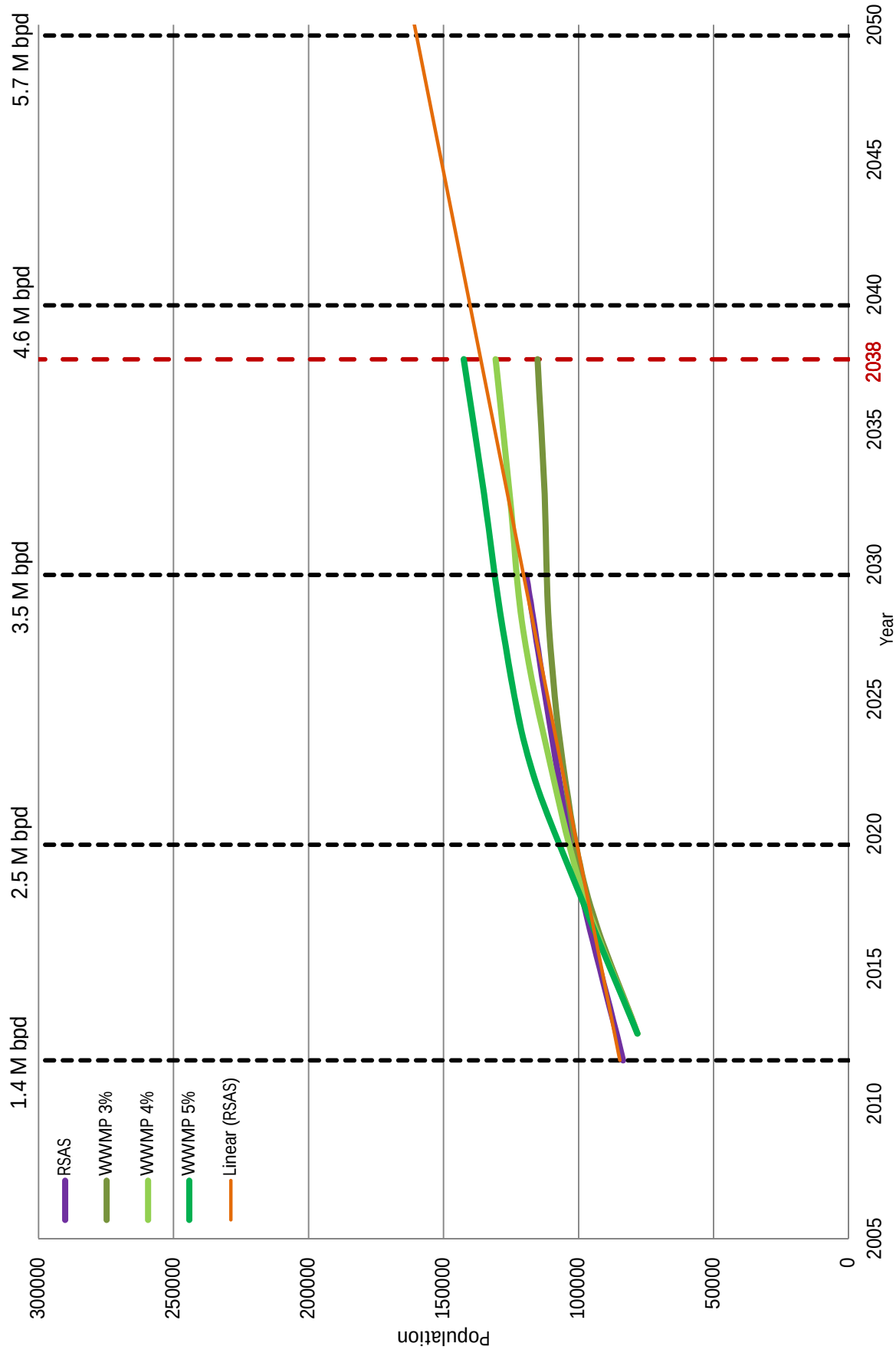
The population projections completed by RSAS in July, 2013 are based on bitumen production in the region. In the projections, RSAS looked at mining based bitumen production, in-situ bitumen production, and upgrader capacity. From the data collected, RSAS generated three scenarios to project populations in region:

- Scenario 1: Population growth and distribution based on existing accommodation and geographic relationships.
- Scenario 2: Population growth and distribution based on moderate shift in accommodation of shadow and camp populations.
- Scenario 3: Population growth and distribution based on a more aggressive shift in accommodation of shadow and camp populations and some additional economic diversification.

Since July, 2013 the RSAS has modified the population projections for the Municipality. Figure 3-3 summarizes the population projections completed by RSAS, including projected bitumen production in the region and the population projections completed by AE for the WWMP. AE has projected the RSAS growth linearly, as the revised data provided in October, 2013 only extends to 2030. Note: all population projections summarized in Figure 3-3 are residential populations.

Figure 3-3

WWMP vs RSAS Residential Population Projections



4 Recommendation

During the November 18, 2013 workshop, the Municipality agreed to adopt the population projection provided in this Tech Memo for the purpose of Wastewater Master Plan. Based on the projections made, the Municipality has identified that the proposed development areas identified will satisfy the residential and commercial/industrial land needs for the next 25 years. With this, AE recommends for the Municipality to carry these population projections forward for all WWMP documentation as well as for the current Water Master Plan being completed.

TECHNICAL MEMORANDUM A.1.5

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to clearly define the future growth areas, the ultimate population projection for the full development of the growth areas, the annual population growth rates for the region, and the 25 year population projection. Population projections are vital for the wastewater master plan in order to check the capacity of the existing infrastructure and to plan for future wastewater infrastructure necessary for residential and commercial/industrial populations.

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.



Herb Kuehne, MBA, P.Eng.
Project Manager



Jacqueline Mykytiuk, P.Eng.
Project Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF
Signature: <u>[Signature]</u>
Date: <u>Jan 28, 2014</u>
APEGA Permit to Practice P-3979



Associated
Engineering

10000 100th Avenue
Edmonton, Alberta T5A 0A6

Appendix A – Development Population Growth

**Table A-1:
3.0% Population Growth Split**

YEAR	2013	2018	2023	2028	2030	2033	2038
North Catchment							
Residential							
Lower Townsite	10,800	11,900	13,000	14,100	14,500	15,100	16,200
Waterways	800	900	1,000	1,100	1,100	1,200	1,300
Draper Valley	200	300	300	300	300	300	400
Abasand	5,200	5,400	5,600	5,800	5,800	6,000	6,000
Beacon Hill	2,200	2,300	2,600	2,600	2,600	2,600	2,600
Gregoire (mixed use)	4,000	4,700	5,300	5,900	6,200	6,500	7,100
Saline Creek	—	3,000	3,500	3,900	4,100	4,400	4,800
Saprae Creek/Spruce Valley	900	1,100	1,300	1,400	1,500	1,600	1,700
Timberlea	33,500	39,600	42,000	42,000	42,000	42,000	42,000
Thickwood	17,500	19,200	19,200	19,200	19,200	19,200	19,200
Parson's Creek	—	5,000	5,800	6,500	6,800	7,300	8,000
West Growth	—	—	—	1,000	1,100	1,200	1,300
Forest Heights	—	—	—	—	—	—	—
Shadow Population	2,000	2,300	2,600	2,900	3,000	3,200	3,500
Commercial/Industrial							
Highway 63 Corridor	3,000	3,900	4,800	5,700	6,100	6,600	7,200
Total North Catchment	80,100	99,600	107,000	112,400	114,300	117,200	121,300
South Catchment							
Commercial/Industrial							
Airport East Industrial Lands + Lynton	—	1,000	1,200	1,300	1,400	1,500	1,600
Southlands Area 1A	—	1,000	1,300	1,500	1,600	1,800	2,000
Southlands Area 1B	—	—	—	2,000	2,200	2,400	2,800
Southlands Area 2	—	—	2,000	2,300	2,500	2,600	2,900
Southlands Area 4	—	—	1,000	1,200	1,300	1,300	1,500
Airport West Industrial	—	—	1,000	1,200	1,300	1,300	1,500
Airport Lands	—	1,000	1,200	1,300	1,400	1,500	1,600
Mackenzie	4,000	4,500	5,100	5,700	5,900	6,200	6,800
Gateway + Quarry Ridge (mixed use)	—	1,000	1,200	1,300	1,400	1,500	1,600
Residential							
Prairie Creek	1,000	1,200	1,200	1,300	1,300	1,300	1,300
Hangingstone	—	—	1,500	1,700	1,800	2,000	2,100
Horse	—	—	1,400	1,500	1,600	1,800	1,900
Total South Catchment	5,000	9,700	18,100	22,300	23,700	25,200	27,600
TOTAL UDSR	85,100	109,300	125,100	134,700	138,000	142,400	148,900

**Table A-2:
4.0% Population Growth Split**

YEAR	2013	2018	2023	2028	2030	2033	2038
North Catchment							
Residential							
Lower Townsite	10,800	13,000	15,100	17,300	18,200	19,500	21,500
Waterways	800	900	1,100	1,200	1,300	1,400	1,400
Draper Valley	200	300	300	300	300	400	400
Abasand	5,200	5,400	5,600	5,800	6,000	6,000	6,000
Beacon Hill	2,200	2,300	2,600	2,600	2,600	2,600	2,600
Gregoire (mixed use)	4,000	4,900	5,700	6,500	6,900	7,300	7,400
Saline Creek	—	3,000	4,500	6,000	6,600	7,500	9,000
Saprae Creek/Spruce Valley	900	1,100	1,100	1,200	1,200	1,300	1,300
Timberlea	33,500	39,600	42,000	42,000	42,000	42,000	42,000
Thickwood	17,500	19,200	19,200	19,200	19,200	19,200	19,200
Parson's Creek	—	5,000	6,500	8,000	8,600	9,500	11,000
West Growth	—	—	—	2,000	2,300	2,700	3,500
Forest Heights	—	—	—	—	—	—	—
Shadow Population	2,000	2,400	2,800	3,200	3,400	3,600	3,900
Commercial/Industrial							
Highway 63 Corridor	3,000	3,900	4,800	5,700	6,100	6,600	7,200
Total North Catchment	80,100	101,000	111,300	121,000	124,700	129,600	136,400
South Catchment							
Commercial/Industrial							
Airport East Industrial Lands + Lynton	—	1,000	1,200	1,400	1,500	1,600	1,800
Southlands Area 1A	—	1,000	1,500	2,000	2,200	2,500	3,000
Southlands Area 1B	—	—	—	2,000	2,200	2,500	2,900
Southlands Area 2	—	—	2,000	2,400	2,600	2,800	3,200
Southlands Area 4	—	—	1,000	1,200	1,300	1,400	1,600
Airport West Industrial	—	—	1,000	1,200	1,300	1,400	1,600
Airport Lands	—	1,000	1,200	1,400	1,500	1,600	1,800
Mackenzie	4,000	4,600	5,100	5,700	5,900	6,200	6,800
Gateway + Quarry Ridge (mixed use)	—	1,000	1,200	1,400	1,500	1,600	1,800
Residential							
Prairie Creek	1,000	1,200	1,200	1,300	1,300	1,300	1,300
Hangingstone	—	—	1,600	2,200	3,100	3,500	4,100
Horse	—	—	1,500	2,100	3,000	3,300	3,900
Total South Catchment	5,000	9,800	18,500	24,300	27,400	29,700	33,800
TOTAL UDSR	85,100	110,800	129,800	145,300	152,100	159,300	170,200

**Table A-3:
5.0% Population Growth Split**

YEAR	2013	2018	2023	2028	2030	2033	2038
North Catchment							
Residential							
Lower Townsite	10,800	13,500	16,200	18,900	20,000	21,600	24,200
Waterways	800	1,000	1,100	1,300	1,400	1,500	1,600
Draper Valley	200	300	300	300	300	400	400
Abasand	5,200	5,400	5,600	5,800	6,000	6,000	6,000
Beacon Hill	2,200	2,300	2,600	2,600	2,600	2,600	2,600
Gregoire (mixed use)	4,000	5,100	6,100	7,100	7,500	8,200	7,400
Saline Creek	—	3,000	4,500	6,000	6,600	7,500	9,000
Saprae Creek/Spruce Valley	900	1,500	1,900	2,400	2,600	2,900	3,300
Timberlea	33,500	39,400	45,300	42,000	42,000	42,000	42,000
Thickwood	17,500	19,200	19,200	19,200	19,200	19,200	19,200
Parson's Creek	—	5,000	7,500	10,000	11,000	12,500	15,000
West Growth	—	—	—	2,000	2,400	3,000	4,000
Forest Heights	—	—	—	—	—	—	—
Shadow Population	2,000	2,600	3,300	4,200	4,600	5,300	6,700
Commercial/Industrial							
Highway 63 Corridor	3,000	4,100	5,400	7,200	7,200	7,200	7,200
Total North Catchment	80,100	102,400	119,000	129,000	133,400	139,900	148,600
South Catchment							
Commercial/Industrial							
Airport East Industrial Lands + Lynton	—	1,000	1,300	1,500	1,600	1,800	2,000
Southlands Area 1A	—	1,000	1,500	2,000	2,200	2,500	3,000
Southlands Area 1B	—	—	—	2,000	2,400	3,000	4,000
Southlands Area 2	—	—	2,000	3,000	3,400	4,000	5,000
Southlands Area 4	—	—	1,000	1,500	1,700	2,000	2,500
Airport West Industrial	—	—	1,000	1,300	1,500	1,600	1,900
Airport Lands	—	1,000	1,300	1,500	1,600	1,800	2,000
Mackenzie	4,000	4,600	5,300	6,000	6,400	6,800	6,800
Gateway + Quarry Ridge (mixed use)	—	1,000	1,800	2,500	2,800	3,300	4,000
Residential							
Prairie Creek	1,000	1,200	1,200	1,300	1,300	1,300	1,300
Hangingstone	—	—	1,800	2,700	4,000	4,500	5,400
Horse	—	—	1,600	2,500	3,700	4,300	5,000
Total South Catchment	5,000	9,800	19,800	27,800	32,600	36,900	42,900
TOTAL UDSR	85,100	112,200	138,800	156,800	166,000	176,800	191,500

TECHNICAL MEMORANDUM A.2.1.2

Regional Municipality of Wood Buffalo

Wastewater Treatment Strategy



January 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering International Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering International Ltd. Information in this document is to be considered the intellectual property of Associated Engineering International Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering International Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering International Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering International Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE

The objective of Tech Memorandum A.2.1.2, Wastewater Treatment Strategy, is to evaluate centralized and decentralized management strategies for the Municipality to help determine which solution is better suited to their needs. To evaluate each wastewater management strategy, wastewater collection and treatment infrastructure is assessed and compared in a detailed cost model.

2 FINDINGS

The Municipality has identified two options to manage collection and treatment of current and future wastewater flows in the UDSR:

- Option 1. Centralized: Bring all wastewater to the existing FMWWTF and expand accordingly
- Option 2. Decentralized: Develop two wastewater catchment areas and construct a new WWTF in the south

Table ES-1 summarizes the new infrastructure identified in each of the strategies.

Table ES-1
Centralized vs. Decentralized Infrastructure

Centralized Wastewater Treatment	Decentralized Wastewater Treatment
63,000 m of sewer force main 14,000 m of gravity sewer main - Six lift stations - FMWWTF expansion	36,000 m of sewer force main 5,000 m of gravity sewer main - Five lift stations - Construction of a new SRWWTF

Based upon the infrastructure identified for centralized and decentralized wastewater management, AE completed a lifecycle cost model for comparison. The cost model evaluated Order of Magnitude phased capital cost estimates, annual O&M cost estimates, and salvage value for the infrastructure identified. As summarized in Table ES-2 below, the results of the cost model indicate that capital investment for the decentralized wastewater strategy is approximately \$75 million less than for centralized; however, the annual O&M costs are slightly higher, due to increased staff and equipment maintenance. The 25 year life cycle cost evaluation indicates the two wastewater management strategies result in nearly equivalent present worth.

Table ES-2
Cost Evaluation Summary

Wastewater Strategy	Total
Centralized	
Capital Cost Estimate	\$465 M
Annual O&M Cost Estimate	\$16.5 M
25 Year Present Worth	\$553 M
Decentralized	
Capital Cost Estimate	\$390 M
Annual O&M Cost Estimate	\$18.5 M
25 Year Present Worth	\$551 M

3 RECOMMENDATIONS

It is difficult to define the optimal wastewater treatment strategy for the Municipality as the life cycle cost model does not present a clear difference between the two strategies. With this it is important to take into consideration the non-economic factors. To quantify the non-economic factors, a detailed Triple Bottom Line + Risk assessment can be completed.

During discussion in the November 18, 2013 workshop, it was agreed that implementing a decentralized wastewater treatment system seems to make sense for the Municipality. This agrees with the non-economic evaluation completed in the South Wastewater Management Concept.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	iv
List of Figures	v
1 Introduction	1-1
1.1 South Regional Wastewater Management Concept – August, 2012	1-1
2 Catchment/Service Area	2-2
3 Centralized Wastewater Management Strategy	3-5
3.1 Centralized Wastewater Collection	3-5
3.2 Centralized Wastewater Treatment	3-6
4 Decentralized Wastewater Management Strategy	4-11
4.1 Decentralized Wastewater Collection	4-11
4.2 Decentralized Wastewater Treatment	4-15
5 Centralized vs. Decentralized Comparison Model	5-16
5.1 Comparative Cost Model	5-16
6 Summary and Conclusions	6-20
7 Recommended Wastewater Management Strategy	7-22
Closure	
Appendix A – Cost Model Assumptions	

List of Tables

	PAGE NO.
Table 5-1 Centralized vs. Decentralized Treatment Strategies	5-16
Table 5-2 Centralized vs. Decentralized Order of Magnitude Capital Cost Estimate	5-18
Table 5-3 Centralized vs. Decentralized Annual O&M Costs	5-19
Table 5-4 Centralized vs. Decentralized 25 Year Present Worth	5-20
Table 6-1 Centralized vs. Decentralized Infrastructure	6-20
Table 6-2 Centralized vs. Decentralized Cost Model Summary	6-21

List of Figures

	PAGE NO.
Figure 2-1 Proposed Wastewater Catchment Areas	2-3
Figure 3-1 Overall Wastewater Conveyance Concepts for Centralized Wastewater Management	3-9
Figure 4-1 Overall Wastewater Conveyance Concept for Decentralized Wastewater Management	4-13

1 Introduction

The Regional Municipality of Wood Buffalo (the Municipality) initiated the Wastewater Master Plan (WWMP) to allow the strategic planning and operation of the existing and future wastewater network. This technical memorandum (Tech Memo) focuses on developing a strategy for the wastewater network in the urban development area of the Municipality.

Associated Engineering (AE) assisted the Municipality in developing a wastewater management concept for future south development areas in August, 2012: "The South Regional Wastewater Management Concept Study". This study will serve as a basis in development of a wastewater strategy for the entire urban service area. This Tech Memo includes the following:

- Review of the South Regional Wastewater Management Concept.
- Review of implications to a centralized wastewater treatment system, with specific reference to pipelines, pumping costs, operations, and collection systems.
- Review of implications to a decentralized wastewater treatment system, with specific reference to pipelines, pumping costs, operations, and collection systems.
- Development of a cost model for centralized and decentralized wastewater systems.
- Summary of findings and recommendations to manage the wastewater system in the urban service area of the Municipality.

The objective of this Tech Memo is to evaluate the difference between centralized and decentralized management strategies to assist the Municipality in determining a preferred strategy.

1.1 SOUTH REGIONAL WASTEWATER MANAGEMENT CONCEPT – AUGUST, 2012

AE was commissioned by the Municipality in 2012 to complete a Wastewater Management Concept for new commercial/industrial developments in the south. The objective of the study was to develop a strategy to manage future wastewater generation from the south developments. While working on the South Regional Wastewater Management Concept, it was noted that the logistics of bringing wastewater from the south developments to the existing Fort McMurray Wastewater Treatment Facility (FMWWTF) would be challenging due to river crossings, restricted pipeline capacities, distance, and reliability.

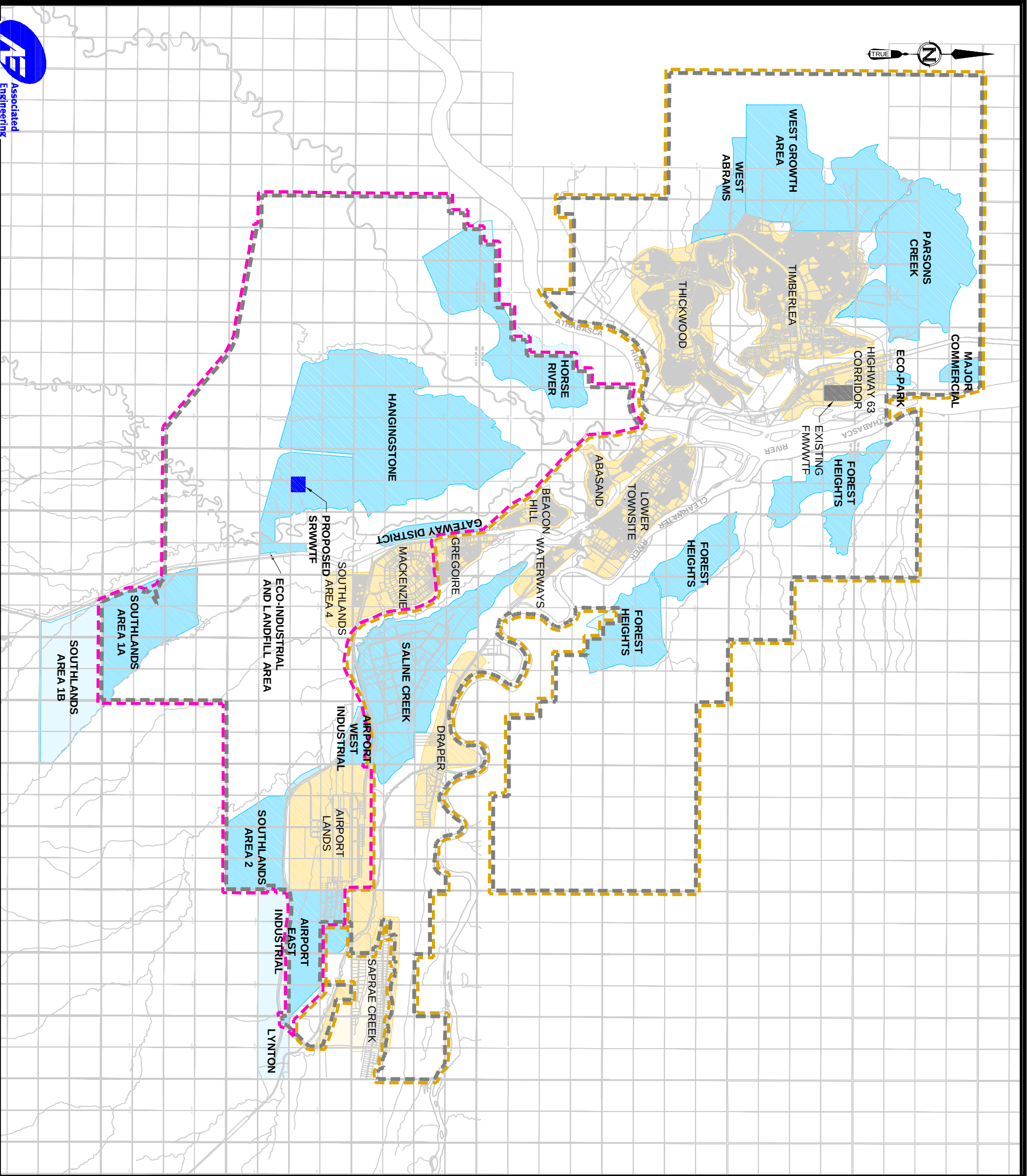
In the South Management Concept Study, AE assessed centralized versus decentralized treatment for the south region. With this, AE assessed the advantages and disadvantages of implementing a single wastewater treatment facility (WWTF), five WWTFs or three WWTFs to manage wastewater generation in the south developments. In addition to evaluating the three independent wastewater management options in the south, AE also assessed the feasibility of bringing the south wastewater to the existing FMWWTF, in the north of Fort McMurray, for a truly centralized strategy for the Municipality's wastewater.

To evaluate the different wastewater management strategies for the south, AE completed a triple bottom line (TBL) and risk assessment of centralized versus decentralized wastewater management. The TBL + Risk assessment reviews environmental, social, and economic principals to evaluate the different management strategies. The option of bringing the south wastewater to the existing, north, WWTF was not evaluated as part of the TBL + risk as it was added after the assessment was complete. Results of the TBL + risk assessment favored centralized wastewater management for the south. To compare a centralized south WWTF to one centralized WWTF in the north, AE, subsequently, completed a detailed cost analysis, which revealed that a new South Regional WWTF was more economical for the Municipality, based upon information available during the Concept Study.

2 Catchment/Service Area

As outlined in Tech Memo A.1.3, the wastewater catchment area is inclusive of all proposed development areas within the proposed Urban Development Sub-Region (UDSR) set forth by Alberta Environment and Sustainable Resource Development (AESRD). Previous work has identified two separate wastewater catchment areas for the UDSR, north and south. Figure 2-1 highlights the two wastewater catchment areas proposed for wastewater management in the Municipality.

Evaluation of a centralized versus decentralized wastewater management strategy is outlined in Sections 3 and 4.



WASTEWATER MASTER PLAN

OVERALL UDSR

- LEGEND:**
- WWMP SOUTH CATCHMENT BOUNDARY
 - WWMP NORTH CATCHMENT BOUNDARY
 - PROPOSED URBAN DEVELOPMENT SUB-REGION

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS

DRAFT

Remove Draft Stamp

SCALE: 1:100,000

January, 2014
OCTOBER, 2013

FIGURE 2-1

3 Centralized Wastewater Management Strategy

Centralized wastewater management is commonly used throughout Alberta and Canada to allow wastewater to be brought to a single location for treatment. A centralized system is generally perceived to be advantageous from an operating and maintenance standpoint, as there are fewer process components to operate and maintain. This is generally determined to be more economical due to high economics of scale. On the other hand, centralized treatment requires large collection sewers that run for long distances from outlying areas to a central facility. In some cases, it may also require additional pumping systems with associated operational and maintenance requirements.

The Municipality currently operates a centralized wastewater treatment system, as all wastewater generated is pumped to the existing FMWWTF in the north of the UDSR. To maintain a centralized wastewater strategy, all wastewater generated from new developments will be brought to the existing FMWWTF site in the north. A large portion of the future developments in the Municipality are planned for areas south of the Athabasca River; therefore, maintaining a centralized wastewater strategy involves pumping wastewater from the future south developments across the Athabasca River to the existing FMWWTF. This approach creates challenges, including river crossings and existing sewer capacity restrictions within the Municipality.

AE evaluated bringing wastewater generated in the south to the existing FMWWTF, as part of the South Regional Wastewater Management Concept Study; however, this study did not include the Horse River and Hangingstone developments. AE has revised the work completed as part of the South Regional Wastewater Management Concept Study to evaluate the infrastructure necessary to bring all wastewater generated in the south catchment to the existing FMWWTF.

3.1 CENTRALIZED WASTEWATER COLLECTION

Regardless of moving forward with a centralized or decentralized wastewater treatment strategy, the north catchment collection infrastructure would not change; however, the south wastewater conveyance infrastructure would change, significantly. Bringing the south catchment wastewater to the existing FMWWTF presents challenges in terms of conveyance, due to the Clearwater and Athabasca Rivers, as well as limitations in existing sewer capacities within the Municipality. In order to bring wastewater from the south catchment to the existing FMWWTF, AE identified that the following major infrastructure is required:

- 14,000 m of gravity conveyance trunks;
- 63,000 m of force mains; and
- Six lift stations.

The suggested conveyance infrastructure is estimated, based on multiple options to bring wastewater from the south developments to the FMWWTF. Figure 3-1 highlights three overall wastewater conveyance concepts for centralized wastewater management. To bring wastewater from the south developments to the existing FMWWTF, the wastewater is brought to central lift stations and pumped north. Bringing the

wastewater to a central location before pumping it north is deemed advantageous due to the hydraulic head requirements necessary to pump wastewater from the south, across the Clearwater and Athabasca Rivers to the FMWWTF. Depending on the route selected to convey wastewater from the south, there may be as many as six river crossings to accommodate a twinned transmission pipeline.

3.1.1 Centralized Collection Pipelines

To collect wastewater from the various developments in the south catchment to the proposed central lift stations, approximately 14,000 linear metres of gravity sewer and 26,000 m of force main would be required. To convey the wastewater from the central lift stations to the FMWWTF, AE proposes approximately 18,500 linear metres of twinned force main. AE proposes a twinned line that would allow a staged construction, depending on the area's growth and for future redundancy, in the event of a break or maintenance shut down. Construction of a twinned conveyance pipeline would require two pipeline river crossings under the Clearwater River and two pipeline crossings under the Athabasca River.

3.1.2 Centralized Collection Pumping

To convey wastewater from the south catchment area to the FMWWTF, a total of six lift stations would be required. Depending on the conveyance route, two of these lift stations may be used as central lift stations to overcome elevation differences and prevent deep sanitary sewers. The following development areas would require lift stations:

1. Horse River
2. Hangingstone
3. Southlands Industrial 1A
4. Southlands Industrial 4
5. Airport East Industrial

In addition to requiring a lift station at each of the developments, a sixth central lift station is required to pump Southlands flow to the FMWWTF.

3.2 CENTRALIZED WASTEWATER TREATMENT

Tech Memo A.2.2.3 assesses the existing system capacity of the FMWWTF. The existing FMWWTF, at full build-out, was designed to serve a population of approximately 133,000 people. As outlined in Tech Memo A.1.5, the population projections for the UDSR ranges from 148,900 to 191,500 people in the next 25 years. With this, if a centralized wastewater strategy were implemented, the hydraulic capacity of the FMWWTF would need to be expanded to accommodate the future growth of the UDSR. The FMWWTF could potentially be twinned to the east to service a population up to 266,000 people (an additional 133,000). Expansion of the facility would be completed in stages to reflect the growth of the UDSR.

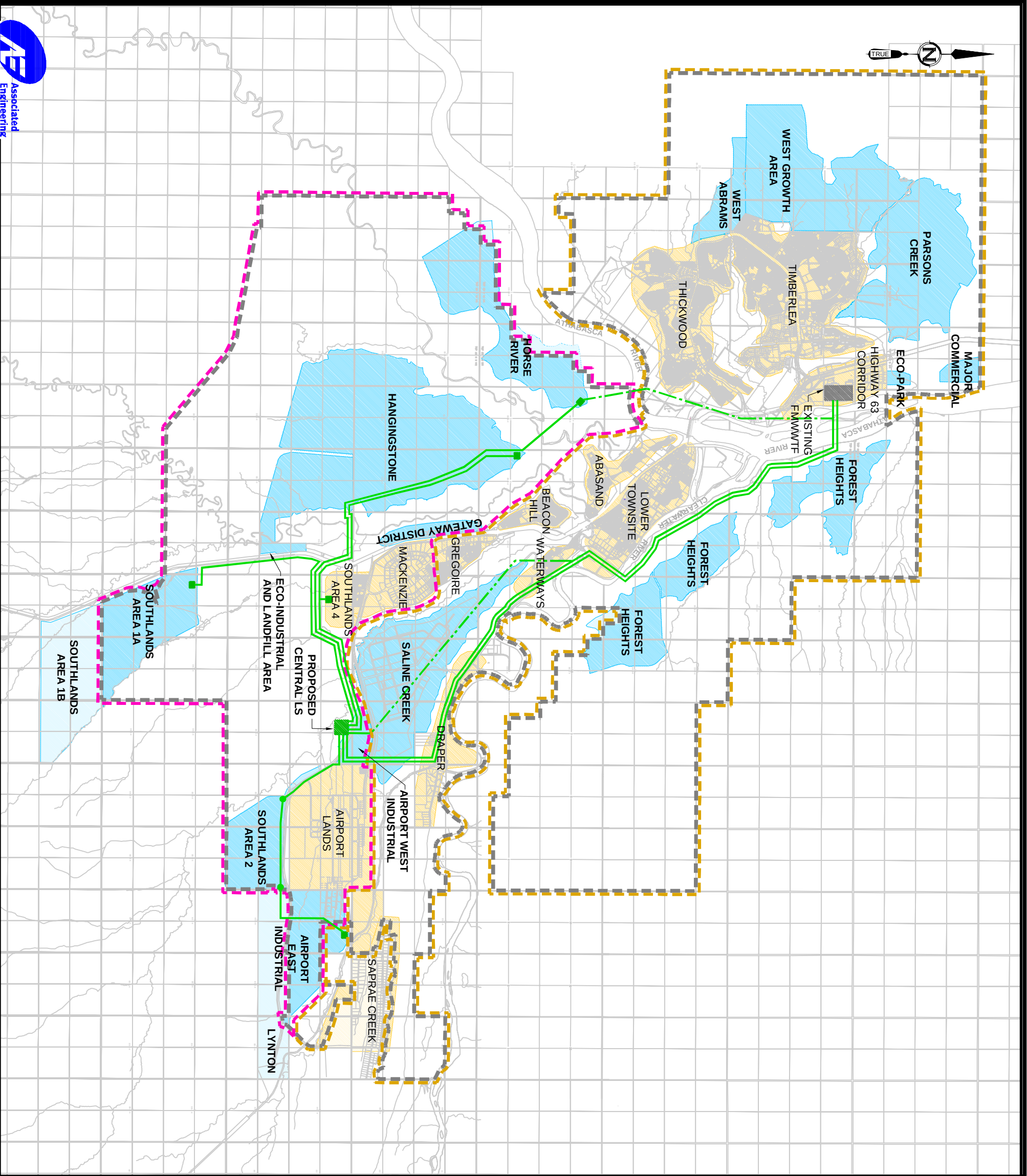
According to Table 2.1 in Tech Memo A.2.3, the firm capacity of the existing FMWWTF liquid stream is 33 MLD, with a firm expansion capability up to 50 MLD once phase 3 is complete. Tech Memo A.1.3 indicates that in 25 years (2038) the average day wastewater generation from the UDSR may be as high as 69 MLD (191,500 people), depending upon population growth rates, without including septage or other wastewater streams.

Assuming the existing conventional treatment process is continued and expanded at the FMWWTF, AE estimates the following major treatment infrastructure would be required to accommodate the 25 year UDSR wastewater generation estimates:

- Screening
- Grit removal
- Influent pumps
- Primary clarifiers
- Bioreactors
- Solids conveyors
- Fermenters
- Secondary clarifiers
- Effluent filtration
- UV disinfection
- Influent and effluent flumes
- Odour control

Solids treatment has not been evaluated, as the Municipality is piloting gasification to determine if it could be a viable solids management strategy in the future.





WASTEWATER MASTER PLAN

CENTRALIZED WASTEWATER MANAGEMENT STRATEGY

LEGEND:

- CONCEPTUAL LIFT STATION
- WMWP SOUTH CATCHMENT BOUNDARY
- WMWP NORTH CATCHMENT BOUNDARY
- PROPOSED URBAN DEVELOPMENT SUB-REGION
- CONCEPTUAL GRAVITY MAIN
- CONCEPTUAL FORCE MAIN ALTERNATE 1
- CONCEPTUAL FORCE MAIN ALTERNATE 2
- CONCEPTUAL FORCE MAIN ALTERNATE 3

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS

DRAFT

Remove Draft Stamp

SCALE: 1:100,000

January, 2014
~~OCTOBER, 2013~~

FIGURE 3-1

4 Decentralized Wastewater Management Strategy

Decentralized wastewater management involves the construction of multiple treatment facilities; it involves implementing a system with collection, treatment, and disposal/reuse of wastewater at or near the point of generation. Implementing a decentralized wastewater strategy for the Municipality would involve splitting the UDSR into two wastewater catchments: north and south, as shown in Figure 2-1. With the majority of new development occurring in the south, this would involve the construction of a new WWTF near the south developments. Construction of a South Regional WWTF (SRWWTF) would remove some challenges, regarding river crossings and the existing pipeline restrictions that would need to be met, if the wastewater were brought to the FMWWTF; however, it would involve the operation and maintenance of another facility.

Implementing a decentralized wastewater strategy would involve designing a collection system to bring wastewater from the south catchment to the new SRWWTF, as well as design and construction of the new SRWWTF. As illustrated in Figure 2-1, the proposed north catchment includes the majority of existing developments in the Municipality; therefore, the north catchment would maintain similar operations to those that exist now. Regardless of a centralized or decentralized wastewater treatment strategy, the lift station and pipeline construction for the north catchment area would remain the same; however, the design of the south catchment facilities could vary significantly.

The South Regional Wastewater Treatment Strategy briefly evaluated construction of a new facility in the south versus conveying wastewater generated in the south to the existing facility and deemed a new SRWWTF to be more cost effective. AE has revised this analysis to accommodate north and south wastewater catchments as outlined in Figure 2-1. Figure 4-1 highlights an overall wastewater conveyance concept for a decentralized wastewater management strategy.

4.1 DECENTRALIZED WASTEWATER COLLECTION

The south collection system would collect wastewater generated in the south developments. Based on previous work AE has completed with the Municipality, the preferred location for the SRWWTF would be at the existing landfill site. To convey wastewater generated in the south to the SRWWTF, AE estimates the following major infrastructure would be required:

- 5,000 m of gravity sewer;
- 36,000 m of force main; and
- Five lift stations.

4.1.1 Decentralized Collection Pipelines

To convey wastewater from the various developments to the SRWWTF, AE estimates there would be approximately 5,000 linear metres of gravity sewer mains and 36,000 linear metres of force mains required, assuming the SRWWTF was located at the existing landfill site. Sewer conveyance to the SRWWTF would decrease pumping and conveyance distance of the wastewater for treatment.

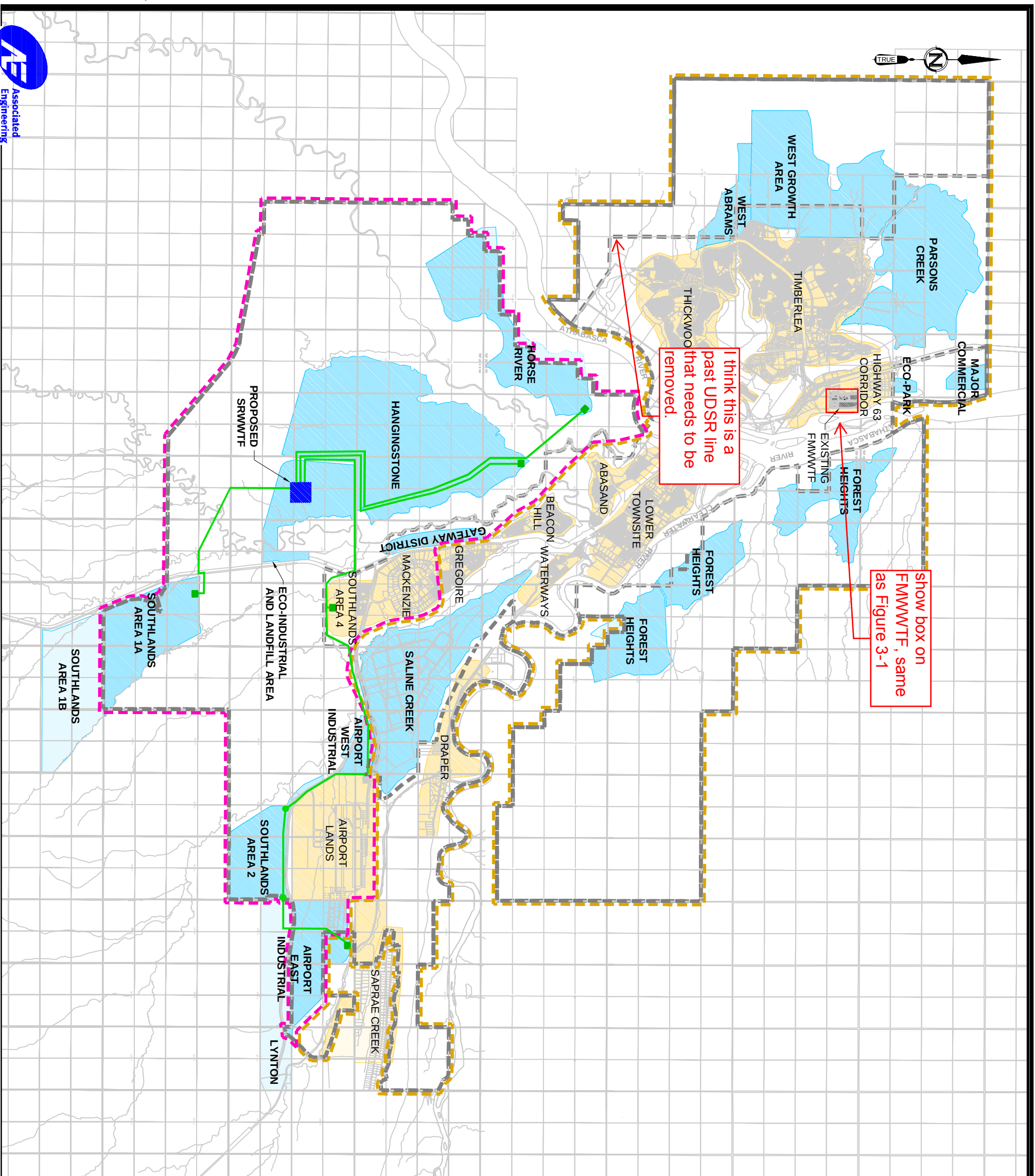
With a decentralized treatment strategy, the wastewater generated in the north would be conveyed to the existing FMWWTF. The north catchment of the UDSR consists predominantly of the existing development. With this, the majority of the underground sewer infrastructure is established in this catchment.

4.1.2 Decentralized Collection Pumping

To transfer wastewater to a new SRWWTF, five new lift stations are required at the following developments, to overcome elevation differences and prevent deep sanitary sewers:

1. Horse River
2. Hangingstone
3. Southlands Industrial 1A
4. Southlands Industrial 4
5. Airport East Industrial

As shown in Figure 2-1, the south catchment also includes the existing developments of MacKenzie and Airport Lands, which include lift stations that currently feed the existing FMWWTF. As discussed in Tech Memo A.1.3, it is proposed that wastewater flow from these areas would be diverted to the south facility in the future to assist with start-up and commissioning of the new SRWWTF, as well as open up capacity at the existing FMWWTF.



WASTEWATER MASTER PLAN

DECENTRALIZED WASTEWATER MANAGEMENT STRATEGY

LEGEND:

-
-  CONCEPTUAL LIFT STATION
 CONCEPTUAL ~~SWMTF~~ **SRWMTF**
 WWMP SOUTH CATCHMENT BOUNDARY
 WWMP NORTH CATCHMENT BOUNDARY
 ~~PROPOSED~~ URBAN DEVELOPMENT SUB-REGION
 **AESKD**
 CONCEPTUAL GRAVITY MAIN
 CONCEPTUAL FORCE MAIN

DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS

SCALE: 1:100,000

January, 2014

~~OCTOBER, 2013~~

~~DRAFT~~

Remove Draft Stamp

4.2 DECENTRALIZED WASTEWATER TREATMENT

With a decentralized wastewater treatment strategy, the Municipality would be operating two separate treatment facilities, one in the north and one in the south. The existing FMWWTF, in the north, was constructed in 2009 to serve an ultimate population of 133,000 people, once Phase 3 is constructed. The current equivalent population of the UDSR is estimated to be approximately 85,100 people, which is predominately located in the north catchment. A decentralized management strategy would increase the time to the next expansion of the existing FMWWTF, as some of the wastewater loads previously planned for the facility would be satisfied by the SRWWTF, including Horse River, Hangingstone, MacKenzie, and Airport lands. This would allow the FMWWTF to delay twinning the existing treatment scheme and increasing the facility's ability to receive septage and wastewater generation from industrial producers to the north of the UDSR.

The SRWWTF would treat all wastewater in the south catchment area, as well as have the flexibility to accept septage from industrial producers to the south of the UDSR, in the future. A new SRWWTF would include the construction of a facility inclusive of a new structure and treatment infrastructure. In the South Regional Wastewater Management Concept Study, AE assumed the construction of a membrane bioreactor WWTF; however, work since this study has indicated that a conventional biological nutrient removal (BNR) treatment regime would be preferable. AE has assumed the construction of a new conventional BNR WWTF would include the following major liquid stream treatment unit operations:

- Screening
- Grit removal
- Primary clarifiers
- Bioreactors
- Secondary clarifiers
- Effluent filtration
- UV disinfection
- Influent and effluent pumping
- Influent and effluent flumes
- Odour control

AE has not included an outfall structure with this work, as co-current design work for a recycle water/reverse effluent discharge pipeline between the SRWWTF and FMWWTF is underway. AE has also not included solids management, due to the Municipality's gasification initiative.

5 Centralized vs. Decentralized Comparison Model

The main difference between centralized and decentralized treatment strategies for the UDSR is defined by wastewater generation in the south developments. Regardless of a centralized or decentralized approach, the collection and treatment of the wastewater generated in the north would remain the same. Table 5-1 summarizes the main collection and treatment differences for the south developments in centralized and decentralized treatment strategies.

Table 5-1
Centralized vs. Decentralized Treatment Strategies

Centralized Wastewater Treatment	Decentralized Wastewater Treatment
• 14,000 m of collection gravity sewer main • 26,000 m of collection force main • Collect south wastewater to a central lift stations and pump to the FMWWTF • 18,500 m of twinned force main from the south central lift station to FMWWTF • 2 pipeline crossings under the Clearwater River • 2-4 pipeline crossings under the Athabasca River • Single recycled water hub to distribute to north and south users • Fewer operators required as all equipment is at a central location	• 5,000 m of collection gravity sewer main • 36,000 m of collection force main • Collect south wastewater to a new south regional WWTF • New conventional SRWWTF at the existing landfill site • Use existing pipeline to outfall to recycle effluent to Athabasca River via existing FMWWTF outfall structure • Provides a level of redundant wastewater treatment • Allows flexibility for wastewater treatment in the future • Allows for flexibility to implement new technologies in the future • Increases longevity of existing FMWWTF for future growth in the north

AE created a comparative cost model to compare centralized and decentralized treatment strategies. The cost model compares capital, operating and maintenance (O&M), and life cycle cost differences between the two strategies, based upon the major infrastructure differences outlined in Table 5-1.

5.1 COMPARATIVE COST MODEL

AE completed a lifecycle cost model to compare centralized and decentralized wastewater management strategies for the Municipality. AE completed a detailed cost model for centralized versus decentralized as part of the South Regional Wastewater Management Concept in 2012, for a membrane bioreactor (MBR) facility, which concluded a new SRWWTF was economically viable in a 25 year lifecycle evaluation. AE has revised this cost analysis to be inclusive of the catchment areas and to reflect a conventional BNR treatment regime instead of MBR.

The lifecycle cost model for centralized versus decentralized wastewater treatment is inclusive of:

- Order of magnitude capital cost estimates;
- Order of magnitude O&M cost estimates; and
- Estimated salvage values for the infrastructure.

5.1.1 Capital Cost Estimates

The capital costs presented are Order of Magnitude estimates, requiring verification during detailed phases of the project. All capital costs include construction and non-construction components, such as engineering, survey, geotechnical assessment, and environmental assessments. Land costs are not included.

For comparative purposes, the capital cost estimates include the following major infrastructure components only:

- Main collection sewers between developments;
- Lift stations; and
- WWTF infrastructure.

The capital costs for centralized and decentralized options have been broken into two phases to satisfy the 10 and 25 year demands, outlined Tech Memo A.2.3.:

- Initial capital costs to satisfy 10 year demands – 20 MLD
- Expansion of the wastewater network and treatment facility to satisfy 25 year demands – 10 MLD expansion

The capital costs have not been divided into further phases, due to uncertainties regarding when areas are planned for development. Table 1 in Appendix A summarizes the infrastructure assumed for Phase 1 and Phase 2.

Table 5-2 summarizes the Order of Magnitude capital cost estimates for the comparison of centralized versus decentralized wastewater treatment.

The estimated capital cost of a decentralized system is approximately \$75 million less expensive than the capital cost of bringing all wastewater generated in the UDSR to the existing FMWWTF site and expanding the facility.

Table 5-2
Centralized vs. Decentralized
Order of Magnitude Capital Cost Estimate in 2013 Dollars (\$ Millions)

Wastewater Strategy	Phase 1 (20 MLD)	Phase 2 (+10 MLD)	Total (30 MLD)
Centralized			
Collection & Conveyance Sewers (force main & gravity)	85	100	185
Sewer Lift Stations	25	25.0	50
Expansion of the Existing FMWWTF	150	80	230
Total	260	205	465
Decentralized			
Collection Sewers (force main & gravity)	30	60	90
Sewer Lift Stations	15	15	30
Conventional South Regional WWTF	190	80	270
Total	235	155	390

5.1.2 Operating and Maintenance Costs

To complete a lifecycle cost model, AE estimated the annual O&M cost for centralized and decentralized wastewater treatment systems. O&M costs include the following expenses:

- Power
- Building heating and electricity
- Chemical costs
- General equipment maintenance
- Piping network maintenance
- Lift station pump costs
- Operating labour
- General administration

Table 5-3 summarizes the estimated annual O&M costs in 2013 dollars for centralized and decentralized wastewater management strategies.

Table 5-3
Centralized vs. Decentralized
Annual O&M Costs in 2013 Dollars (\$ Millions)

Wastewater Strategy	Phase 1 (20 MLD)	Phase 2 (+10 MLD)
Centralized	7.5	16.5
Decentralized	9.5	18.5

O&M costs for a decentralized system are higher compared to a centralized system due to increased staff, additional equipment maintenance, etc.; however, the decentralized system offers the benefits of reduced initial capital cost. To determine the overall life cycle cost, a 25 year lifecycle cost analysis model was completed.

5.1.3 Lifecycle Cost Model

The lifecycle cost model incorporates the phased capital, annual O&M costs, as well as salvage value. Salvage value for the infrastructure, at the end of the 25 year analysis period, was estimated assuming the following life times:

- Pipeline 50 years
- Concrete structures 50 years
- WWTF & lift station equipment 25 Years

To complete the lifecycle cost analysis, the following assumptions were applied:

- Cost of borrowing 6.25%
- Inflation rate 2.5%
- Net present value discount rate 3.75%
- Analysis period 25 years

Table 5-4 below outlines the present value of the centralized and decentralized wastewater management strategies based upon the information outlined above.

Table 5-4
Centralized vs. Decentralized 25 Year Present Worth
in 2013 Dollars (\$ Millions)

Wastewater Strategy	25 Year Present Worth
Centralized	553.0
Decentralized	551.0

The lifecycle cost model indicates that the difference in 25 year present worth between centralized and decentralized wastewater management strategies is minimal, less than 0.4%. At this level, this is less than the range of accuracy of the model. As such, the two management strategies are perceived to have the same 25 year present worth, at this level of analysis.

6 Summary and Conclusions

The Municipality initiated the WWMP to generate a strategic plan for the operation of the existing and future wastewater network. The majority of new developments planned for the Municipality will be located in the south of the community, south of the Athabasca and Clearwater Rivers. The Municipality identified two options to manage collection and treatment of current and future wastewater flows in the UDSR:

- Option 1. Centralized: Bring all wastewater to the existing FMWWTF and expand accordingly
- Option 2. Decentralized: Develop two wastewater catchment areas and construct a new WWTF in the south

This tech memo compared the two wastewater collection and treatment strategies to help the Municipality determine which solution is better suited to their needs. This Tech Memo outlines the infrastructure required for each wastewater management strategy and provides a cost model for comparison.

Table 6-1 summarizes the new infrastructure identified in each of the strategies.

Table 6-1
Centralized vs. Decentralized Infrastructure

Centralized Wastewater Treatment	Decentralized Wastewater Treatment
63,000 m of sewer force main 14,000 m of gravity sewer main - Six lift stations - FMWWTF expansion	36,000 m of sewer force main 5,000 m of gravity sewer main - Five lift stations - Construction of a new SRWWTF

Based upon the infrastructure identified for centralized and decentralized wastewater management, AE completed a lifecycle cost model for comparison. The cost model evaluated Order of Magnitude phased capital cost estimates, annual O&M cost estimates, and salvage value for the infrastructure identified. Table 6-2 summarizes the results of the lifecycle cost model.

Table 6-2
Centralized vs. Decentralized
Cost Model Summary in 2013 Dollars (\$ Millions)

Wastewater Strategy	Phase 1 (20 MLD)	Phase 2 (+10 MLD)	Total (30 MLD)
Centralized			
Phased Capital Cost Estimate	260	205	465
Phased Annual O&M Cost Estimate	7.5	16.5	
25 Year Present Worth			553
Decentralized			
Phased Capital Cost Estimate	235	155	390
Phased Annual O&M Cost Estimate	9.5	18.5	
25 Year Present Worth			551

The results of the cost model indicate that capital investment for the decentralized wastewater strategy is approximately \$75 million less than for centralized; however, the annual O&M costs are slightly higher, due to increased staff and equipment maintenance. In a 25 year life cycle cost evaluation, the two wastewater management strategies result in nearly equivalent present worth.

In Table 6-1, many of the major non-economic differences between the two strategies were summarized. At this stage of analysis, a more formal Triple Bottom Line plus Risk evaluation has not been completed.

7 Recommended Wastewater Management Strategy

Based on the evaluation completed, it is difficult to define the optimal wastewater treatment strategy for the Municipality, as the life cycle cost model does not present a clear difference between the two strategies. Several non-economic factors have been identified as advantages or disadvantages for either strategy; however, without a quantitative evaluation of these factors, it is difficult to determine the preferred strategy. To quantify the non-economic factors, a detailed Triple Bottom Line + Risk assessment could be completed. Also, at this level of evaluation, there have been several assumptions, which may impact the economic evaluation. For example, it has been assumed that a new outfall would not be required for a new SRWWTF in decentralized treatment; should an outfall be required, there would be an economic impact on the decentralized treatment.

During discussion in the November 18, 2013 workshop, consensus agreed that implementing a decentralized wastewater treatment system seems to make sense for the Municipality. This agrees with the non-economic evaluation completed on the past South Wastewater Management Concept.

TECHNICAL MEMORANDUM A.2.1.2

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to evaluate centralized and decentralized management strategies for the Municipality to help determine which solution is better suited to their needs.

The services provided by Associated Engineering International 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 International Ltd



Daniel du Toit, P.Eng.
Project Manager



Jacqueline Mykytiuk, P. Eng.
Project Engineer

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF

Signature: E. J. H. H. H. H.

Date: Jun 23, 2014

APEGA Permit to Practice P 3979

Appendix A – Cost Model Assumptions



Cost Model Assumptions

Centralized	Decentralized
Sewer Pipeline/Lift Station	
PHASE 1 • Southlands 1 – 5,300 m gravity • Southlands 1 – lift station • Hangingstone – 10,000 m force main • Hangingstone – lift station • Central lift station • FMWWTF -18,250 m discharge force main	PHASE 1 • Southlands 1 – 5,100 m force main • Southlands 1 – lift station • Hangingstone – 7,500 m force main • Hangingstone – lift station • No outfall required
PHASE 2 • Southlands 4 – 3,400 m force main • Southlands 4 – lift station • Airport East Ind – 4,900 m gravity • Airport East Ind – 1,400 m force main • Airport East Ind – lift station • Southlands 2 – 3,850 m gravity • Horse River – 12,000 m force main • Horse River – lift station • Upgrades to central lift station • Twin - 18,250 m discharge force main	PHASE 2 • Southlands 4 – 150 m force main • Southlands 4 – lift station • Airport East Ind – 2,500 m force main • Airport East Ind – lift station • Southlands 2 – 4,700 m gravity • Southlands 2 – 10,700 m force main • Horse River – 9,800 m force main • Horse River – lift station • No outfall required

Centralized	Decentralized
Wastewater Treatment	
PHASE 1 • 2 x raw water pumps • 2 x screens • 2 x compactor • 1 x grit removal • 1 x primary clarifier • 2 x bioreactor • 1 x secondary clarifier • 1 x UV reactor • 2 x thickener • 1 x centrifuge • 2 x flume • filter equipment • chemical feed system upgrades	PHASE 1 • 4 x raw water pumps • raw water equalization tank/mixing system • 2 x screens • 2 x compactor • 1 x grit removal • 3 x primary clarifier • 3 x bioreactor • 3 x secondary clarifier • 2 x UV reactor • 2 x thickener • 2 x centrifuge • 2 x flume • filter equipment • chemical feed system upgrades

Centralized	Decentralized
PHASE 2 • 1 x raw water pumps • 1 x screens • 1 x grit removal • 1 x primary clarifier • 1 x bioreactor • 1 x secondary clarifier • 1 x centrifuge • filter equipment upgrades • chemical feed system upgrades	PHASE 2 • 1 x raw water pumps • 1 x screens • 1 x grit removal • 1 x primary clarifier • 1 x bioreactor • 1 x secondary clarifier • 1 x centrifuge • 1 x UV reactor • filter equipment upgrades • chemical feed system upgrades

TECHNICAL MEMORANDUM A.2.2.3

Regional Municipality of Wood Buffalo

Existing Treatment System Capacity



February 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE/PURPOSE

The main objectives of Technical Memorandum A.1.4, Existing Treatment System Capacity, are to:

- Review the existing Fort McMurray Wastewater Treatment Facility (WWTF) capacity to treat projected flows and loads.
- Confirm planned upgrades and the increase in system capacity that would be achieved.
- Review of the existing WWTF treatment redundancy risks.
- Summarize risk workshop outcomes.

2 MAIN FINDINGS

The main findings of this work are summarized as follows:

- **WWTF Firm Capacity (with the largest unit of each major process component out of service) and Direct Septage Treatment:**
 - Current Conditions: Seven processes may be over capacity during high flow or high loading conditions. These include the influent fine screens, single grit tank, UV disinfection, fermenters, dissolved air flotation thickeners, centrifuges, and biofilters.
 - Near Term (5 years): Firm capacities of two additional processes could be exceeded: process air blowers and secondary clarifiers.
 - Near Term with Full Build-out: two processes appear to be at risk of overloading during high flow or high loading events: grit removal and UV disinfection.
- **Redundancy Risks:** In addition to the above, there are a number of single components (e.g. sludge conveyors) which, should they fail, satisfactory operations would be challenged.
- **Effluent Quality:** To provide reasonable assurance of meeting the more stringent 2015 approval limits for Total Suspended Solids (TSS) and Total Phosphorus (TP), effluent filtration will be required. Coagulation/flocculation may also be required ahead of filtration to precipitate dissolved phosphorus.
- **Risk Workshop Priority Areas:** The Municipality identified seven priority areas:
 - Vortex grit chamber
 - Bioreactors
 - Secondary clarifiers
 - Raw compost mixer
 - Foul air wet scrubber
 - SCADA

3 RECOMMENDATIONS

The main recommendations are summarized as follows:

- **General:** The Municipality should undertake full scale performance evaluations to confirm if the identified risks are real and/or if the indicated component capacities need to be re-rated (decreased or increased).
- **Septage Impacts:** The Municipality should gather additional data on individual septage loads. The Municipality may also wish to encourage high strength/load haulers to seek other waste management solutions in an effort to defer costly WWTF component additions. When the septage is discharged directly to the plant in the near future, the Municipality should closely monitor the loading and performance impacts, and be prepared to make adjustments to the direct septage plan.
- **Effluent Quality:**
 - Prior to July 1, 2015, the Municipality should consider the future limits as target limits to gain improved operation experience. Alum feeding, BNR process optimization, and maintenance scheduling should be utilized as required to meet the target limits.
 - The Municipality start communications with AESRD regarding the planned improvements and seek an Approval amendment or authorization to consider the more stringent limits are target limits rather than fixed limits until the filtration facility is commissioned and operating reliably.
 - Planning, design, construction, and operation of the proposed filtration facility should commence as soon as possible. Filtration will also help assure adequate disinfection when one of the UV banks is out of service. Bench or pilot scale testing should be considered as part of the filtration facilities predesign to confirm coagulation/flocculation requirements prior to filtration.
- **Prioritization of Improvements:** In addition to the recommended filtration upgrade, a prioritized plan of action should be developed, mainly focusing on the items identified with critical risk consequences at the risk assessment workshop. Tentatively this plan should include:
 - Vortex grit chamber – operations procedures
 - Bioreactors – full build-out (4th bioreactor)
 - Secondary clarifiers – full build-out (4th secondary clarifier)
 - Raw compost mixer – operational procedures
 - Foul air blowers – replacement (in progress)
 - Foul air wet scrubber – operational procedures
 - SCADA – provide sufficient backup to enable automated operation at all times
 - Other redundancy risks – operational procedures.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	iv
List of Figures	v
1 Introduction	1
2 Review of Current FMWWTF Capacity	1
2.1 Hydraulic Capacity	1
2.2 Load Capacity	2
2.3 Capacity Summary	9
3 Effluent Quality Review	10
3.1 Current and 2015 Approval Limits	10
3.2 Recent Effluent Quality	10
3.3 Effluent Quality with Major Components Out of Service	12
3.4 Effluent Filtration and Other Options	13
3.5 Recommendations	13
4 Risk Assessment	13
4.1 Redundancy Risks	13
4.2 Risk Assessment Workshop	14
4.3 Risk Summary	14
5 Conclusions	23
6 Recommendations	24
Closure	
Appendix A – WWTF Brochure	
Appendix B – Mean Effluent Monthly Data	

List of Tables

	PAGE NO.
Table 2-1 Fort McMurray WWTF: Summary of Major Process Equipment and Flow Capacities	3
Table 2-2 Fort McMurray WWTF Average Day Design Loads	5
Table 2-3 Current and Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each of the Major Components Out of Service	6
Table 2-4 Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each Major Component Out of Service at Full Build-out	8
Table 3-1 Fort McMurray WWTF Approval Limits	10
Table 3-2 Fort McMurray WWTF Monthly Effluent Quality Summary 2010 to 2013	11
Table 4-1 Preliminary Component List Comparison	15
Table 4-2 Risk Assessment Metrics	17
Table 4-3 Results of the Municipality's Redundancy Risk Assessments	19
Table 4-4 Identified Risks Ranked Highest to Lowest	21

List of Figures

	PAGE NO.
Figure 3-1 Effluent TSS Monthly Average Variation (2010-2013)	12
Figure 3-3 Effluent TP Monthly Average Variation (2010-2013)	12

1 Introduction

The Existing Treatment System Capacity Review sub-task (Task A.2.2.3) reviews the treatment capacity of Fort McMurray's main Wastewater Treatment Facility (WWTF) components. Refer to the appended brochure for further information on the WWTF.

This task also reviews the redundancy systems incorporated into the existing WWTF and the possible consequences of failure of the redundancy systems. A workshop with the Regional Municipality of Wood Buffalo (Municipality) was held on June 26, 2013, to identify risk items and assign severity and probability ratings to the risk items.

This Tech Memo includes:

- Review of the existing Wastewater Treatment Facility (WWTF) capacity for projected flows and loads.
- Confirmation of planned upgrades and the increase in system capacity that would be achieved.
- Review of the existing WWTF treatment redundancy risks.
- Summary of risk workshop outcome.

2 Review of Current FMWWTF Capacity

2.1 HYDRAULIC CAPACITY

Table 2-1 lists major process units and their estimated hydraulic capacities. The estimates are based on information from the Predesign report¹, a Peer Review report², various contract documents, and first-hand knowledge.

Individual unit capacities, firm capacities and total capacities are indicated for the current facility as well as for an expanded Phase 3 facility (capacity at full build-out). Please note the following meanings of terms:

- Hydraulic Capacity: The nominal flow rate (ML/d) that can be reliably treated. Peak instantaneous capacity is implied unless otherwise indicated. Where two values are presented, they indicate both the average day flow (ADF) hydraulic capacity and peak hourly flow capacity. Both the average and peak capacities are considered limiting for some unit processes (e.g. bioreactors); and therefore, they are both shown.
- Firm Capacity: The hydraulic capacity with one of the units out of service, except for equivalent flow capacity for compost tunnels where two tunnels may be out of service at a time.
- Total Capacity: The hydraulic capacity with all of the units in service.
- Equivalent Hydraulic Capacity: Applicable to solids stream processes where the process will handle the solids loadings from a facility treating the indicated design flows.

¹ Earth Tech, November 2004. Predesign Report, Fort McMurray Water Reclamation Facility.

² Associated Engineering, May 2007. Regional Municipality of Wood Buffalo Fort McMurray WWTP Peer Review - Phases 2 and 3.

Phase 3: The initial facility was designed for “Phase 1”, average day flow (ADF) capacity of 33 MLD, with expansion provisions for “Phase 2” (39 MLD) and “Phase 3” (52 MLD). During construction, some of the Phase 2 and 3 planned expansions were brought into the initial construction project to address concerns of accelerated population growth. The remaining space and layout provisions for the Phase 3 facility are indicated in Table 2-1.

During the planning of the facility, it was also envisaged that the ultimate facility capacity could potentially be double that of the Phase 3 capacity. This may require expansion and mirroring of the facility within the space currently occupied by the various lagoons/ponds to the east.

A difficulty in reviewing capacities is that some are expressed in terms of average day flow and others are expressed in terms of peak hour flow. To facilitate the evaluation, AE has, therefore, indicated the corresponding average day flow for each process component.

Typically, wastewater treatment facilities have some single components, and as such, those components have no back-up or standby units. Without back-up, single components therefore have zero (0) firm capacity. Table 2-1 identifies a number of process components with no (zero) firm capacity. This may or may not be of concern depending on the risk that the single component must be removed from service and whether there are mitigative measures to compensate during the shutdown.

This is discussed further in Section 3, under “Redundancy Risks”.

2.2 LOAD CAPACITY

The term “Load” in this tech memo refers to the daily mass of specific constituents in the raw wastewater. The “load” simply represents the product of flow and concentration of each specific constituent.³ The estimated load capacities are based on the same information sources as for the hydraulic capacities. Table 2-2 summarizes overall plant design loads.

The indicated design loads for the current components, as well as at full build-out, assume full redundancy; the firm design capacities are indicated assuming the largest unit process component of each type is out of operation. Note that these estimates do not apply uniformly to all facility components. These differences are analyzed further in the next section.

³ Example load calculation: Say flow is 20 ML/d and one constituent concentration is 200 mg/L. Then the loading rate is 20 ML/d x 200 mg/L x 10⁶ L/ML x kg/10⁶ mg = 4,000 kg/d.

Table 2-1
Fort McMurray WWTF - Summary of Major Process Equipment and Flow Capacities*

Process Component	# of Units				Capacity, MLD (Peak / Avg)						Comments/References
	Existing Total	Existing Firm	Full Build-out Total	Full Build-out Firm	Each Unit	Existing Total	Existing Firm	Full Build-out Total	Full Build-out Firm		
Liquid Streams											
Influent Parshall Flume	1	0	1	0	166 / 55	166 / 55	0	166 / 55	0	Based on 1200 mm throat width, 760 mm head. Note, downstream submergence due to screen head losses may reduce accuracy of Parshall flume at high flows.	
Influent Fine Screens	2	1	3	2	80 / 27	160 / 54	80 / 27	240 / 81	160 / 54	Peer Review Report & QU1599. Space for an additional screen is provided in a third channel that has a manual coarse screen.	
Bypass Channel Manual Coarse Screen	1	0	0	0	Unknown			Assumed to be replaced with redundant fine screen	Assumed to be replaced with redundant fine screen	Manual screen may not reliably provide screening at high flows due to difficulty and safety concerns with raking during high flows. Potentially the screen could be replaced with a mechanical coarse or fine screen to provide reliable, standby screening during peak wet weather flow events.	
Vortex Grit Chamber	1	0	1	0	156 / 52	156 / 52	0	0	0	Peer Review Report	
Influent Pumps	5	4	6	5	32	158 / 53	126 / 42	190 / 63	156 / 52	Peer Review Report	
Primary Clarifiers	3	2	3	2	78 / 26	254 / 78	156 / 52	254 / 78	156 / 52	Peer Review Report	
Bioreactors	3	2	4	3	39.6 / 16.5	119 / 49.5	79 / 33	158 / 66	119 / 49.5	Subject to nitrifier growth rate	
Process Air Blowers	3	2	4	3	39.6 / 16.5	119 / 49.5	79 / 33	119 / 49.5	119 / 49.5	Peer Review Report	
Secondary Clarifiers	3	2	4	3	47 / 19.5	141 / 59	94 / 39	141 / 59	141 / 59	Peer Review Report	
UV Disinfection	2 banks (1 channel)	1	2	1	62.5 / 26	125 / 52	62.5 / 26	125 / 52	62.5 / 26	Peer Review Report. Firm capacity assumed to be based on # of UV banks, not # of UV channels.	
Effluent Parshall Flume	1	0	1	0	125 / 52	125 / 52	0 / 0	125 / 52	0 / 0	Restricted to max flow through UV disinfection.	
Effluent Outfall Pipe	1	0	1	0	125 / 52	125 / 52	0 / 0	125 / 52	0 / 0	Subject to flood levels <250 m.	
Effluent Outfall Structure	1	0	1	0	250 / 104	250 / 104	0 / 0	250 / 104	0 / 0	AECOM Nov 2011 report. Fort McMurray Wastewater Treatment Facility New Outfall – Fish and Fish Habitat Assessment	
Solids & Related Streams**											
Fermenters	2	1	3	2	26	52	26	78	52	Equivalent ADF capacity	
DAF - WAS Thickening	2	1	3	2	33	66	33	99	66	Equivalent ADF capacity	
Centrifuges - Raw Solids Dewatering	2	1	3	2	33	66	33	99	66	Equivalent ADF capacity	
Centrifuged Solids Conveyor System	1	0	1	0	66	66	0	66	0	Equivalent ADF capacity after upgrading	
Raw Compost Mixer	1	0	1	0	33?	33?	0	33?	0	Appears to be a future bottleneck	
Raw Compost Conveyor	1	0	1	0	33?	33?	0	33?	0	Appears to be a future bottleneck	
Compost Tunnels	7	5	9	7	7.8	55	39	70	55	Firm ADF capacity with 5/7 tunnels current, 7/9 future operating.	
Foul Air Blowers	Under review									Undergoing replacement due to explosion	
Stage 1 Wet Scrubber	1	0	1	0	52	52	0	52	0	Equivalent ADF capacity	
Stage 2 Biofilters	2	1	3	2	26	52	26	78	52	Equivalent ADF capacity	
Other											
Septage Receiving	1				15.2					Capacity of two influent pipes, macerator and influent pumps to be confirmed.	
Influent Distribution Chambers	2				Not confirmed					A new chamber was recently constructed, joining with the main distribution chamber.	
Peak Wet Weather Flow Management					Bypasses for temporary lagoon storage					Also required in the event of the Athabasca River reaching 1:100 year ice-jam flood level.	

* Peak capacities are shown in red, average day flow (ADF) capacities values are shown in green.

Total flow capacity for a major process component is the rated hydraulic capacity with all units in operation.

Firm flow capacity for a major process component is the rated hydraulic capacity with the largest unit out of operation (except for compost tunnels where 2 units may be out of operation).

** The "flow capacities" for solids and related streams refer to the equivalent liquid stream capacities that the solids stream components need to handle. Average values are shown in green.

Table 2-2
Fort McMurray WWTF Average Day Design Loads^a

Load	Design Loads ^b	
	Current Capacity ^c	Full Build-out Capacity ^d
Hydraulic, MLD	39	52
BOD, kg/d	8,000	10,640
COD, kg/d	17,600	23,408
TSS, kg/d	10,000	13,300
TKN, kg/d	1,350	1,796
TP, kg/d	250	333

^a Average day values are indicated. The facility is also designed to handle peaks (e.g. hydraulic peak factors up to 3.0 for headworks and primary, 2.4 for remainder). The design loads for Hydraulic apply principally to influent pumps, primary clarifiers, secondary clarifiers, and UV disinfection. The design loads for BOD and COD apply principally to the bioreactors, process air blowers, fermenters, and DAF. The design loads for TSS apply principally to the influent screens and solids handling facilities. The design loads for TKN and TP apply principally to the secondary treatment processes.

^b Based on Earth Tech Predesign Report.

^c Generally recognized current firm capacity with the largest of each major process component out of operation (excludes major pipes and related infrastructure).

^d Firm capacity following full build-out and with the largest of each major process component out of operation (excludes major pipes and related infrastructure).

2.2.1 Firm Load Capacities

Table 2-3 shows the estimated firm capacities if individual processes. The estimated firm capacities are based on the estimated design values with the largest component out of service. The actual capacities may be greater or less. Therefore, AE suggests that in-plant capacity verifications be completed in order to better define the capacity risks prior to planning costly additions.

Percentage loadings less than 80% of design capacity are shaded **GREEN**, those between 80% and 99% of design capacity are shaded **YELLOW**, and those at 100% or greater of design capacity are shaded **RED**.

The analysis assumes that:

- The base year upon which future FMWWTF flows are projected is 2012, using actual 2012 effluent flow data.
- High linear annual population growth rate of 5%.
- With septage fed directly to the WWTF, its average strength reflects the 2009 septage study findings. 100% of the total projected septage volume is discharged directly to the FMWWTF in 2013

and 60% will be discharged in 2015 and subsequent years (the remaining 40% would be hauled to Anzac or Conklin).

- The design capacities for process components are most impacted as follows:
 - Hydraulic loading (flow rate) is the principal factor impacting the capacity of influent pumps, primary clarifiers, secondary clarifiers, and UV disinfection.
 - BOD loading is the principal factor impacting the capacity of bioreactors, process air blowers, fermenters, and dissolved air flotation (DAF) thickeners used for thickening waste activated sludge (WAS).
 - TSS loading is the principal factor impacting the capacity of influent fine screens, centrifuges for raw solids dewatering, centrifuged solids conveyor system, raw compost mixer, raw compost conveyor, compost tunnels, foul air blowers, Stage 1 wet scrubber, and Stage 2 biofilters for odour control.
 - All major channels and conduits are assumed to be in operation.
 - All solids stream conveyance systems are assumed to be in operation.

For both the 2013 and 2018 projections, there are areas of possible concern with the firm capacity.

Table 2-3
Current and Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each of the Major Components Out of Service

Component	2013	2018
	% of Total	% of Total
Equivalent Population	129,400	139,100
Liquid Stream		
Influent Fine Screens	154%	160%
Grit Tank	>100%	>100%
Influent Pumps	78%	95%
Primary Clarifiers	63%	77%
Bioreactors	92%	102%
Process Air Blowers	79%	87%
Secondary Clarifiers	84%	102%
UV Disinfection	126%	154%
Solids Stream & Other		
Fermenters	118%	130%
DAF - WAS Thickening	118%	130%
Centrifuges - Raw Solids Dewatering	102%	106%

Component	2013	2018
	% of Total	% of Total
Equivalent Population	129,400	139,100
Centrifuged Solids Conveyor System	34%	35%
Raw Compost Mixer	77%	80%
Raw Compost Conveyor	77%	80%
Compost Tunnels	77%	80%
Foul Air Blowers	77%	80%
Stage 1 Wet Scrubber	77%	80%
Stage 2 Biofilters	154%	160%

Notes:

	< 80% of capacity
	80% to 99% of design capacity
	≥ 100% of design capacity

1. Equivalent population based on high wastewater projections and 6.6 TSS load factor for direct septage discharge.
2. For illustration of firm capacities, largest unit process of each type is assumed to be out of operation except for the following single components which are assumed to remain in operation: solids conveyor system, raw compost mixer, and raw compost conveyor.
3. Conveyor assessment based on upgraded conveyors (to be tendered).

2.2.2 Full Build-out Load Capacities

Table 2-4 shows the firm build-out capacities as a percentage of the estimated loads that the FMWWTF will have to treat in the near-term (2018). The same assumptions apply as indicated under Section 2.2.1 and it is also assumed that the septage loads are directly applied to the headworks of the FMWWTF and one of two UV banks in the single UV channel is out of operation.

The table illustrates that there are some possible areas of concern, specifically:

- Grit tank: No firm capacity with single grit tank out of service.
- UV disinfection: Loads greater than firm design capacity (with one of the two UV banks out of service).

Table 2-4
Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each Major Component Out of Service at Full Build-out

Component	2018
	% of Total
Equivalent Population	139,100
Liquid Stream	
Influent Fine Screens	80%
Grit Tank	>100%
Influent Pumps	75%
Primary Clarifiers	77%
Bioreactors	65%
Process Air Blowers	65%
Secondary Clarifiers	68%
UV Disinfection	154%
Solids Stream & Other	
Fermenters	65%
DAF - WAS Thickening	65%
Centrifuges - Raw Solids Dewatering	53%
Centrifuged Solids Conveyor System	35%
Raw Compost Mixer	80%
Raw Compost Conveyor	35%
Compost Tunnels	80%
Foul Air Blowers	80%
Stage 1 Wet Scrubber	80%
Stage 2 Biofilters	80%

Notes:

	< 80% of capacity
	80% to 99% of design capacity
	≥ 100% of design capacity

2.3 CAPACITY SUMMARY

- The existing FMWWTF was designed to accommodate wastewater flows from an equivalent population of 133,000 persons generating 52 MLD average wastewater flows.
- Some major process components can treat the flows with one of the components out of service; these components therefore have a firm design capacity sufficient to serve 133,000 equivalent population.
- Other major process components require the operation of all of the components to adequately treat the flows. These components therefore do not have a firm design capacity sufficient to serve 133,000 equivalent population.
- The direct addition of high strength septage with the incoming piped system flows contributes higher organic and solids loads per unit volume and, therefore, impacts the equivalent population or load capacity proportionately more than the piped system flow.
- In terms of population equivalent, the current and near term (2018) projected population equivalent loadings for the FMWWTF are as follows:

Year / Condition	Equivalent Population	Comments
2013 / Current	98,300	Septage is currently discharged to lagoons.
2013 / Direct Septage	129,400	New septage receiving facility will macerate and pump septage directly to FMWWTF.
2018	139,100 (exceeds 133,000 stated design capacity)	Assumes 5% linear growth rate and 40% of septage is diverted to Anzac or Conklin.

- With plant optimization, e.g., improved septage load management, the plant may effectively treat greater flows.
- The firm capacity for several processes is less than required to treat the current (2013) loads with direct septage discharge. This will worsen if the loads continue to increase in the near future (2018).
- To address this concern, the Municipality may develop specific operational procedures and/or consider full build-out of capacity-challenged processes.
- With full build out of FMWWTF all of the major process units at FMWWTF will have adequate firm capacity to treat the 2018 projected loads with the exception of:
 - Grit tank: Only one grit tank is available and the design does not readily accommodate the addition of a second grit tank. We suggest that the Municipality ensure operational strategies are in place to minimize downtime. Also consider design modifications to improve operating reliability (e.g. air or water scour at suction pipe entrance during peak grit loadings).
 - UV disinfection: Two UV banks are located in one channel. We suggest that the Municipality ensure adequate spare parts are available in the event that one of the banks completely fails. Note that the UV disinfection efficiency is expected to improve once the

proposed filtration facility is constructed. Possibly the UV system's firm capacity will be re-rated at that time to 133,000 population equivalent or more.

- In the longer term, the full build-out capacity may be increased much more through emerging technology enhancements⁴ or expanding into the existing lagoon area.

3 Effluent Quality Review

3.1 CURRENT AND 2015 APPROVAL LIMITS

The Municipality's Approval for the City of Fort McMurray WWTF (Approval No. 689-02-00), under the Environmental Protection and Enhancement Act is dated February 25, 2009. The current approval limits are applicable until June 30, 2015. Future, more stringent limits become effective July 1, 2015. Table 3-1 summarizes both the current and future limits. The CBOD, TSS, Total Phosphorus, and Ammonia-Nitrogen limits apply to the monthly arithmetic mean of daily composite samples. The pH limit basis (single sample or arithmetic mean) is not defined. The *E. Coli* limit applies to the monthly geometric mean of grab samples taken 5 days per week.

Table 3-1
Fort McMurray WWTF Approval Limits

Parameter	Units	Current Limit	Future Limit
CBOD	mg/L	20	10
Total Suspended Solids (TSS)	mg/L	20	10
Total Phosphorus (TP)	mg/L	1	0.5
Ammonia-Nitrogen (NH ₃ -N)	mg/L	10 / 5 ^a	6 / 3 ^b
pH	pH Units	6.5-9.5	6.5-9.5
<i>E Coli</i>	CFU/100 mL	200	200

^a Current winter (Oct 1-June 30 period) NH₃-N limit is 10 mg/L; summer (July 1-Sept 30 period) limit is 5 mg/L.

^b Future winter (Oct 1-June 30 period) NH₃-N limit is 6 mg/L; summer (July 1-Sept 30 period) limit is 3 mg/L.

3.2 RECENT EFFLUENT QUALITY

Table 3-2 summarizes the Municipality's average and maximum month effluent quality results for 41 months between January 2010 and May 2013, along with applicable future approval limits for comparison. Appendix B provides the detailed results for the approval parameters and some additional parameters.

⁴ Refer to TM A2.2.4, Treatment Technology Review.

AE's review of the data showed that the WWTF has performed very well with final effluent quality consistently within the current approval limits. Also, the effluent water quality was typically much better than the current approval limits.

With respect to future effluent limits to be achieved after July 1, 2015, the TSS and total phosphorus limits would not have been met consistently, suggesting that the WWTF may be at risk of violating the approval after that date unless plans to address this are put in place before that time.

Figures 3-1 and 3-2 illustrate the frequency distributions for TSS and TP between January 2010 and May 2013.

With respect to TSS, 3 of 41 (7%) monthly average TSS values exceeded the future TSS limit (10 mg/L). However, no exceedances of the future limit have been observed over the last 22 consecutive months of operation (since August 2011). That may reflect more stable secondary clarifier performance as a result of launder cover installation.

With respect to TP, 16 of 41 (39%) monthly average TP values exceeded the future TP limit (0.5 mg/L). Most of the exceedances (14 of 16) occurred during the colder operating months, generally within the January to May time period when biological nutrient removal (BNR) efficiency may have decreased slightly. Also, it should be noted that the phosphorus was primarily dissolved (not particulate). Therefore, it appears that coagulation / flocculation will be required prior to filtration in order to meet the lower TP limit consistently.

Table 3-2
Fort McMurray WWTF Monthly Effluent Quality Summary 2010 to 2013

Parameter	Units	Avg. ^a	Max. ^b	Future Limit	% Above Future Limit
CBOD	mg/L	3.3	5.7	10	0%
Total Suspended Solids (TSS)	mg/L	5.9	16.5	10	7% ^c
Total Phosphorus (TP)	mg/L	0.43	0.82	0.5	39% ^d
Ammonia-Nitrogen (NH ₃ -N)	mg/L	0.67	5.85	6 / 3	0%
pH	pH Units	7.24	7.44	6.5-9.5	0%
<i>E. Coli</i>	CFU/100 mL	38	151	200	0%

^a Except for *E. coli*, indicated values are the average of monthly averages based on daily composite samples.

For *E. coli*, values are the average of monthly geometric means based on grab samples 5 days per week.

^b Except for *E. coli*, indicated values are the maximum of all monthly averages based on daily composite samples.

For *E. coli*, values are the maximum of monthly geometric means based on grab samples 5 days per week.

^c Note 3 of 41 monthly average TSS values exceeded the future TSS limit.

^d Note 16 of 41 monthly average TP values exceeded the future TP limit.

3.3 EFFLUENT QUALITY WITH MAJOR COMPONENTS OUT OF SERVICE

As actual operating loads approach design loads, or with a major component out of service (e.g., a bioreactor or a clarifier), some deterioration of effluent quality would be expected. That would lead to more frequent exceedances of approval limits.

Figure 3-1
Effluent TSS Monthly Average Variation (2010-2013)

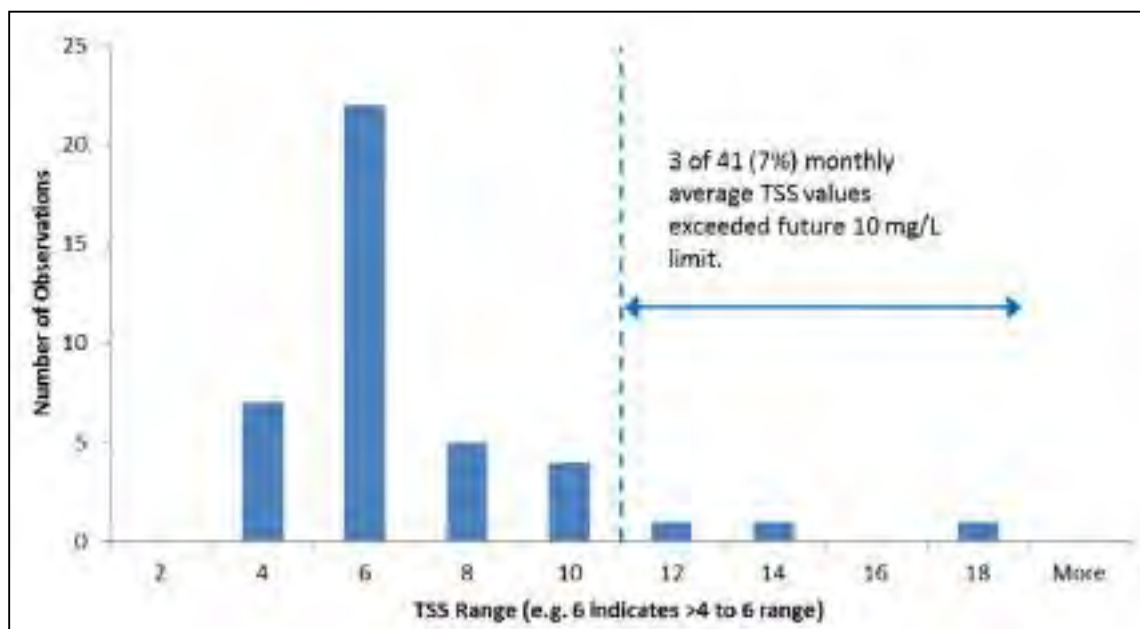
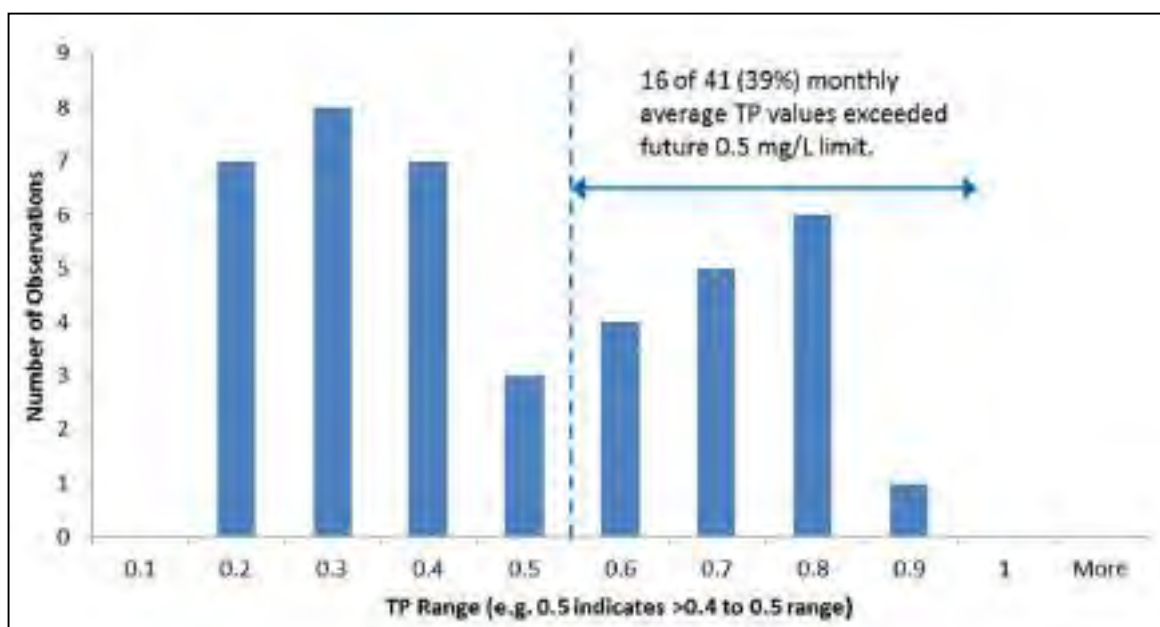


Figure 3-2
Effluent TP Monthly Average Variation (2010-2013)



3.4 EFFLUENT FILTRATION AND OTHER OPTIONS

It appears probable that the future 2015 Approval limits, especially for TSS and TP, will not be consistently met unless appropriate actions are taken. Following is a preliminary list of possible measures for consideration:

- Alum feed: Feed alum when effluent quality starts to deteriorate (TSS >10 mg/L or TP >0.5 mg/L). The facility already has alum feed facilities, so this measure could be readily accommodated without additional capital expenditures.
- BNR process optimization: Undertake a study of the facility's BNR process and determine if there are operational modifications that should be made to improve TP removal.
- Maintenance scheduling: If possible, schedule maintenance of major components during warmer summer months and non-high wastewater flow periods.
- Effluent filtration: Proceed with planning, design, and construction and operation of an effluent filtration facility. The detail design of the filtration facility needs to be initiated immediately to have the filtration facility operational by July 2015.
- All of the above.

3.5 RECOMMENDATIONS

AE recommends that the Municipality proceed with all of the above. Specifically:

- Target limits: Prior to July 1, 2015, consider the future limits as target limits so that operational experience can be gained with measures to meet the future limits.
- Maintenance scheduling: If/when major process components need to be taken off line for inspection or maintenance, try to schedule the work during warmer summer months and non-high wastewater flow periods.
- BNR process optimization: Review the BNR process and optimize, if possible, to meet the future limits.
- Alum feed: Operate the alum trim feed system when necessary to meet the future limits.
- Effluent filtration: Commence planning, design, construction, and operation of a new filtration facility as soon as possible to reduce the risk of non-compliant effluent quality.

4 Risk Assessment

4.1 REDUNDANCY RISKS

Based on Table 2-3 and related reviews, there are some areas of the WWTF that may be vulnerable to failure should one of the components fail or require removal from service for maintenance. Table 4-1 provides a preliminary list of the components along with their associated risks, implications, and preliminary estimates of risk severity. This table provided the basis for review at a Risk Workshop where the probability and severity of risks were assessed and prioritized for appropriate action (e.g., development of improved

operating protocols, alternative emergency operation, or addition of redundant equipment for operating reliability).

4.2 RISK ASSESSMENT WORKSHOP

AE facilitated a redundancy risk assessment workshop held at FMWWTF on June 26, 2013 with six individuals from the Municipality. The main purpose of the workshop was to identify and assess risks associated with the possible loss of a major process component either through a planned maintenance shutdown or through an unexpected failure, for example, one of two fine screens out of service or one of three bioreactors out of service. With the loss of a major component, the facility's total available capacity is reduced to its firm capacity.

Table 4-2 shows the risk assessment metrics that were utilized in the evaluation of redundancy risks. The probability of Identified risks occurring was evaluated ranging from "rare" to "almost certain" and assigned corresponding numerical values between "1" and "100". In addition, the severity of the risks occurring was evaluated ranging from "insignificant" to "extreme" and assigned corresponding numerical values between "5" and "700". The risk factor consequence was numerically determined as the product of "Probability" and "Severity". Lower consequence scores up to 199 were classified as "Negligible" and visually indicated as **GREEN**; medium consequence scores between 200 and 4999 were classified as "Medium" and visually indicated as **YELLOW**; higher consequence scores 5000 and above were classified as "Critical" and visually indicated as **RED**. These classifications are illustrated in a 5x5 risk consequence matrix in the lower right-hand corner of the Table.

Table 4-3 shows the results of the Municipality's redundancy risk assessments. The evaluation is based on the estimated firm capacities with 2013 loadings including direct septage discharges to the FMWWTF. Of the 29 redundancy risks that were identified and evaluated, seven (7) were determined to be critical risks, 19 were determined to be medium risks, and three (3) were determined to be negligible risks. The seven **CRITICAL** risk consequences clearly prioritize areas for which the Municipality should focus:

- Vortex grit chamber – single grit chamber out of service for maintenance: operations impact.
- Bioreactors – capacity reduction with one bioreactor out of service: effluent quality deterioration.
- Secondary clarifiers – exceedance of the 2015 TSS or TP limits without filtration: inadequate future effluent quality.
- Raw compost mixer – failure of single raw compost mixer: operations impact.
- Foul air blowers – explosion requiring complete shutdown of compost system: operations impact.
- Foul air wet scrubber – failure requiring termination of compost operations.
- SCADA – failure (no backup; manual operation not possible through entire plant): operations impact to the aeration system and automatic processes.

4.3 RISK SUMMARY

Table 4-4 shows the identified risks ranked from the highest down to the lowest priority areas.

Table 4-1
Existing WWTF Redundancy Risks

Component	Risks	Implications	Possible Mitigation	Risk Severity
Liquid Streams				
Influent Parshall Flume &/or Pipe	Need for Repair or Zero-Flow Calibration	Influent channel may require temporary shutdown – requires influent flow diversion to Cell 1.		M
Influent Fine Screens	Failure of 1 of 2 screens could result in the capacity of the remaining screen to be exceeded during peak flow events.	Surcharge Parshall flume - inaccurate influent flow measurement. Require raw sewage bypass to Cell 1.	Install a third screen.	H
	Excessive solids loading from direct septage discharge to facility may overload 2 operating screens, during peak Wet Weather Flow (WWF) events.	As above.	Could manage by directing septage discharges to the septage lagoon during peak WWF events, or install a third screen.	H
Vortex Grit Chamber	No grit removal during maintenance.	Grit tank needs to be bypassed either to influent pump wet wells or to Lagoon Cell 1. If flow is diverted to the pump wells, then there may be increased plant maintenance concerns. If flow is diverted to Cell 1, then there may be increased odour/maintenance concerns with Cell 1.		M
Bioreactors	Excessive grit loadings during WWF or high-inert solids in direct septage loads.	Possibility of grit equipment malfunctions and grit carry-over to downstream processes, increasing maintenance needs.	Septage haulers may require closer monitoring and control.	M
	Future treatment capacity restriction when 1 of 3 bioreactors is removed from service for maintenance.	Effluent quality may not meet the Approval limits.	Proposed SRWWTF may reduce some of the load. In future, consider 4" bioreactor for redundancy.	L
	Possible septage constituents that may upset or reduce biological treatment performance.	As above.	Septage haulers may require closer monitoring and control.	M
Process Air Blowers	Increased BOD loads from direct septage discharges may increase air supply requirements beyond the capability of 2 of 3 operating blowers.	Process implication – exceeds BOD limit	May require a 4" blower soon for complete redundancy, without the proposed SRWWTF to relieve some of the load.	H
Process Air Diffusers	Condition and/or oxygen transfer efficiency of air diffusers may have deteriorated.	Diffusers should be inspected. Oxygen transfer deterioration can be roughly checked by comparing blower operating records between years.	Diffuser membrane replacement may be desirable.	M
Secondary Clarifiers	With the effluent Approval limits lowering in 2015, satisfactory clarifier performance could be challenged.	Effluent quality may not meet the Approval limits.	Likely necessary to design/construct an effluent filtration system.	H
UV Disinfection	Periodic inadequate performance with increasing flows? Previous review of partial 2009/10 data showed that the monthly limit (200 E.coli/100 mL) is sometimes approached; therefore we wonder if meeting the limit will be more challenging as flows increase.	Possible exceedance of the approval limit with increasing flows.	The proposed SRWWTF should help by treating a portion of the flow.	M
	One or two UV banks are out of service.	Possible inadequate disinfection.	Effluent filtration to improve disinfection efficiency.	H
Effluent Parshall Flume	Need for Repair or Zero Flow Calibration	Flows to secondary treatment may require temporary diversion to Cell 1.		M
Effluent Outfall Pipe	No capacity if ice jam causes floods approaching 250 m elevation.	No hydraulic capacity to discharge effluent.	Plant flows would require temporary diversion to the on-site lagoon storage during such an event.	H
	Reduced capacity for the WWTF if the future SRWWTF eventually discharges effluent through the outfall pipe.	The SRWWTF may require its own filtration and UV disinfection rather than relying on the FMWWTF.	The possible future tie-in of the SRWWTF outfall should enable multiple connection locations at FMWWTF.	M
	Need for repair or maintenance.	Flows to secondary treatment may require temporary diversion to Cell 1.		M

Component	Risks		Implications	Possible Mitigation	Risk Severity
Solids and Related Streams					
Fermenters	If one fermenter is off-line for maintenance, the other fermenter may have inadequate VFA production capacity for biological phosphorus removal.		May need to dose significant amounts of alum for chemical phosphorus removal until VFA production capacity is restored.	May need to install a third fermenter, subject to confirmation of fermenter performance.	H
Centrifuged Solids Conveyor System	No redundancy if single horizontal dewatered sludge conveyor is off-line for an extended period (a few days).	Centrifuges cannot operate.	Raw dilute sludge may have to be pumped to the lagoons - significant odour concerns.	Raw dilute sludge may have to be pumped to the lagoons - significant odour concerns.	M
	No redundancy if single inclined dewatered sludge conveyor is off-line for an extended period (a few days).	The proposed new horizontal conveyor will have a reversing function to enable centrifuging to continue; however, this may incur significant operating difficulties since the dewater sludge would have to be continually removed from the centrifuge room floor and transported to the compost building.	As above or ensure operations can manage sludge removal from the centrifuge room floor.	As above or ensure operations can manage sludge removal from the centrifuge room floor.	M
DAF – WAS Thickening	Failure of 1 of 2 DAF units	Hydraulic overloading of centrifuges	Discharge excess dilute WAS to Cell 1	Discharge excess dilute WAS to Cell 1	H
Raw Compost Mixer	The single raw compost mixer equipment may fail (no redundancy).	This would be a cumbersome, time-intensive operation.	The dewatered solids could be manually mixed with recycled compost and wood chips using the loader.	The dewatered solids could be manually mixed with recycled compost and wood chips using the loader.	M
	The effective capacity of the raw compost mixer could be reached.	May require extended operating hours (to load the mixer).	Alternatively an additional mixer could be considered.	Alternatively an additional mixer could be considered.	M
Raw Compost Conveyor	The single raw compost inclined conveyor may fail (no redundancy).	The compost mixer would have to be bypassed.	The dewatered solids could be manually mixed as described above.	The dewatered solids could be manually mixed as described above.	M
Compost Tunnels	Potential dangerous gas production (H2S - health/safety hazard and CH4 - fire/explosion hazard) if the single compost blower for an operating tunnel fails and compost is left for a prolonged period (a few days) in the tunnel.	The defective compost blower could be repaired (if parts are available) or replaced (if a spare blower is available). Alternatively, the compost mixture would have to be moved to another tunnel to continue composting.			H
Foul Air Blowers (extracting air from compost tunnels)	Explosion - 100% probability as that happened!	The compost system needs to be shut down. Raw, dewatered solids need to be transported to the landfill. This is a temporary measure as the landfill does not want to dispose of raw sludge.	Design/install improved foul air blowers.	Design/install improved foul air blowers.	H
	Freezing of foul air drain pipes and ice accumulations - building shell is open and has no heat.	Hazardous environment.	Improve building environment.	Improve building environment.	H
Foul Air Treatment - Stage 1 Wet Scrubber	No redundancy when scrubber requires maintenance.	Compost system cannot be operated when scrubber is off line.	Consider duplicate scrubber.	Consider duplicate scrubber.	M
Foul Air Treatment - Stage 2 Biofilters	Possible inadequate odour control when one of the two biofilters is off line for maintenance.	Excessive odor.	Consider additional biofilter.	Consider additional biofilter.	M

Low:

Medium:

High:

L

M

H

Risk Severity:

Table 4-2
Risk Assessment Metrics

Project:

Client:

File No.:

Subject:

Created By:

Revision:

Fort McMurray WWTF Wastewater Master Plan

Regional Municipality of Wood Buffalo

2012-3694.00.E.03.02

Redundancy Risk Assessment TM A.2.2.3

Daniel du Toit / Pat Given / RMWB Workshop

June 26/13 rev 2

		cells with input/ assumed values										
Probability of Occurrence		Description		Value								
rare unlikely possible likely almost certain		possible but surprising not expected within next 5 years less than 50-50 chance within next 5 years more than 50-50 chance within next 5 years expected (more than 50/50 chance within next year)		1 10 25 50 100								
No Severity of Impact		Risk Factor-Specific Description		Value								
insignificant minor 1 moderate major extreme		Potential for short- and long-term deterioration of effluent quality: - no impact on ability to meet AENV Approval monthly average concentration requirements - minor regulatory breach (e.g. effluent out of compliance 1 month out of 12 months for only 1 parameter (e.g. N or P only)) - moderate regulatory breach (e.g. effluent out of compliance 1 month out of 12 months for multiple parameters (e.g. N and P)) - major regulatory breach (e.g. effluent out of compliance for multiple months of the year for multiple parameters) - inability to meet AENV Approval monthly average concentration requirements		5 15 50 200 700								
insignificant minor 2 moderate major extreme		Potential for operations disruption: - up to \$10K increase in event annual O&M cost - \$11K to \$50K increase in event annual O&M cost - \$51K to \$200K increase in event annual O&M cost - \$201K to \$400K increase in event annual O&M cost - > \$400K increase in event annual event O&M cost		5 15 50 200 700								
insignificant minor 3 moderate major extreme		Potential for odour generation: - No noticeable fence-line odours and not more than one odour complaint annually. - Occasional noticeable fence-line odours and not more than four odour complaints annually. - Occasional significant fence-line odours and not more than four odour complaints annually. - Frequent odour complaints or ABENV intervention. - Frequent odour complaints, ABENV intervention, and negative press.		5 15 50 200 700								
Risk Factor Consequence (Probability x Severity)		Procedural Notes		Severity Definition								
negligible		upper boundary set by a minor impact with an unlikely probability; include in calculation of total risk severity score		0 to 199								
medium		lower boundary set by a moderate impact with likely probability; include in calculation of total risk severity score		200 to 4999								
critical		lower boundary set by a major impact with a likely probability		>=5000								

Table 4-3
Municipality Risk Workshop Assessment
Based on 2013 Firm Capacity with Direct Septage Discharge

#	Redundancy Risk Factor	Primary Risk Impact	With Direct Septage			Notes, Assumptions, Event Duration
			Prob (P)	Severity (S)	Conseq (P*S)	
Liquid Streams						
1	Influent Parshall Flume - channel shut down for calibration/repair	2. Operations	1	5	5	Manual flow diversion to Cell 1 required for up to 1 day duration.
2	Influent Fine Screens - 1 of 2 screens not operational during peak flow event.	2. Operations	100	5	500	Partial diversion of influent flow to Cell 1 over a 1 day period (during peak flow event).
3	Vortex Grit Chamber - Out of service for maintenance.	2. Operations	100	50	5000	Contingent upon parts availability, vortex grit chamber may be out of operation for 3 mths. Screened, un-degritted wastewater will flow to the influent pump station during this condition. Down on high flow event for 6 hrs.
4	Bioreactors - capacity reduction with one bioreactor out of service for maintenance.	1. Quality	100	200	20000	For planned maintenance, bioreactor will be shut down for 5 mths. Under an emergency event (e.g. structural crack/leakage), bioreactor will be out of service for up to 9 mths. During cold weather.
5	Blowers - reduced capacity with 1 of 3 blowers out of service.	1. Quality	100	5	500	1 blower may be out of service for up to 6 mths for parts/repair.
6	Diffusers - reduced bioreactor capacity with deterioration of diffusers or downtime for diffuser replacement.	1. Quality	50	15	750	For planned maintenance, bioreactor will be shut down for 1 mth. Under an emergency event (e.g. sudden deterioration of diffusers), bioreactor will be out of service for up to 9 mths.
7	Secondary clarifiers - exceedance of 2015 TSS or TP limits without effluent filtration.	1. Quality	100	200	20000	With a clarifier out of service for planned maintenance, duration will be up to 1 mth; this will increase the risk of the clarifiers not meeting the TSS or TP limits. Alum may have to be fed to improve TSS & TP removal during this time.
8	UV Disinfection - bacterial quality of effluent deterioration as UV bulbs age.	1. Quality	100	5	500	With proper tracking of UV system performance, this event should be predictable and last no more than 1 wk. Effluent E.coli numbers may slightly exceed the approval limit during this period.
9	UV Disinfection - One of two UV banks out of service.	1. Quality	100	15	1500	1 of 2 UV banks out of service for up to 1 wk for repair.
10	Effluent Parshall Flume - channel shut down for calibration/repair	2. Operations	10	5	50	Diversion of primary effluent to Cell 1 over a 1 wk period. Alternatively, temporary pumping around the flume to maintain continuous flow through the effluent outfall.
11	Effluent Outfall - Inadequate capacity if 1:100 year ice jam level is approached (250 m).	2. Operations	1	700	700	Total influent diversion to Cell 1/6 over a 1 wk period.At 248 m downtown is flooded.
12	Effluent Outfall - Need for repair or maintenance.	2. Operations	1	700	700	Re-direct flow through existing outfall (assuming it is not de-commissioned) during normal flow conditions.

Table 4-3
Municipality Risk Workshop Assessment
Based on 2013 Firm Capacity with Direct Septage Discharge

#	Redundancy Risk Factor	Primary Risk Impact	With Direct Septage			Notes, Assumptions, Event Duration
			Prob (P)	Severity (S)	Conseq (P*S)	
Solids and Related Streams						
13	Fermenters - 1 of 2 fermenters off line for maintenance.	1. Quality	75	50	3750	Potentially inadequate VFA production and fermenter off line for up to 3 mths. Alum feed may be required as a backup measure. Proper BNR operation may take an additional month to become established.
14	Horizontal Centrifuged Solids Conveyor - No solids processing capacity if converer down for maintenance.	3. Odour	100	15	1500	Subject to parts availability, conveyer may be out of service for up to 2 days; primary and secondary sludge may be diverted to lagoons during this period. As a temporary measure, a badly damaged horizontal conveyer could be moved out of the way and dewatered solids discharged to the floor for manual transfer to the compost building.
15	Inclined Centrifuged Solids Conveyor - Operational challenges if conveyer down for maintenance (interim manual handling of dewatered sludge).	2. Operations	100	5	500	Inclined sludge conveyor may be down for up to 2 days (spare parts on site).
16	DAF WAS Thickening - Failure of 1 of 2 DAF units.	3. Odour	100	5	500	One DAF out o service all the time (one is standby)
17	Raw Compost Mixer - Failure of single raw compost mixer.	2. Operations	50	200	10000	Raw sludge will need to be mixed with wood chips using the loader for up to 3 mths duration.
18	Raw Compost Conveyor - Failure of conveyer.	2. Operations	100	5	500	Raw sludge will need to be mixed with wood chips using the loader for up to 2 days duration (spare parts on site).
19	Compost tunnels - Dangerous gas formation if blower for tunnel goes down and composting solids not promptly removed.	2. Operations	50	15	750	Any 1 compost tunnel may be out of operation for up to 3 mths. SOP should ensure partially composted sludge is promptly removed for processing in an operational tunnel.
20	Foul air blowers - Explosion requiring complete shutdown of composting system.	2. Operations	100	700	70000	Compost operation could be out of service for at least 1 year. Interim haulage of raw dewatered sludge to landfill.
21	Foul air blowers - Freezing issues.	2. Operations	5	700	3500	Permanent heat being installed and space enclosed.
22	Foul air scrubber - Failure requiring termination of compost operations.	2. Operations	100	50	5000	The Stage 1 scrubber cannot be bypassed (nor should it due to overloading of the biofilters. Compost process may be interrupted for up to 3 days.
23	Biofilters - 1 of 2 biofilters off line for maintenance.	3. Odour	25	15	375	The operational biofilter will have increased loading for up to 1 mth duration.
Electrical						
24	Electrical Supply	2. Operations	100	5	500	Failure of power supply. Two backup generators available.
25	Backup generator fails.	2. Operations	1	700	700	
26	Main MCC failure	2. Operations	1	700	700	Internal equipment failure.
27	SCADA failure	2. Operations	10	700	7000	No backup at present. Manual operation required and not possible through whole plant.
28	Server Room failure	2. Operations	1	700	700	Potential fire/overheat/intrusion/lightning
29	UPS	2. Operations	1	5	5	By-pass on UPS

Table 4-4
Municipality Risk Workshop Assessment
Risk Prioritization and Risk Mitigation Plan

Redundancy Risk Factor	Risk Severity	Risk Mitigation
Foul air blowers - Explosion requiring complete shutdown of composting system.	70000	Re-design / re-construct foul air system.
Bioreactors - capacity reduction with one bioreactor out of service for maintenance.	20000	Full build out: 4 th bioreactor.
Secondary clarifiers - exceedance of 2015 TSS or TP limits without effluent filtration.	20000	Full build out: 4 th secondary clarifier.
Raw Compost Mixer - Failure of single raw compost mixer.	10000	Ensure complete spare parts are stocked and labour will be available for emergency repairs.
SCADA failure	7000	Ensure shelf spare PLC and contract for integrator emergency service.
Vortex Grit Chamber - Out of service for maintenance.	5000	Ensure operational strategies are in place to minimize downtime. Also consider design modifications to improve operating reliability (e.g. air or water scour at suction pipe entrance during peak grit loadings). Ensure complete spare parts are stocked and labour will be available for emergency repairs.
Foul air scrubber - Failure requiring termination of compost operations.	5000	Ensure operational strategies are in place to minimize downtime. Ensure complete spare parts are stocked and labour will be available for emergency repairs.
Fermenters - 1 of 2 fermenters off line for maintenance.	3750	Full build out: 3 rd fermenter.
Foul air blowers - Freezing issues.	3500	Permanent heat being installed and space enclosed.
UV Disinfection - One of two UV banks out of service.	1500	Ensure adequate spare parts are available in the event that one of the banks completely fails. Note that the UV disinfection efficiency is expected to improve once the proposed filtration facility is constructed. Possibly the UV system's firm capacity will be adequate following filter installation.
Horizontal Centrifuged Solids Conveyor - No solids processing capacity if conveyor down for maintenance.	1500	Ensure operational strategies are in place to minimize downtime. Ensure complete spare parts are stocked and labour will be available for emergency repairs.
Diffusers - reduced bioreactor capacity with deterioration of diffusers or downtime for diffuser replacement.	750	Full build out: 4 th bioreactor.
Compost tunnels - Dangerous gas formation if blower for tunnel goes down and composting solids not promptly removed.	750	Ensure operational strategies are in place to minimize downtime. In the longer term, consider sludge gasification.
Effluent Outfall - Inadequate capacity if 1:100 year ice jam level is approached (250 m).	700	Ensure emergency response plans are well developed to cope with floods and other possible emergency conditions.
Effluent Outfall - Need for repair or maintenance.	700	Re-direct flow through existing outfall (assuming it is not de-commissioned) during normal flow conditions.
Backup generator fails.	700	No additional risk mitigation is recommended. The generators provide back-up to power supplies. Backing up a back up would be expensive.
Main MCC failure	700	Consider making prior arrangements for temporary generator(s) that could run critical components that are affected.
Server Room failure	700	Provide off-site standby server.
Influent Fine Screens - 1 of 2 screens not operational during peak flow event.	500	Full build out: 3 rd screen.
Blowers - reduced capacity with 1 of 3 blowers out of service.	500	Full build out: 4 th process air blower.
UV Disinfection - bacterial quality of effluent deterioration as UV bulbs age.	500	Ensure proper tracking of UV system performance and clean or replace bulbs proactively.

Table 4-4
Municipality Risk Workshop Assessment
Risk Prioritization and Risk Mitigation Plan

Redundancy Risk Factor	Risk Severity	Risk Mitigation
Inclined Centrifuged Solids Conveyer - Operational challenges if conveyer down for maintenance (interim manual handling of dewatered sludge).	500	Ensure operational strategies are in place to minimize downtime. Ensure complete spare parts are stocked and labour will be available for emergency repairs.
DAF WAS Thickening - Failure of 1 of 2 DAF units.	500	Full build out: 3 rd DAF unit.
Raw Compost Conveyer - Failure of conveyer.	500	Ensure operational strategies are in place to minimize downtime. Ensure complete spare parts are stocked and labour will be available for emergency repairs.
Electrical Supply	500	No additional mitigation recommended.
Biofilters - 1 of 2 biofilters off line for maintenance.	375	Temporarily reduce compost operations as may be required to reduce foul air flows during biofilter maintenance.
Effluent Parshall Flume - channel shut down for calibration/repair	50	Either divert primary effluent to Cell 1 or temporarily pump around the flume.
Influent Parshall Flume - channel shut down for calibration/repair	5	Manual flow diversion to Cell 1.
UPS	5	Replace with "Always ON" UPS when existing UPS requires replacement.

5 Conclusions

The main conclusions arising from the review of the FMWWTF component capacities and redundancy risks are summarized as follows:

- **Firm Hydraulic Capacity:** The firm hydraulic capacity currently may be approached or exceeded for some major processes with the largest unit process of each type out of service (UV disinfection, fermenters, DAF, centrifuges, Stage 1 wet scrubber, and Stage 2 biofilters). In addition, the possible need to remove various other single components from service could impact the hydraulic capacity (influent conduit and Parshall flume, vortex grit chamber, effluent conduit and Parshall flume, centrifuged solids conveyor system, raw compost mixer, and raw compost conveyor).
- **Load Capacity:** The rated hydraulic capacities will be reduced if higher strength wastewater from direct handling of septage contributes to higher loads than accommodated by the design.
- **Firm Current (2013) Load Capacity:** Several processes appear at risk of having their design loads exceeded with direct septage addition during peak flow or loading events if a critical component is out of service.
- **Firm Near-Term (2018) Load Capacity:** The risks increase. These include possible excessive loads applied to the influent fine screens, grit tank, UV disinfection, fermenters, DAF, and Stage 2 biofilters. Therefore, full build-out of FMWWTF will be necessary if performance verifications (see recommendations) do not re-rate component capacities significantly upwards.
- **Firm Near-Term (2018) Full Build-Out Load Capacity:** With full build-out, two processes (grit removal and UV disinfection) appear at risk of overloading, during peak flow or loading events, if one of the major units is out of service (i.e. one of two UV banks or the one grit tank).
- **Redundancy Risks:** There are several major processes that rely on all components to be operating effectively to provide full treatment. In addition, there are a number of single components (e.g. sludge conveyors), which should they fail, satisfactory operations would be challenged.
- **Effluent Quality:** The WWTF has been in full compliance with its approval limits. However, it appears probable that the future 2015 Approval limits will not be met, unless appropriate actions are taken. In particular, effluent filtration should improve TSS and TP removal, as well as UV-transmittance for improved disinfection. Effluent filtration may have to be preceded by coagulation/flocculation to precipitate dissolved phosphorus.
- **Priority Areas:** At the redundancy risk workshop, the Municipality identified the following priority areas for upgrade or operations optimization:
 - Vortex grit chamber – single grit chamber out of service for maintenance: operations impact.
 - Bioreactors – capacity reduction with one bioreactor out of service: inadequate effluent quality deterioration.
 - Secondary clarifiers – exceedance of the 2015 TSS or TP limits without filtration: inadequate future effluent quality.
 - Raw compost mixer – failure of single raw compost mixer: operations impact.
 - Foul air blowers – explosion requiring complete shutdown of compost system: operations impact.

- Foul air wet scrubber – failure requiring termination of compost operations.
- SCADA – failure (no backup; manual operation not possible through entire plant): operations impact to the aeration system and automatic processes.

6 Recommendations

- **General:** The identified redundancy risks are largely established based on the review of available information on WWTF component design capacities.
- **Septage Impacts:** The Municipality should gather additional data on individual septage loads. The Municipality may also wish to encourage high strength/load haulers to seek other waste management solutions in an effort to defer costly WWTF component additions. When the septage is discharged directly to the plant in the near future, the Municipality should closely monitor the loading and performance impacts, and be prepared to make adjustments to the direct septage plan.
- **Effluent Quality:**
 - Prior to July 1, 2015, the Municipality should consider the future limits as target limits to gain improved operation experience. Alum feeding, BNR process optimization, and maintenance scheduling should be utilized as required to meet the target limits.
 - The Municipality start communications with AESRD regarding the planned improvements and seek an Approval amendment or authorization to consider the more stringent limits are target limits rather than fixed limits until the filtration facility is commissioned and operating reliably.
 - Planning, design, construction, and operation of the proposed filtration facility should commence as soon as possible. Filtration will also help assure adequate disinfection when one of the UV banks is out of service. Bench or pilot scale testing should be considered as part of the filtration facilities predesign to confirm coagulation/flocculation requirements prior to filtration.
- **Prioritization of Improvements:** In addition to the recommended filtration upgrade, a prioritized plan of action should be developed, mainly focusing on the items identified with critical risk consequences at the risk assessment workshop. Tentatively this plan should include:
 - Vortex grit chamber – operations procedures;
 - Bioreactors – full build-out (4th bioreactor);
 - Secondary clarifiers – full build-out (4th secondary clarifier);
 - Raw compost mixer – operational procedures;
 - Foul air blowers – replacement (in progress);
 - Foul air wet scrubber – operational procedures;
 - SCADA – provide sufficient backup to enable automated operation at all times; and
 - Other redundancy risks – operational procedures.

TECHNICAL MEMORANDUM A.2.2.3

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to review the treatment capacity of Fort McMurray's main Wastewater Treatment Facility components. The report also reviewed the redundancy systems incorporated into the existing plant and the possible consequences of failure of the redundancy systems.

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.

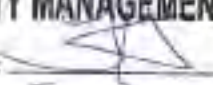
Respectfully submitted,
Associated Engineering Alberta Ltd.



Edith Asselin, M.Eng., P.Eng., LEED AP
Project Manager



Patrick W. Given, P.Eng.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF	
Signature:	
Date:	Feb 10, 2014
APEGA Permit to Practice P 3979	

Appendix A – WWTF Brochure



Regional Municipality of Wood Buffalo Waste Water Treatment Facility

Grand Opening
Tuesday, May 25, 2010



Overview

Fort McMurray was treating its sewage in mechanically aerated treatment lagoons that were built in the 1970s and 1980s. Designed to meet the needs of up to 62,000 residents, the former plant was reaching both its capacity and lifespan.

To address the significant growth in Fort McMurray and new operating license requirements, the existing aerated sewage lagoon had to be replaced with a tertiary waste water treatment plant.

The project involved the construction of a new state-of-the-art facility which reclaims the City of Fort McMurray's wastewater and returns to the environment with significantly improved effluent quality.

Demonstrating leadership in environmental design, the Waste Water Treatment Plant strives to achieve LEED (Leadership in Energy and Environmental Design) Certification from the Green Building Council. The plant uses Biological Nutrient Removal Technology and has a composting facility to further reduce its environmental footprint. This plant will be unique in Canada as one of the new LEED certified wastewater facilities.

The project was separated into three phases. Phase 1 was built to serve 85,000 people with a capacity of 52 million litres per day. During Phase 1 construction, rapid population growth necessitated Phase 2 advancement to serve 133,000 people with a capacity of 52 million litres a day. A future Phase 3 will provide additional process back-up for the Phase 2 design population.

In addition to addressing the increased population in Fort McMurray, the new facility now can handle the increase in trucked sewage, much of which is from industrial construction camps. Wastewater from truck haul has more than tripled since 2004, adding an equivalent population of 16,000 to 20,000 people.

Owner:

Regional Municipality of Wood Buffalo

Project Management:

Associated Engineering

Prime Consultant:

AECOM

Contractor:

Bird Construction

Facility Specifications

Design Population:

133,000 people

Average Capacity:

52 million litres per day

Maximum Capacity:

125 million litres per day

Technologies Used:

- fine screening
- vortex grit removal
- biological nutrient removal
- ultraviolet disinfection
- dissolved air flotation
- biosolids composting
- solids dewatering with centrifuges
- odour control (scrubber and biofilters)

Project Challenges

One of the major challenges for this project was defining the population forecasts for such a dynamic and growing city.

Population census results confirmed that the population was increasing much faster than originally projected. Based on increased population growth rates, Phase 1 capacity of 85,000 persons was reached in 2009 (nearly tripling the population in less than ten years), and was originally projected to be reached in 2015. As a result, Phase 2 expansion was fast-tracked for completion in early 2010.

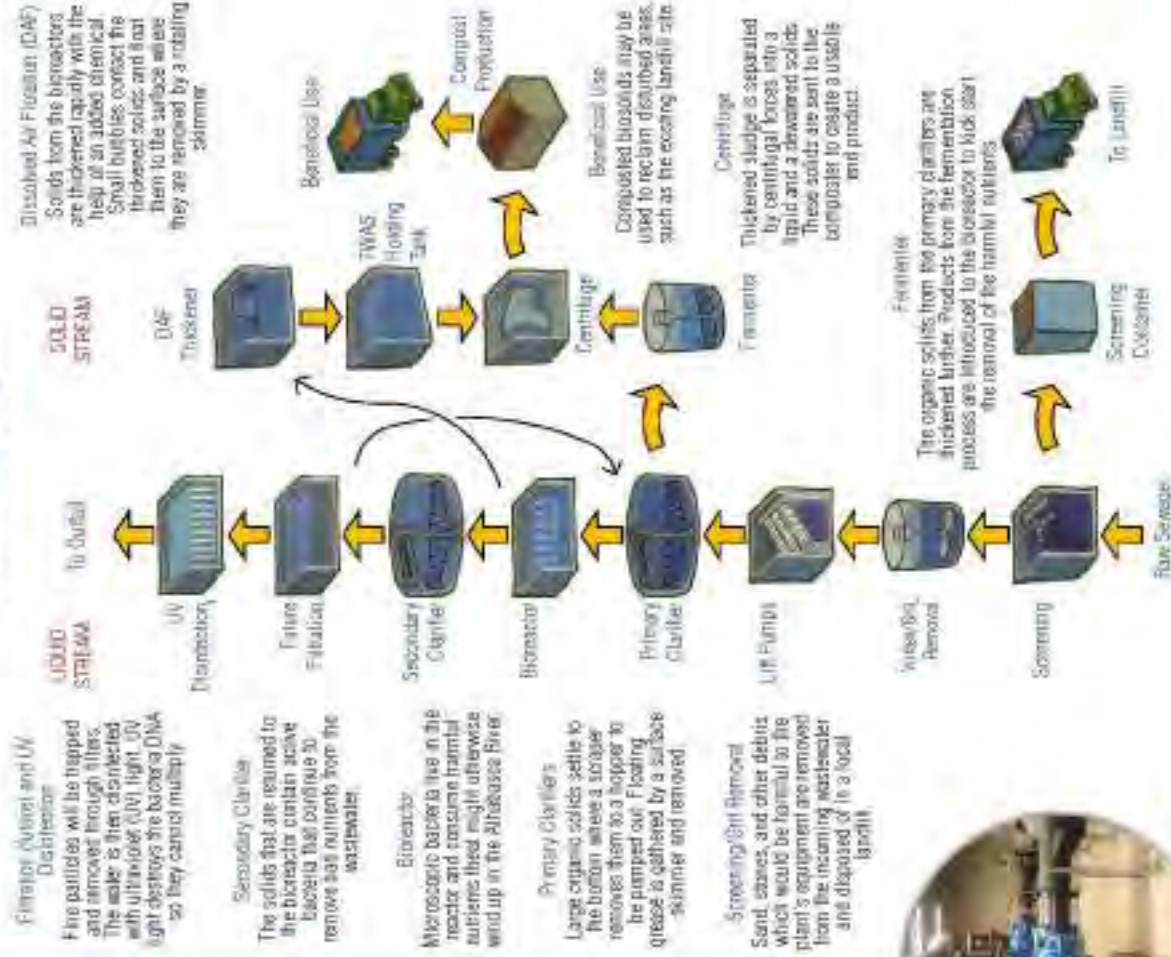
Costs

Phase 1 - Main Construction Contract - \$160,900,000

Phase 2 - Advancement - \$58,100,000

Total - \$219,000,000

Process Flow Diagram



Appendix B – Mean Effluent Monthly Data

Appendix B
RMWB Fort McMurray WWTF - Mean Effluent Monthly Data

Month	BOD mg/L	CBOD mg/L	TSS mg/L	Total Phosphorus mg/L	Ammonia- Nitrogen mg/L	pH	E Coli CFU/100 ml	UV Transmit- tance %	Flow ML/day
Current Limit		20	20	1.0	10 / 5	6.5 - 9.5	200		
2015 Limit		10	10	0.5	6 / 3	6.5 - 9.5	200		
2010/01	7	4	6	0.32	0.33	6.98	102	61.1	20.6
2010/02	9	5	12	0.37	1.23	7.21	46	64.2	21.2
2010/03	15	4	6	0.46	3.80	7.03	81	60.3	25.4
2010/04	11	5	9	0.59	1.29	7.14	34	59.4	24.9
2010/05	10	6	17	0.50	0.29	7.19	37	59.5	26.0
2010/06	5	3	6	0.27	0.10	7.28	30	53.7	24.8
2010/07	5	3	5	0.23	1.28	7.37	21	57.8	23.4
2010/08	5	3	3	0.13	0.65	7.35	17	63.1	25.2
2010/09	4	2	3	0.16	0.34	7.24	27	62.4	25.7
2010/10	5	2	3	0.19	0.26	7.29	46	58.1	24.2
2010/11	6	4	4	0.21	0.72	7.32	31	58.9	24.2
2010/12	9	3	5	0.34	0.76	7.37	54	58.4	24.4
2011/01	7	2	3	0.21	0.71	7.40	53	59.4	23.6
2011/02	9	3	4	0.37	0.57	7.38	40	59.6	23.7
2011/03	8	3	5	0.74	0.37	7.35	39	59.4	23.7
2011/04	5	3	5	0.66	0.27	7.33	151	60.6	25.6
2011/05	6	4	8	0.68	0.16	7.27	14	55.2	25.0
2011/06	7	3	8	0.34	0.27	7.28	11	59.1	22.1
2011/07	6	4	11	0.60	0.13	7.32	19	55.4	20.2
2011/08	5	3	6	0.45	0.28	7.41	53	49.4	24.2
2011/09	6	4	8	0.82	2.33	7.33	44	59.0	22.0
2011/10	6	3	5	0.22	0.66	7.21	10	64.5	19.7
2011/11	5	2	5	0.15	0.24	7.32	46	62.7	22.6
2011/12	6	3	6	0.22	0.07	7.37	72	56.3	25.0
2012/01	7	3	6	0.71	0.24	7.33	7	57.7	26.2
2012/02	7	3	6	0.63	0.08	7.29	50	57.4	25.6
2012/03	8	4	6	0.76	0.17	7.36	51	57.7	25.5
2012/04	6	2	5	0.78	0.22	7.29	20	75.2	24.2
2012/05	4	3	3	0.38	0.43	7.33	47	55.0	22.9
2012/06	5	4	8	0.35	2.05	7.44	54	51.5	24.6
2012/07	4	2	6	0.28	0.03	7.42	19	57.4	28.9
2012/08	4	2	4	0.13	0.04	7.43	30	57.3	21.6
2012/09	4	2	5	0.13	0.07	7.34	30	58.6	25.7
2012/10	4	3	4	0.15	0.03	7.17	15	59.4	25.8
2012/11	5	3	4	0.30	0.07	7.05	27	54.5	26.9
2012/12	6	4	4	0.58	0.19	6.91	42	51.7	25.7
2013/01	7	5	6	0.78	0.08	6.84	11	52.7	
2013/02	6	4	5	0.56	0.06	6.95	10	55.7	
2013/03	8	5	6	0.73	0.33	6.87	12	55.7	
2013/04	23	4	5	0.66	5.85	7.05	7	55.8	
2013/05	7	3	6	0.42	0.60	7.19	35	51.6	

Values exceeding the July 1, 2015 approval limit.

No values exceeded the current approval limit.

Summary:

Min Month	4	2	3	0.13	0.03	6.84	7	49.4	19.7
Avg Month	7	3	6	0.43	0.67	7.24	38	58.1	24.2
Max Month	23	6	17	0.82	5.85	7.44	151	75.2	28.9

TECHNICAL MEMORANDUM A.2.2.4

Regional Municipality of Wood Buffalo

Treatment Technology Review



January 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE

Master planning work necessarily considers long-term horizons (25 year +) and this technical memorandum (TM) raises the question of how treatment technology is changing, or may change, over such a horizon in response to three key contexts: 1) responding to changing effluent quality requirements as needed, 2) implementing more efficient “core” WWTF technology as appropriate and 3) adopting main-stream resource recovery as justified.

In response to this situation, the primary objective of this TM is to identify key technical drivers that could significantly influence the Municipality's near- and longer-term decision-making as related to its wastewater treatment facilities (WWTFs) and their associated technologies. A secondary objective is to outline a practical strategy that the Municipality can implement to assist in ongoing planning and decision-making in light of technology change.

2 MAIN FINDINGS

In terms of **Context 1**, the Alberta Environment and Sustainable Resource Development (AESRD) Approval 689-02-00 requirements, and the technologies required to achieve them, likely provide 10 years plus future-proofing in currently regulated and un-regulated effluent constituents. Accommodating the potential future addition of trace organic compounds (TOxC) as a newly added class of regulated effluent constituents in the longer-term will likely be the most significant challenge for the Municipality. This situation may drive a need for add-on unit processes to complement the core technologies currently used at the Fort McMurray WWTF and are planned for the proposed South Regional WWTF that provide secondary treatment and nutrient removal.

For currently regulated effluent constituents, a future lowering of Approval concentration-based limits, should it occur, would most likely impact the Municipality from an operations perspective rather than requiring capital-intensive outright technology change or addition. Minor capital works improvements might be needed. These conclusions are predicated on the assumption, which remains to be confirmed, that effluent filtration will be needed to meet the Year 2015 total phosphorus limits in the Approval. At the same time, optimization opportunities may exist currently to reduce effluent ortho-phosphate levels and could be important for the filtration topic as related to the Year 2015 total phosphorus requirements.

With respect to **Context 2**, the technology decisions made by the Municipality for the Fort McMurray WWTF were based on what is now essentially 30 year old nutrient removal technology. Today, a decade following those decisions, finds the industry on the cusp of some dramatic step changes in biological system technology in the years ahead. Although the Municipality is well-advised to continually monitor technology development in terms of its existing and planned WWTFs, two specific examples stand out. Aerobic

granular biomass (ASB) technology has already seen full-scale implementation in both the municipal and industrial sectors and its purported advantages are difficult to ignore. At the time (e.g. 10 years from now) the Municipality needs to confirm technology choices for the existing Fort McMurray WWTF, and potentially a new South Regional WWTF, it is likely that sufficient industry experience will exist to make confident decisions on the technology. Main-stream deammonification (MSD) is another technology that the Municipality ought to consider earnestly for its potential benefits should it be successfully developed and implemented in a municipal setting. Facility technology decisions needed at a point in time of 10 years from now will likely provide opportunity for the Municipality to consider MSD process technology. Planning for potential transition to MSD could begin sooner.

Context 3 is essentially new for the Municipality and could have a significant influence on its WWTFs in terms of effluent nutrient removal simultaneous with nutrient recovery. However, Fort McMurray WWTF technology-related decisions that the Municipality will need to make in the foreseeable future appear reasonably insensitive to the influences of at-source urine separation should the Municipality wish to adopt such a wastewater management strategy as it is a long-term initiative. The greenfield nature of the proposed South Regional system and WWTF means technology decisions could be significantly influenced if urine separation was pursued. Furthermore, post-treatment extractive nutrient recovery (PTENR) technologies are still very early in their development stages and, perhaps more importantly, the commercial market (i.e., oil sand-related reclamation activities) for the resultant products is presumably largely unknown at this time. But this may change over time and, given the range of potential PTENR benefits, it would be prudent for the Municipality to consider it in its WWTF decision-making.

3 RECOMMENDATIONS

On the basis of these findings, we offer the following strategy to guide the Municipality in its ongoing planning and decision-making in light of technology change:

- Develop a **conservative plan** for cash flow and land area requirements: One of the purposes of a master plan, at least where WWTFs are concerned, is to provide an understanding of the cash flow requirements over time to ensure future capital, operations and maintenance costs are adequately funded. Similarly, WWTFs require land area and master planning ensures sufficient space for long-term needs gets secured. Both ends can be accomplished reasonably using business-as-usual WWTF technology assumptions as they are a known commodity in many ways. And these assumptions will end up being conservative—the promise of the kinds of technology change discussed in this TM are less expensive, more compact, less energy use, etc.—thus, they will help to future-proof the cost and land area topics.
- Formulate a **future uncertainty analysis** that can be integrated with a triple-bottom-line (TBL) evaluation to assist in technology decision-making: If such a master plan is a conservative, high-level road map for future cash flow and land area requirements, it is important to separate from it more detailed, WWTF/situation-specific efforts and technology decisions that are best made at a time nearer their point of implementation. Integrating the future uncertainty analysis with a broader triple-bottom-line evaluation methodology can beneficially inform decision-making. Proactively

developing these methodologies in advance of when they are needed avoids project time-pressures and ensures Municipality staff is comfortable in their intent and design.

- Regularly review **technology developments** to enable appropriate decision-making near the time of implementation: Aerobic granular biomass and main-stream deammonification process technologies, and others, continue to develop and industry experience gained will inform future Municipality decision-making. The Municipality needs to remain abreast of technical advances so that it is fully informed at the point when it needs to make final technology choices. Related to this point is information needed to inform the aforementioned future uncertainty analysis that, given some of the technologies under deliberation, may require facility tours and meetings with their operations staff. The Municipality should allow schedule and budget in projects to this end.
- Plan and design WWTFs for **adaptation**: The Municipality should plan and design its WWTFs for adaptation. Arguably more so now than at any other time in wastewater management the need to plan for and accommodate core technology change/transition is critical, as is providing footprint and hydraulic gradeline space for add-on technology that may be needed to meet future effluent quality requirements or support main-stream resource recovery initiatives.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iv
List of Tables	vi
List of Figures	vii
1 Introduction	1
2 Technology Review Context: Potential Changes in Currently Regulated Effluent Constituents	2
2.1 Overview	2
2.2 Total Phosphorus	2
2.3 Ammonia	6
2.4 Total Suspended Solids and Carbonaceous Biochemical Oxygen Demand	8
2.5 E. coli	8
2.6 Summary of Municipality Implications	9
3 Technology Review Context: Potential Future Addition of Currently Un-Regulated Effluent Constituents	10
3.1 Overview	10
3.2 Enterococci	10
3.3 Trace Organic Compounds	11
3.4 Total Nitrogen	12
3.5 Engineered Nanomaterials	13
3.6 Summary of Municipality Implications	14
4 Technology Review Context: More Efficient Processes	15
4.1 Overview	15
4.2 Aerobic Granular Biomass	16
4.3 Main-Stream Deammonification	21
5 Main-Stream Resource Recovery	27
5.1 Overview	27
5.2 At-Source	28
5.3 Post-Treatment	30

6	Moving Forward: Summary & Recommendations	33
6.1	Summary	33
6.2	Recommendations	35
	Closure	
	References	



List of Tables

	PAGE NO.
Table 4-1 Example Uncertainty Analysis	21

List of Figures

		PAGE NO.
Figure 2-1	Final Effluent Total Phosphorus Concentration	3
Figure 2-2	Final Effluent Phosphorus Concentration	4
Figure 2-3	Final Effluent TP versus TSS Concentrations	4
Figure 2-4	Final Effluent Ammonia Concentration	6
Figure 3-1	Final Effluent Ammonia and Nitrate	12
Figure 4-1	Photograph of Aerobic Granule	16
Figure 4-2	Typical Structure of an Aerobic Granule Showing Aerobic, Anoxic and Anaerobic Zones within the Granule Structure	17
Figure 4-3	Aerobic Granular Biomass Reactor Operation	18
Figure 4-4	Phases 1 and 2 Construction of the Fort McMurray WWTF	20
Figure 4-5	Liquid-stream Process Configuration of a Typical Canadian BNR WWTF	22
Figure 4-6	Conceptual A-Stage/B-Stage Configuration for Main-Stream Deammoniafication	23
Figure 4-7	Blue Plains WWTF Aerial Photo Showing A-side HRAS Bioreactors and Clarifiers and the B-Side Nitrification/Denitrification Bioreactors and Clarifiers	26
Figure 5-1	Relative Contributions of Urine to the Volume, Nitrogen and Phosphorus Content of Municipal Wastewater	28
Figure 5-2	Elements of Post-Treatment Extractive Nutrient Recovery from the Main-Stream Wastewater Flow	31
Figure 6-1	Interrelation Between WWTF Technology Change Contexts	33

1 Introduction

The Regional Municipality of Wood Buffalo (Municipality) is developing a Wastewater Master Plan (WWMP) to allow the strategic planning and operation of its entire wastewater system and is doing so in consideration of related “green” initiatives, stormwater management, and asset management capital planning. Master planning work considers long-term horizons and, specific to the subject of this document, raises the question of how treatment technology is changing, or may change, over such a horizon. Such change has implications on technology decisions already made by the Municipality and those that it will need to make in both the relative near-term and longer horizons.

In response to this situation, the primary objective of this TM is to identify key technical drivers that could significantly influence the Municipality’s near- and longer-term decision-making as related to its wastewater treatment facilities (WWTFs) and their associated technologies. A secondary objective is to outline a practical strategy that the Municipality can implement to assist in ongoing planning and decision-making in light of technology change.

There are three key dimensions or contexts to the technology change question:

- One relates to producing a higher quality effluent from the Municipality’s WWTFs in the future relative to current requirements contained in Alberta Environment and Sustainable Resource Development (AESRD) Approval 689-02-00.

Technical memorandum (TM) A.2.3.2 – Regulatory Review (Associated Engineering, 2013a) – explored potential, distant effluent quality requirements with the objective of identifying key viewpoints to capture in the WWMP that the Municipality can review during future conceptual studies of its wastewater treatment facilities (WWTFs). This forward-looking exercise focused largely on “best practicable technology” (BPT) drivers that may influence future regulatory philosophy and requirements and provides perspective for the general trends being observed in the wastewater industry at this time. TM A.2.3.2 discussed these trends independent of specific technology considerations.

Section 2 begins by discussing technology-related implications of changes in currently regulated effluent constituents identified in TM A.2.3.2 on WWTF technology currently used at / envisioned for Municipality facilities (i.e. business-as-usual technologies), with Section 3 doing the same for currently un-regulated effluent constituents.

Because of the close association between TM’s A.2.3.2 (Regulatory Review) and A.2.2.4 (Treatment Technology Review), the reader is encouraged to first review TM A.2.3.2 (Regulatory Review) to understand its overall context and linkage to this document.

- The second technology change dimension relates to using more efficient processes to produce an effluent with comparable quality to that required today (i.e., Approval 689-02-00), or potentially better, in the future. Thus, this document identifies a few select emerging secondary treatment / nutrient removal technology developments that have the potential to, due to their reported advantages, profoundly influence decisions made regarding the future configuration of Municipality

- facilities. Section 4 contains this discussion, which focuses on aerobic granular biomass (AGB) and main-stream deammonification (MSD) technologies and potential implications of their implementation on Municipality WWTF facilities and related decision-making.
- The third technology change dimension is broader still – will the Municipality facilities be providing main-stream resource recovery that will significantly impact treatment aspects related to production of the required quality of effluent (e.g. post-treatment extractive nutrient recovery)? Similarly, how might Municipality-implemented resource recovery strategies outside-the-fence of WWTFs (i.e., at-source urine separation) impact the inside-the-fence technology, again in the context of producing the needed effluent quality? Section 5 provides insights on the implications of the noted technologies/strategies on Municipality WWTF technology and decision-making.

These dimensions all point to the need to future-proof the Municipality's wastewater infrastructure investments, and thus, the facilities themselves to the extent practical. To this end, Section 6 speaks to the idea of planning and designing for adaptation by providing a summary of findings and recommended strategy to assist the Municipality in ongoing planning and decision-making.

2 Technology Review Context: Potential Changes in Currently Regulated Effluent Constituents

2.1 OVERVIEW

The question considered in Section 2 is: If the regulator(s) (e.g. AESRD) tighten the currently regulated effluent constituent limits beyond those contained in the current Approval 689-02-00 what are the implications for existing and future Municipality WWTFs?

Obviously the answers depend on the extent of such tightening and the absolute value of allowable effluent concentrations. The answers also depend on the technology currently used, or proposed to be used, at Municipality facilities. Another important dimension is one of "capacity", i.e. while a technology might produce the needed effluent quality the currently available capacity may need to be down-rated to accomplish this end. The following sub-sections consider such points for the various constituents.

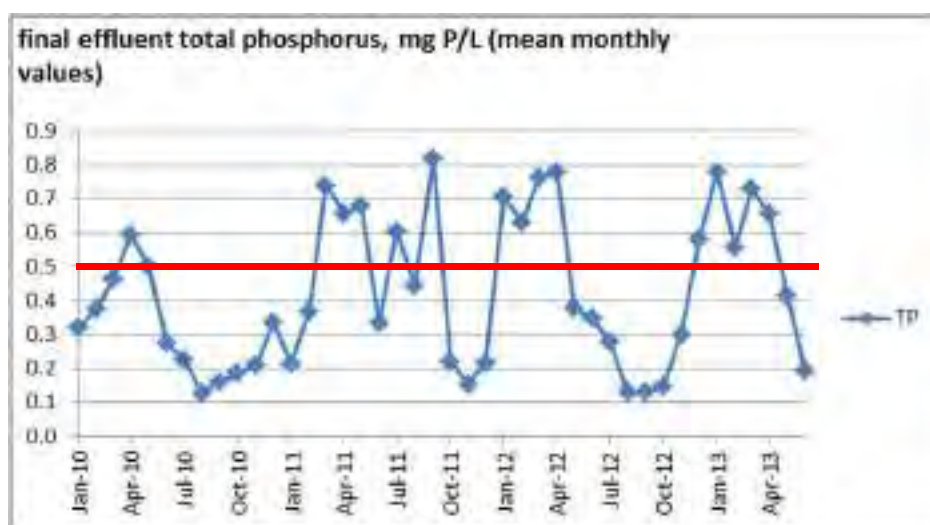
2.2 TOTAL PHOSPHORUS

As discussed in TM A.2.3.2 (Regulatory Review), recent research commissioned by the Water Environment Research Foundation (WERF) (Pagilla and Urgan-Demirtas, 2009) has confirmed that total phosphorus (TP) levels of 0.10 mg P/L and lower are achievable with technology available today. Similarly, some facilities in Canada and the United States are currently regulated with such effluent quality requirements. On this basis, for the purposes of this discussion, it is reasonable to speculate that the next level of AESRD-induced BPT tightening for TP could be from the Approval 689-02-00 Year 2015 TP requirement of 0.50 mg P/L to 0.10 mg P/L that extends to Year 2019. Set in this light what could be the implications for the Municipality facilities?

The relevant technology currently used at the existing Fort McMurray WWTF includes enhanced biological phosphorus removal (EBPR) via a 3-Stage Bardenpho bioreactor configuration with return activated sludge (RAS) denitrification, primary sludge fermentation, and secondary clarification only (Earth Tech, 2004). In addition, the Municipality also intermittently uses chemical precipitation via metal addition (i.e. alum) to remove residual soluble phosphorus that contributes to measured effluent TP concentrations.

To date the WWTF has performed well with a Year 2010 to 2013 average monthly effluent TP concentration of 0.43 mg/L that is based on daily composite samples (Figure 4-2, TM A.2.2.3, Associated Engineering, 2013b). When considering its performance on a single month basis during this period the facility has not produced a monthly average effluent TP concentration of less than 0.10 mg P/L (Figure 2-1) and this is no surprise given the current Approval requirements.

Figure 2-1
Final Effluent Total Phosphorus Concentration
(*red line is Approval proposed 2015 limit)



However, this observation does not necessarily preclude the WWTF from attaining lower effluent TP levels. Key in accomplishing such performance lies in converting the residual soluble phosphorus (i.e. ortho-phosphate (OP), which is implicitly assumed to equal soluble or dissolved P) into either cellular poly-P via EBPR and/or P precipitates via alum addition and removal of these solids from the effluent. Figure 2-2 provides some insight into the topic. As can be seen OP makes up the dominant fraction of the measured TP concentrations for what is acknowledged to be a small dataset from Year 2013.

Not surprisingly, there is no observed correlation between measured TP and total suspended solids (TSS) concentrations for this dataset because of the high OP / TP (0.72) ratio (Figure 2-3). Data from other similar Canadian facilities have ratios in the 0.35 to 0.55 range.

Figure 2-2
Final Effluent Phosphorus Concentration

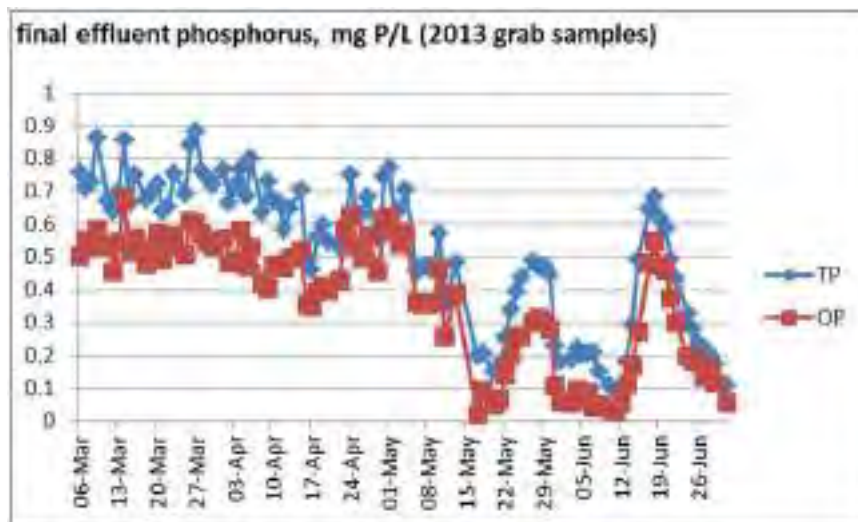
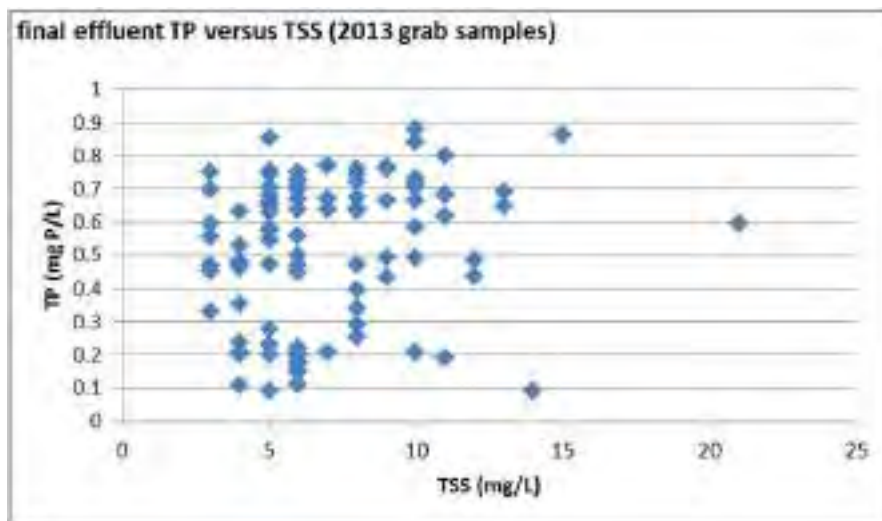


Figure 2-3
Final Effluent TP versus TSS Concentrations



Consistently achieving 0.1 mg P/L effluent TP concentrations at the Fort McMurray facility would require some form of tertiary filtration to further remove particulate P that contributes to effluent TP concentrations. At the same time, OP levels need to be reduced (i.e. Figure 2-2). This may be accomplished by increased metal salt (i.e. alum) addition to chemically precipitate residual soluble P that currently exists. However, EBPR system optimization may reduce the OP levels such that less reliance is placed on chemical addition. Enhanced fermenter optimization, potentially coupled with measures to minimize secondary P release in the clarifiers (e.g. bioreactor DO manipulations to control stored carbon utilization, RAS manipulations to manage clarifier solids inventory, etc.) may assist to this end. However, further analysis is needed to fully understand the situation and validate optimization approaches.

We recognize that the water treatment facility Plant Waste Management System (PWMS) is not currently operating. Aluminum-based precipitates from the PWMS discharged to the sewer system will further interact with P contained in wastewater and can result in primary effluent containing notably reduced P concentrations if more of the P entering the primary clarifiers leaves the system via the primary sludge. If occurring, and particularly if in a time-varying manner, EBPR performance and thus final effluent quality can be compromised. If it is assumed that OP represents essentially all the dissolved P in the effluent samples, the data shown in Figures 2-2 and 2-3 reveal that the particulate P content of the effluent solids is only about 2.1%. This value is substantially lower than the 5% plus values for other similar Canadian WWTFs. This number on its own suggests a significant fraction of wastewater P is leaving the system in the primary sludge, which is conceptually consistent with the PWMS not operating. However, a detailed review of other facility data is needed to further understand the situation and the implications, if any, on system operation and nuances to reaching lower effluent TP levels.

In any case, such effluent TP levels (i.e. 0.10 mg P/L) have consistently been attained by the Region of York Schomberg WPCP that uses chemical precipitation with continuous-backwash, deep bed, granular media filtration and the Community of Field, BC WWTF that uses membrane micro-filtration for solids separation (Whalley et al., 2013). The Town of Lake Louise WWTF uses rotating-disk, cloth-media surface filtration and consistently meets its 0.15 mg P/L limit and has been demonstrated to achieve less than 0.10 mg P/L at times.

If the Municipality implemented tertiary filtration in order to meet the Approval 689-02-00 Year 2015 TP requirement of 0.50 mg P/L, with optimized EBPR performance and possibly enhanced metal salt (e.g. alum) addition for trimming residual soluble P (TM A.2.2.3, Associated Engineering, 2013b), it is likely that a future limit of 0.10 mg P/L could also be met using the same technology approach. Use of a metal salt for trimming residual soluble P does generate additional solids that need to be accommodated by both the liquid- and solid-stream systems. To achieve very low effluent P levels (e.g., 0.1 versus 0.5 mg P/L versus 1.0 mg P/L) the required metal salt: soluble P molar ratio for precipitation can deviate significantly from stoichiometric requirements due to competing reactions. Thus chemical use and sludge production at the low end of this P range would likely increase non-linearly relative to the higher end of this range and result in a disproportionately increased sludge production rate.

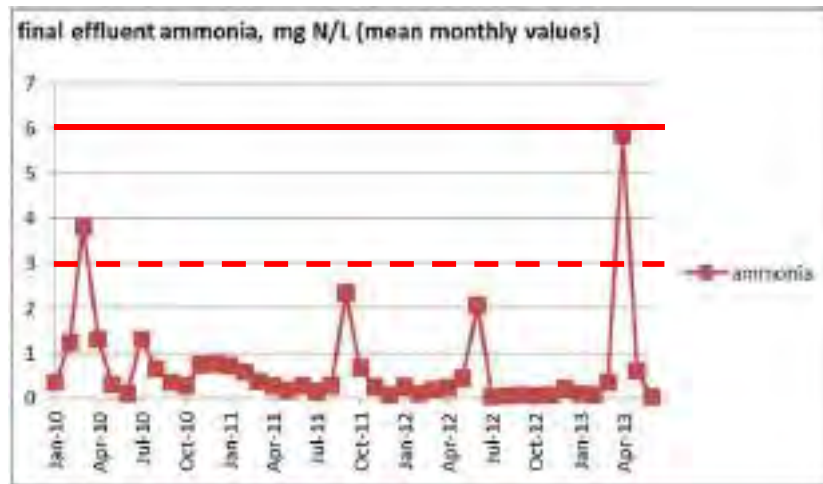
take-away messages

- ✓ Optimization opportunities may exist to reduce effluent ortho-phosphate levels and could be important for the filtration topic as related to the Year 2015 0.5 mg P/L total phosphorus objective.
- ✓ The low P content of effluent TSS, at least for some samples, suggests water treatment facility PWMS non-operation may be notably affecting WWTF operations and performance.
- ✓ The combination of in-place (i.e., EBPR, chemical precipitation) and anticipated (i.e., filtration for Year 2015 Approval requirements) technology at the Fort McMurray WWTF provides regulatory "future-proofing" down to effluent total phosphorus levels in the order of 0.1 mg P/L.

2.3 AMMONIA

TM A.2.3.2 (Regulatory Review) noted that the Approval 689-02-00 values for ammonia nitrogen, even those for Year 2015 (average 3 mg/L summer: July 1 to September 30, and 6 mg N/L winter: October 1 to June 30), are well above the concentrations that can be achieved with today's technology. This conclusion has been demonstrated by the Fort McMurray WWTF where the technology relevant to this discussion is the suspended-growth, 3-stage Bardenpho bioreactor. The facility consistently produces very low effluent ammonia levels (Figure 2-4) with a Year 2010 to 2013 average monthly value of 0.67 mg N/L that is based on daily composite samples (Table 4-2, TM A.2.2.3, Associated Engineering, 2013b).

**Figure 2-4
Final Effluent Ammonia Concentration***



* Monthly Averages (solid red line is Approval proposed 2015 Oct 1 to June 30 - 6 mg N/L objective; dashed red line is proposed July 1 to Sept 30 - 3 mg N/L objective).

Given the *typical* level-of-performance of the Municipality WWTF there are no obvious BPT-type drivers in the wastewater industry that would suggest that AESRD or another regulator would require even lower ammonia concentrations in the foreseeable future. If they were, the technology implications would most likely be associated with the two situations discussed below.

One are the occasional events, which are generally due to infiltration and inflow (I/I) of snowmelt in combination with rainfall events that can dramatically reduce wastewater temperatures and slow down the nitrification kinetic rates and thus increase effluent ammonia levels. Various operational manipulations of the existing system could potentially reduce effluent ammonia levels during such events and reduce the monthly average effluent ammonia concentration that is of Approval significance:

- Given all other things being equal (e.g. absence of inhibitory wastewater compounds, sufficient bioreactor oxygen availability, etc.) effluent ammonia concentrations have generally been observed to be a function of the overall bioreactor solids retention time (SRT) and the biomass mass fraction

- carried in the aerated cells. For example, process simulation work conducted during the preliminary design of the Fort McMurray WWTF found that increasing the aerated cell volume of the bioreactor, via an anoxic/aerobic swing zone, by approximately 10% could reduce the predicted steady-state effluent ammonia concentrations by about 1/3 from 0.78 to 0.54 mg N/L when the overall bioreactor SRT was maintained at 16 days (Earth Tech, 2004). Thus conversion of the Anoxic 2 cells into swing zones that could operate as aerobic cells could provide some improved nitrification performance during and in advance of I/I events. Provision of this flexibility would invoke some capital cost.
- Lower effluent ammonia levels could also be theoretically achieved during such events by increasing the overall bioreactor SRT, which would also increase bioreactor MLSS levels. The SRT and MLSS increase needed to notably reduce average effluent ammonia levels could be significant, particularly given the relatively long SRT already used in the facility at this point (e.g. 16 day SRT in winter (Earth Tech, 2004)). This in turn could necessitate a down-rating of secondary clarifier capacity due to increased solids loading rates.
 - Increasing bioreactor aerated cell dissolved oxygen levels (DO) during cold-weather I/I events, thus increasing the nitrification rate, could potentially be used to reduce elevated effluent ammonia levels during such periods and reduce seasonal monthly average effluent ammonia concentrations. Increased nitrified mixed liquor (NML) and return activated sludge (RAS) DO levels may impact upstream anaerobic and anoxic processes and thus would need to be considered before implementing such action.
 - Beyond such operational measures within the WWTF *per se*, equalization storage can be used to help mitigate the effects of reduced kinetic rates during I/I events and limit the fraction of biomass shifted to the secondary clarifier, because of the high flow rates, which further magnifies the rate reduction effect. The Municipality currently does have such systems in place via the lagoon system for the Fort McMurray WWTF. Optimization of their use and capacity may further enhance the benefit they provide to WWTF operations and effluent quality.

The second situation relates to septage management and short-term septage impacts on the process and effluent quality. The current use of the lagoon system to accept and equalize septage loadings may benefit effluent quality in this regard. However, whatever benefit the lagoon system currently provides will be lost when the Municipality moves to direct septage discharge to the sewer system in the future. Some of the other mitigations discussed above for wet-weather flows may be applicable but the unpredictable nature of septage discharges may limit their practicality.

take-away messages

- ✓ The Fort McMurray WWTF technology has demonstrated capability to produce very low effluent ammonia levels and in general could likely accommodate further future tightening of regulatory limits.
- ✓ The key to the above point is managing wet-weather flows, and potentially septage loading, through flow/load equalization.
- ✓ Operational measures such as increased bioreactor DO levels and increasing the bioreactor aerated mass fraction through use of anoxic/aerobic swing zones may be mitigation actions of particular relevance for the wet-weather flow situation.

2.4 TOTAL SUSPENDED SOLIDS AND CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND

Even without tertiary filtration the Fort McMurray WWTF currently produces a low total suspended solids (TSS) effluent, where the Year 2010 to 2013 average monthly value was about 6 mg/L based on daily composite samples (Table 4-2, TM A.2.2.3, Associated Engineering, 2013b). As discussed in TM A.2.3.2 (Regulatory Review), any future regulatory requirement to reduce effluent TSS levels will most probably be associated with a need to reduce TP concentrations and the filtration technology selected to do so will impact the achievable effluent TSS levels. Typical (i.e. 90th percentile) effluent TSS levels for the aforementioned facilities are as noted below (Whalley et al., 2013):

- Schomberg (continuous-backwash, deep bed, granular media filtration) < 5 mg/L
- Lake Louise (rotating-disk, cloth-media surface filtration) < 3 mg/L
- Field (membrane micro-filtration) < 1 mg/L

These achieved TSS levels represent a notable improvement beyond the monthly average value observed at the Fort McMurray facility.

Enhanced solids separation for TP removal purposes will also provide some reduction in effluent carbonaceous biochemical oxygen demand (CBOD) levels because of the oxygen demand associated with effluent solids. However, current Fort McMurray WWTF monthly average CBOD concentrations are already very low at around 3 mg/L (TM, A.2.2.3, Associated Engineering, 2013b). Removal of additional effluent TSS via tertiary filtration would likely reduce average effluent CBOD levels in the order of 1 mg/L.

take-away messages

- ✓ The Municipality has a number of filtration technology alternatives available in terms of meeting Year 2015 Approval TSS and BOD limits simultaneous with achieving the 0.5 mg P/L total phosphorus limit
- ✓ There are broader filtration technology aspects, related to currently un-regulated effluent constituents discussed later in this document, that the Municipality should contemplate in its near-term decision-making.

2.5 E. COLI

TM A.2.3.2 (Regulatory Review) suggested it is reasonable to expect a relatively near-term tightening of effluent *E. coli* levels from the 200 cfu/100 mL value currently stipulated in Approval 689-02-00. This supposition was based in part on recent United States Environmental Protection Agency (USEPA) 2012 *Recreational Water Quality Criteria* and what has been adopted by the California Environmental Protection Agency State Water Resources Control Board, the latter using a geometric mean *E. coli* value of 126 cfu/100 mL for limited contact recreation fresh waters. In many jurisdictions these values are applied end-of-pipe rather than at the edge of an *in-situ* initial dilution zone.

For the Fort McMurray WWTF the relevant technology is the ultra-violet (UV) irradiation system that processes effluent that currently not yet benefits from enhanced solids separation via tertiary filtration. The current monthly average *E. coli* value for the Fort McMurray WWTF for Year 2010 to 2013 (i.e. average of monthly geometric means based on grab samples 5 days per week) is 38 cfu/100 mL, with a maximum monthly average (i.e. maximum of monthly geometric means based on grab samples 5 days per week) value of 151 cfu/100 mL (Table 4-2, TM A.2.2.3, Associated Engineering, 2013b).

Reducing the gap between the currently observed maximum monthly 151 cfu/100 mL value and potentially regulated 126 cfu/100 mL value might be accomplished via an increased applied UV dose and/or reduction in effluent TSS concentration provided by tertiary filtration. The former measure is contingent on the UV system design and is influenced by the UV intensity and exposure time. If additional UV intensity is not available in the existing system to provide the applied dose needed to meet the 126 cfu/100 mL value, it might still be achieved through additional exposure time. If so, the existing UV system capacity will need to be down-rated to reflect this requirement.

Alternatively, the performance of the existing UV system may be enhanced by reducing the particulate matter in the effluent and the shielding it provides from UV light. This effect may be accomplished synergistically with the need for effluent TP and associated TSS reductions.

take-away messages

- ✓ The Fort McMurray WWTF disinfection technology in general is suitable for achieving potentially reduced effluent *E. coli* levels suggested by the Regulatory Review, which could be required in the relative near-term (within a 10 yr horizon).
- ✓ Capacity-related constraints of the existing system in this context, if they exist, will be mitigated in part and potentially entirely if effluent filtration is implemented.

2.6 SUMMARY OF MUNICIPALITY IMPLICATIONS

In terms of currently regulated effluent constituents contained in Approval 689-02-00 and after full build-out, a future lowering of their concentration-based limits beyond the July 2015 Approval requirements would most likely impact the existing Fort McMurray WWTF from an operations perspective (e.g. fermenter/bioreactor operation, chemical addition for P removal) rather than requiring capital-intensive outright technology change or addition. Minor capital works (e.g. bioreactor swing zone, lagoon equalization system) improvements might be needed. These conclusions are predicated on the assumption, which remains to be confirmed, that effluent filtration will be needed to meet the Year 2015 TP limits in Approval 689-02-00.

3 Technology Review Context: Potential Future Addition of Currently Un-Regulated Effluent Constituents

3.1 OVERVIEW

The question considered now in Section 3 is more of an unknown – if the regulator(s) add currently un-regulated effluent constituents beyond those contained in Approval 689-02-00 in the future what are the implications for existing and future Municipality's WWTFs?

3.2 ENTEROCOCCI

The recent addition of *Enterococci* to the USEPA freshwater recreational contact criteria provided the TM A.2.3.2 (Regulatory Review) hypothesis that it may be included in a future Municipality Approval as a regulated effluent constituent. As discussed in the earlier TM the value of such a criterion will likely be in the order of 30 cfu/100 mL.

Section 2.5 noted that the Fort McMurray WWTF uses UV irradiation for effluent disinfection. Although *Enterococci* data are not available for this facility, published information for other facilities provide insights on the potential of such a system to meet a 30 cfu/100 mL *Enterococci* criterion. For example, demonstration-scale testing conducted on effluent from the Wschod EBPR facility in Gdansk, Poland found that *Enterococci* log reduction was only slightly lower (i.e. 3.1 to 3.3 log removal) than that obtained for *E. coli* (i.e., 3.4 to 3.8 log removal) under the same test conditions (Olanczuk-Neyman et al., 2001). The geometric mean of *Enterococci* values for disinfected effluent ranged from 17 to 32 MPN/100 mL depending on test condition, whereas the *E. coli* values were lower and varied between 10 and 15 MPN/100 mL. Similarly, bench-scale collimated beam testing of effluent from a trickling filter facility in Leavenworth, Kansas found that under the same UV dose concentration comparable log removals (i.e. 3 to 4) for both *E. coli* and *Enterococci* could be achieved with disinfected samples containing less than 160 cfu / 100 mL *E. coli* and 33 cfu/100 mL *Enterococci* (Hunter et al., 2011).

This information, when viewed in light of current effluent *E. coli* levels (Section 2.5), suggests that the UV disinfection technology currently used at the Fort McMurray WWTF, and potentially other Municipality facilities, should be able to produce effluent with *Enterococci* concentrations that meet anticipated, future regulatory requirements.

take-away message

- ✓ The Fort McMurray WWTF disinfection technology in general is suitable for achieving potential future effluent *Enterococci* levels, which as suggested by the Regulatory Review, could be required in the relative near-term (within a 10 yr horizon).

3.3 TRACE ORGANIC COMPOUNDS

As discussed in TM A.2.3.2 (Regulatory Review), there is a broad and intensive interest in trace organic compounds (TOrc), which includes such items such as personal care products and those that can potentially disrupt endocrine function in organisms. This attention, combined with the uncertainty in most jurisdictions as to “what” might become a regulated constituent and “when”, has resulted in many municipalities and utilities asking the same question – how might this impact our WWTFs?

Compared to some WWTF owners and operators the Municipality already is in an advantageous position with the existing Fort McMurray WWTF because of its process technology. Consider the secondary treatment system that uses a suspended-growth bioreactor operated at a relatively long SRT (e.g. $\approx$ 16 days) designed to provide a high level of ammonia removal. The diverse microbial community in such bioreactors, relative to those operated at shorter SRTs, appear to provide enhanced removal of many TOrc (Anderson, 2008).



www.trojanuv.com

With a robust core technology in place, further improvements in Fort McMurray WWTF's performance would most likely be gained from the addition of downstream unit processes. Technology examples include nanofiltration and reverse osmosis, advanced oxidation (UV irradiation + hydrogen peroxide or ozone) and activated carbon adsorption (Anderson, 2008). Much research has been and continues to be conducted in such areas and water reclamation for planned indirect potable reuse (IPR) is a key driver for much of the effort. For example, Orange County Water District's high-profile Groundwater Replacement System (Wedge, 2003), and other significant planned IPR systems, subject high-quality secondary effluent to membrane microfiltration, reverse osmosis and UV irradiation + hydrogen peroxide to remove TOrcs from reclaimed water prior to blending with natural source waters for potable supply. This combination of unit processes might represent the extreme in terms of what may be needed for protection of aquatic systems receiving effluent but it does give a sense of possibility.

Scruggs et al. (2004) note that such a combination of unit processes provides a multi-barrier approach, which could be added as necessary in a step-wise manner to meet future requirements:

- biological oxidation (e.g. secondary treatment with nitrification)
- physical separation (e.g. reverse osmosis)
- chemical oxidation (e.g. UV + hydrogen peroxide)

take-away messages

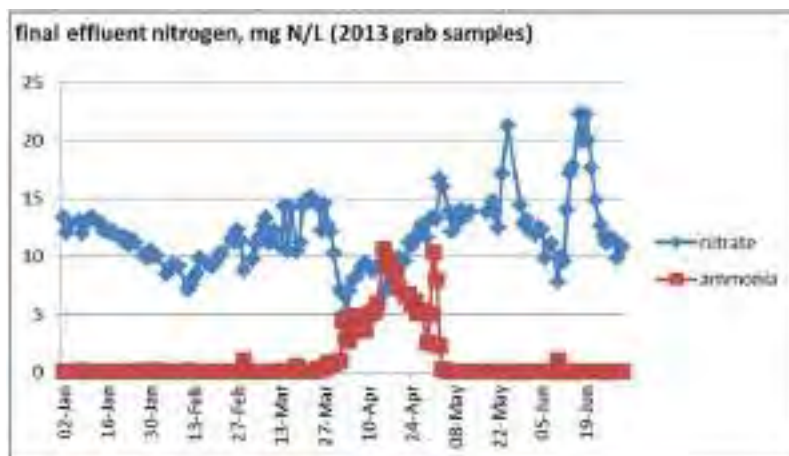
- ✓ The Fort McMurray WWTF already utilizes “core” technologies that provide some level of future-proofing against a future effluent TOrc requirement that might be implemented by a regulatory agency.
- ✓ Long-range facility planning should leave room, both in footprint area and in the hydraulic profile, to accommodate additional physical/chemical unit processes and their supporting equipment and systems that may be needed in the longer-term (beyond a 10 yr horizon) to meet future regulatory requirements discussed in the Regulatory Review.

3.4 TOTAL NITROGEN

TM A.2.3.2 (Regulatory Review) considered the possibility of a future regulatory requirement for effluent total nitrogen, based on the potential for nitrous oxide (N_2O) greenhouse gas generation in water bodies receiving nitrogen-containing effluents along with the traditional context of eutrophication control. Like the TOrC question, the Municipality is already reasonably positioned for such a total nitrogen requirement based on the current technology used at the Fort McMurray WWTF. The 3-stage Bardenpho bioreactor is configured in a pre-denitrification arrangement, where oxidized forms of nitrogen contained in the aerobic cell mixed liquor recycle and return activated sludge (RAS) streams are converted to di-nitrogen gas (N_2) in the anoxic cells. Such a process provides oxygen and alkalinity recovery that aid facility operation regardless of whether or not denitrification is needed to provide total nitrogen removal for regulatory purposes. Furthermore, tapered aeration across the bioreactor's aerated cells, and in particular the final aerated cells that have the lowest dissolved oxygen (DO) levels, can also provide some simultaneous nitrification/denitrification (SND) that can further reduce effluent total nitrogen concentrations.

Available grab sample data from 2013 (Figure 3-1) show that when effluent ammonia levels are very low (i.e. < 1 mg N/L), and thus effluent total nitrogen is comprised mostly of nitrate assuming nitrite is not present in notable amounts, effluent nitrate concentrations are typically around 12 mg N/L but range widely from about 7 to over 20 mg N/L.

Figure 3-1
Final Effluent Ammonia and Nitrate



Canadian experience with similar process configurations has found effluent nitrate levels typically in the 5 to 10 mg N/L range (e.g., Oldham and Rabinowitz, 2002). Achievable effluent nitrate levels are a function of primary effluent nitrogen concentrations, as well as available wastewater carbon in the primary effluent and fermenter overflow (minus that used for enhanced biological phosphorus removal (EBPR)), mixed liquor and RAS recycle rates, and DO levels in the final aerated bioreactor cell. Therefore, with some optimization, the existing Fort McMurray WWTF likely could produce notably lower effluent nitrate levels more consistently.

Beyond such measures post-denitrification systems with external carbon addition (e.g. denitrifying filters with methanol), which would receive secondary clarifier effluent, could reduce Fort McMurray WWTF effluent nitrate levels to practically zero. The remaining total nitrogen in the effluent would be comprised primarily of what has been termed recalcitrant dissolved organic nitrogen (rDON). Included in this definition are non-biodegradable nitrogen forms contained in raw wastewater as well as by-products formed during wastewater treatment (Pagilla and Urgan-Demirtas, 2009). For very low total nitrogen effluents (i.e., < 3 mg N/L) rDON can be a significant and even dominant fraction of measured nitrogen. Thus achieving even lower effluent total nitrogen levels could require additional unit operations such as carbon adsorption, reverse osmosis or advanced oxidation (Pagilla and Urgan-Demirtas, 2009). Overall, similar to the total phosphorus discussion contained in TM A.2.3.2 (Regulatory Review), the “limit-of-technology” question as applied to total nitrogen has generated significant industry discussion with regards to the sustainability of trying to reach ever-lower levels.

take-away messages

- ✓ The Fort McMurray WWTF process technology, with some optimization, can likely produce effluent with consistently lower effluent total nitrogen concentrations in the 5 to 10 mg N/L range, and thus below a 15 mg N/L limit that may be implemented by AESRD in the relative near-term.
- ✓ Achieving lower effluent total nitrogen levels (e.g. 3 mg N/L) would require a post-denitrification system; further reductions, because of recalcitrant dissolved organic nitrogen, would likely require add-on physical/chemical unit processes.
- ✓ As discussed in the Regulatory Review, any such future GHG-related total nitrogen regulatory requirement could be several decades in the future, if at all, and so the need to consider future footprint and hydraulic profile considerations in the shorter-term is limited.

3.5 ENGINEERED NANOMATERIALS

The last effluent constituent, or more properly class of effluent constituents, identified in TM A.2.3.2 (Regulatory Review) was engineered nanomaterials (ENMs). As described in a comprehensive literature review by Westerhoff et al. (2013), there is a significant amount of research information available, spanning both laboratory and full-scale facility studies, about the removal of these sub-100 nm particles in suspended-growth bioreactors used in WWTFs. Many studies have found that > 90% of the ENMs contained in wastewater are removed via attachment to biomass that is separated from effluent using gravity clarification. Still, some studies have reported low removal of silicon dioxide-based ENMs in such processes. These general findings suggest that the bioreactor/secondary clarifier system currently used at the Fort McMurray WWTF also provides a high overall degree of ENM removal from wastewater.



www.uwaterloo.ca

Westerhoff et al. (2013) also noted the potential for membrane filtration to further increase ENM removal efficiency. Interestingly, high levels of ENM rejection (>99%) have been achieved in some cases where the membrane pore diameters were in excess of one order-of-magnitude larger than the ENM particles. In such

cases a variety of phenomena, related to what appears primarily to the properties of the ENMs themselves rather than the membrane, provides ENM removal not by physical separation but by sorption.

Such findings suggest that addition of tertiary membrane filtration to the Fort McMurray WWTF could notably enhance ENM removal beyond that provided by its current technology. However, Hu (2010) provides a potential counter argument to this suggestion. The hypothesis is that long-term biomass exposure to nanosilver, for example, could result in a defensive bacterial response that produces additional soluble microbial products and extracellular polymer substances that could severely foul membrane pores and thus compromise system operation.

take-away messages

- ✓ The Fort McMurray already utilizes “core” technologies that provide some level of future-proofing against a future effluent ENM requirement that might be implemented by a regulatory agency.
- ✓ Membrane filtration may prove advantageous in this context relative to other available filtration technologies, but issues such as fouling are currently not well understood in an ENM context.
- ✓ As discussed in the Regulatory Review, any such future regulatory requirement could be several decades in the future, if at all, and so near-term filtration technology decisions can be made in relative isolation of the ENM topic.

3.6 SUMMARY OF MUNICIPALITY IMPLICATIONS

With respect to currently un-regulated effluent constituents, the Fort McMurray WWTF, and others planned for the Municipality using similar processes, already utilize “core” technologies that position it favourably for the kinds of regulatory changes considered in this document. Given the industry and regulatory interest in them, TORCs represent what will likely be the effluent constituent (class) of most significance to the Municipality in the longer horizon. Addressing future regulatory requirements, if they materialize, will probably require the addition of unit processes downstream of those currently in use or planned for future facilities. The advice provided by Scruggs et al. (2004) - long-range facility planning should leave room, both in footprint area and in the hydraulic profile, to accommodate additional unit processes and their supporting equipment and systems – is sound. A Canadian example of a wastewater utility explicitly doing so is the Capital Regional District on Vancouver Island. Here the recent request-for-proposal issued for design-build implementation of the new McLoughlin Point WWTF includes a requirement for a future advanced oxidation process.

Tertiary filtration is the unit process of most immediacy to the Municipality in light of the TP issue and the 2015 Approval requirements for both the existing Fort McMurray WWTF. Different alternatives are available (e.g., deep-bed granular media filtration; rotating-disk, cloth-media surface filtration) to satisfy this single need but membrane filtration likely has the greatest ability to accommodate diverse future requirements. For example, if physical separation via reverse osmosis (RO) was needed as part of a TORC removal scheme the RO system would need to be preceded by membrane micro-filtration in order to protect the RO membranes from excess suspended solids loading and related fouling. Potential fouling issues aside, ENM

removal provided by biomass separation via clarification would also likely be enhanced by membrane micro-filtration in a manner not provided by other filtration technologies.

But should these uncertain and potentially distance requirements influence near-term Municipality tertiary filtration decisions? Maybe, if a structured comparative evaluation of alternatives found them essentially “equal” in all other ways (e.g., performance and reliability, capital and operating costs, etc.) in aggregate and these points (i.e., ENM removal performance, RO system “protection” related to TSS removal) provide a differentiator amongst them. Otherwise, given the lifespan of filtration systems, their low cost relative to the core WWTF systems, and the long horizon of the TORC and ENM topics it would appear that near-term Municipality tertiary filtration decisions can be made in relative isolation of these topics.

4 Technology Review Context: More Efficient Processes

4.1 OVERVIEW

In all sectors, including wastewater management, the development and advancement of technology marches on with the promise of greater efficiency however it may be defined. In this document, as highlighted in Section 1, the context is producing effluent with comparable quality to that required today (i.e., Approval 689-02-00), or potentially better, in the future but in a more efficient manner.

The following sub-sections discuss two select secondary treatment / nutrient removal technology developments in this light because of the potential step-change in efficiency they may provide. In both cases these gains are better described as revolutionary as opposed to evolutionary and this is why, amongst many other industry developments at this time, they are included in this document. Furthermore, both have been and continue to be the focus of much research and development that includes bench-, pilot- and full-scale demonstration trials and for one of them multiple examples of full-scale implementation to this point. Such efforts provide appropriate due diligence and risk management that is consistent with and explains the wastewater industry’s admirable record of success.

While this technology itself is interesting and is discussed in the following sub-sections, more immediate to the Municipality are its implications on technology decisions already made by the Municipality for the Fort McMurray WWTF and those that it will need to make in both the relative near-term and longer horizons for this and other facilities. The next sub-sections will speak to this point.

4.2 AEROBIC GRANULAR BIOMASS

4.2.1 Technology Description

The suspended-growth biological processes used in municipal wastewater secondary treatment systems, and that used by the Municipality, have traditionally used *flocculent* biomass, which provides a means and structure to agglomerate individual microorganism cells into a collective mass that can be separated from effluent via gravity settling. While being capable of providing a high-quality effluent in terms of low TSS levels, flocculent biomass systems are inefficient in that their resultant biomass settling velocity / thickening rate is slow and in the order of meters-per-hour.

Alternatively, *granular* biomass systems allow essentially the same microorganisms to produce discrete spherical granules (Figure 4-1) rather than a flocculent structure. These granules, with millimetre-scale diameters, have settling velocities in the order of tens of metres-per-hour.

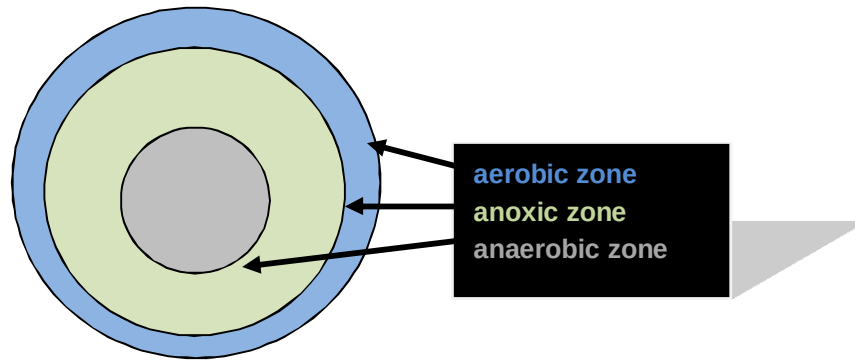
Figure 4-1
Photograph of Aerobic Granule



http://en.wikipedia.org/wiki/Aerobic_granulation
Image source: University of Santiago de Compostela, May 23, 2008

Furthermore, traditional suspended-growth biological processes typically compartmentalize either in space (e.g. 3-stage bioreactor in a continuous flow system) or time (sequencing batch reactor) different biochemical environments (anaerobic/anoxic/aerobic) to support EBPR, denitrification, nitrification and carbon oxidation. However, “aerobic” granules can be grown such that all three environments can be contained within a single granule as shown conceptually in Figure 4-2. Use of DNA/RNA molecular identification tools has found that nitrifying organisms generally populate the outer aerobic zone of the granule, followed by phosphorus-accumulating organisms and denitrifying heterotrophs in the anoxic zone and distributed across its thickness to the anaerobic zone.

Figure 4-2
Typical Structure of an Aerobic Granule Showing Aerobic, Anoxic and Anaerobic Zones within the Granule Structure
(adapted from Winkler (2012a))

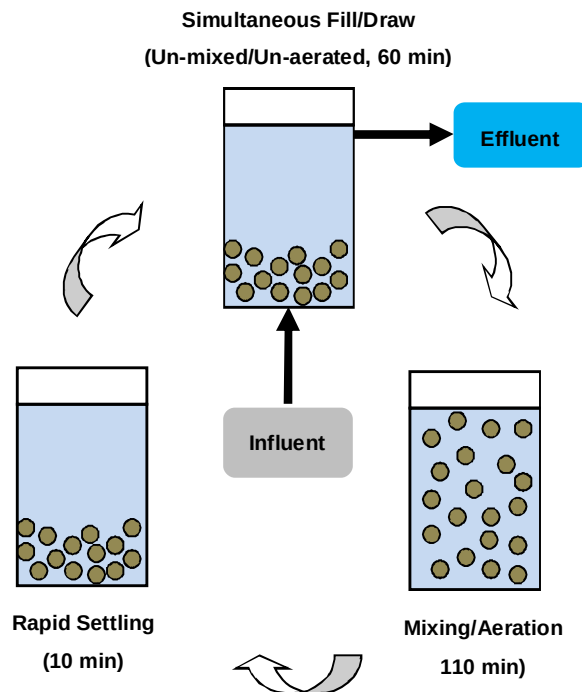


The elegance of granular biomass systems is that they could provide a very compact treatment system via a biotechnology means rather than a mechanically-intensive approach applied to flocculent (e.g. membrane bioreactor) and even fixed-film (e.g. moving bed biofilm reactor) biomass. Even though the potential advantages of granular biomass systems have been well-known for decades, and has been developed into viable *anaerobic* technology (i.e. upflow anaerobic sludge bed (UASB)) for high-carbon wastewaters, it has taken two more decades to develop *aerobic* granular biomass (AGB) technology (Winkler, 2012a). Key technical challenges included understanding the mechanisms to grow granules aerobically and the operating conditions to support these mechanisms: promotion of the selection of slow-growing organisms that produce biopolymers and controlling detachment forces (Winkler, 2012a; Giesen et al., 2011).

While aerobic granular biomass research is being conducted around the world, the research conducted by the Technical University of Delft (TUD, the Netherlands) and its partners to develop, commercialize and manage the risks of early-adopter implementation of a new technology provides one of the most interesting stories in wastewater treatment (e.g. van Loosdrecht and van der Roest, 2011 and Giesen et al., 2012). The result of this effort, the Nereda® process, involves a fill-and-draw or sequencing batch reactor operated as shown in Figure 4-3. Cited advantages for the process, relative to traditional flocculent biomass systems, include:

- 75% reduction in biological system surface area owing to a combination of the high biomass concentrations that can be maintained in the system along with the very high settling velocities
- 20% reduction in construction and operation costs due to the simplicity of the system relative to a continuous-flow system that uses multi-stage bioreactors and internal recycle stream pumping to provide alternating biochemical environments
- 20% reduction in energy, again relative to conventional, continuous-flow BNR systems, due to the lower pumping and mixing requirements. Demonstration-scale operation at the Frielas WWTF in Portugal provided data that also suggests the oxygen transfer efficiency to granular biomass may be significantly higher relative to flocculent biomass, at least in the case of the non-nitrifying system under study (Inocencio et al., 2013)

Figure 4-3
Aerobic Granular Biomass Reactor Operation
 (adapted from Winkler, 2010; Giesen et al., 2011; van Loosdrecht and van der Roest, 2011)



While several full-scale, but small, industrial systems have been installed to date, the first full-scale municipal Nereda® application is in Epe, the Netherlands for the District Veluwe Water Board. This WWTF was commissioned in late 2011; key facility design aspects include (van Loosdrecht and van der Roest, 2011; Giesen et al., 2012; Landers, 2012; Inocencio et al., 2013):

- Service population = 59,000 person equivalents (PE); includes a high contribution of slaughterhouse wastewater discharged to municipal system
- 8 ML/d design capacity with a maximum hydraulic capacity of 36 ML/d to handle wet-weather flows
- Preliminary treatment provides raw wastewater screening and aerated grit/grease removal
- Secondary treatment and nutrient removal provided by a 3-reactor, fill-and-draw Nereda® system. Each circular bioreactor is 25 m in diameter and 9 m deep
- Tertiary treatment for suspended solids and TP removal is provided by down-flow, granular-media (sand) filtration.
- Effluent regulatory requirements: TP < 0.3 mg P/L and total nitrogen < 5.0 mg N/L.

The Epe facility, based on verification data from March to May, 2012, when wastewater temperatures ranged from 14 to 16°C, appears to be performing as intended from an effluent quality perspective based on reported average values (Inocencio et al., 2013):

- BOD of < 2 mg/L
- ammonia of 0.1 mg N/L and total nitrogen under 4.0 mg N/L
- TP at 0.3 mg P/L

During this period the notably high-strength wastewater contained BOD and TSS levels of 333 mg/L and 341 mg/L, respectively; TKN and ammonia of 77 and 54 mg N/L, respectively; and total phosphorus of 9.3 mg P/L.

The Epe's facility three reactors provide a total volume of approximately 13,000 m³. This volume is one-half of the 26,000 m³ volume we estimated using conventional SBR flocculent biomass system design (e.g. 4 SBR units, 3 hr storm cycles, 0.17 decant volume / total SBR unit volume ratio). However, if the Epe facility used a 0.5 decant volume / total reactor volume ratio instead of the apparent 0.34 value used in its design, as has been suggested by van Loosdrecht and van der Roest (2011) as possible, the total reactor volume could be reduced to 9,000 m³ from 13,000 m³. Thus, there appears to be some conservatism in its design as two of its reactors could be used to process the peak wet-weather flow rate. It is likely the Epe design approach was purposeful to mitigate risks during technology adoption at this scale.

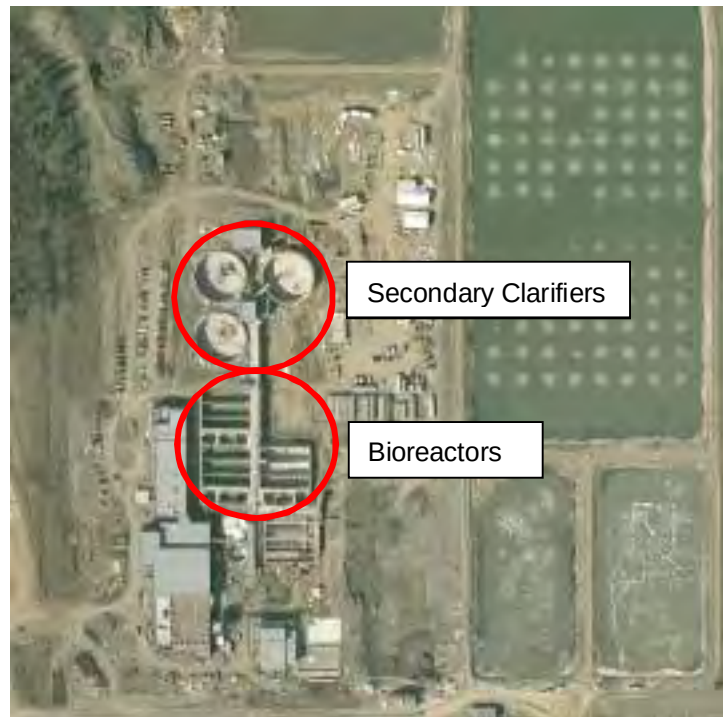
Landers (2012) notes that as of mid-2012 at least 6 other full-scale Nereda®-based facilities were under construction in the Netherlands and South Africa. Once commissioned these WWTFs, like the Epe facility, will contribute to the AGB system knowledge base in terms of design and performance.

4.2.2 Municipality Implications

The potential aerobic granular biomass (AGB) advantages described in Section 4.2.1 are significant. But what might they mean for the Municipality at this point in time given the early stage of full-scale municipal system implementation?

First consider the existing Fort McMurray WWTF. The site itself is relatively unconstrained in terms of future capacity expansions (Figure 4-4) and this fact erodes a significant AGB benefit. Alternately, much tankage has already been constructed and thus the potential exists to use this tankage for an AGB system and substantially increase the capacity of the works that currently exist. The obvious questions include: at what "effort" and is it worth it? A proposed new South Regional WWTF has yet to be built and it too could benefit from reduced constructed works.

Figure 4-4
Phases 1 and 2 Construction of the Fort McMurray WWTF



The other question is of timing→ early adoption of a technology includes risks. Time and industry experience provides knowledge to understand and mitigate these risks. For the existing Fort McMurray WWTF, the 4th bioreactor and secondary clarifier is required essentially immediately to provide an appropriate level of redundancy. Future expansions are anticipated to be needed in a 10 years plus timeline. The need for a new South Regional WWTF is more uncertain and could be as distant as 10 years as well.

Could a confident decision be made regarding AGB at these points in time? Essentially “no” in terms of displacing the need for a 4th bioreactor and secondary clarifier at the existing Fort McMurray WWTF. However, the current pace of Nereda® system implementation, for at least this specific AGB technology, suggests that, whatever the conclusion might be, the information will largely be available to do so for future expansions of the existing Fort McMurray WWTF and a new South Regional WWTF. Any significant unknowns will likely relate to cold-weather climate applications in places such as Fort McMurray, although pilot-scale research has confirmed granulation and performance at process temperatures below 10°C (de Bruin et al., 2010). Mitigating some of the implementation risks could be accomplished with a hybrid approach similar to that in place for the Frielas WWTF in Portugal (Inocencio et al., 2013). Here one of six bioreactors from a 70 ML/d conventional, continuous-flow activated sludge (AS) facility has been converted to a Nereda® reactor. The intent is to seed the remaining five bioreactors with waste AGB from the Nereda® reactor to increase the AS system capacity in the short-term, with eventual conversion of all AS reactors to AGB configuration.

In the end, appropriate information needs to be available to the Municipality at the point in time when it needs to confirm its technology decisions. One way to structure this information is a future uncertainty analysis, which examines the potential consequences of making different technology decisions using a likelihood-of-occurrence / extent-of-impact methodology used in risk assessments. The following information shows a simplistic example using *fictitious* values:

Table 4-1
Example Uncertainty Analysis

likelihood-of-occurrence	extent-of-impact	consequence score
Probability that a specific new technology can perform as required for the Municipality = 0.7 (i.e. fictitious value for illustration purposes)	Capital cost of expanding the Fort McMurray WWTF using current technology = \$10,000 (i.e. fictitious value for illustration purposes)	$= 0.7 \times \$10,000 = \$7,000$ This value is essentially the capital at risk or “stranded” in pursuing existing technology when the new technology could be implemented (i.e. fictitious value for illustration purposes)
Probability that a specific new technology will not perform as required for the Municipality = 0.3 (i.e. fictitious value for illustration purposes)	Capital cost of modifying existing works to accommodate the new technology to provide the required capacity = \$2,000 (i.e. fictitious value for illustration purposes)	$= 0.3 \times \$2,000 = \600 This value represents the effective capital at risk in the pursuit of a new technology (i.e. fictitious value for illustration purposes)

Such an analysis would need to be more comprehensive, and consider other elements while normalizing the extent-of-impact scales across other elements, but this example provides a general framework for the evaluation.

take-away messages

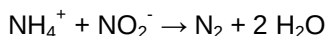
- ✓ Aerobic granular biomass (AGB) technology has already seen full-scale implementation in both the municipal and industrial sectors and its purported advantages are difficult to ignore.
- ✓ Sufficient industry AGB experience, to enable confident decision-making, will likely be available in the relative near-term and at the point in time (e.g. 10 years from now) when the Municipality will need to make technology choices for an expanded Fort McMurray WWTF or new South Regional WWTF.
- ✓ The Municipality can use a risk assessment-based future uncertainty analysis framework to inform such technology decisions for AGB and other technologies discussed in this document.

4.3 MAIN-STREAM DEAMMONIFICATION

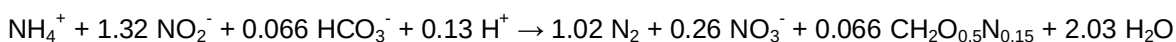
4.3.1 Technology Description

The term “deammonification” refers to the two-step conversion of ammonia to nitrogen gas (N_2) through a combination of what is termed *partial nitrification* and *anaerobic ammonia oxidation* (anammox). Anammox is the novel part of deammonification and a good place to start a brief description of the biochemical processes.

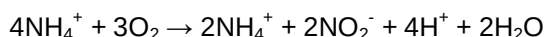
The anammox pathway was hypothesized to exist, based on thermodynamic considerations, in the 1920s but it took a long time to discover it in reality. The first direct evidence of this “missing lithotroph” was found in an anoxic fluidized bed reactor in 1985 but it wasn’t until 1999 that the microbes involved in the pathway were confirmed as members of the bacterial phylum *Planctomycetes* (Winkler, 2012a). The pathway is elegant in its simplicity where, as shown below, equal molar amounts of ammonia and nitrite are oxidized to N₂:



In reality the reaction is slightly more complicated and approximately 11% of the nitrogen is converted to nitrate (Grady et al., 2011):



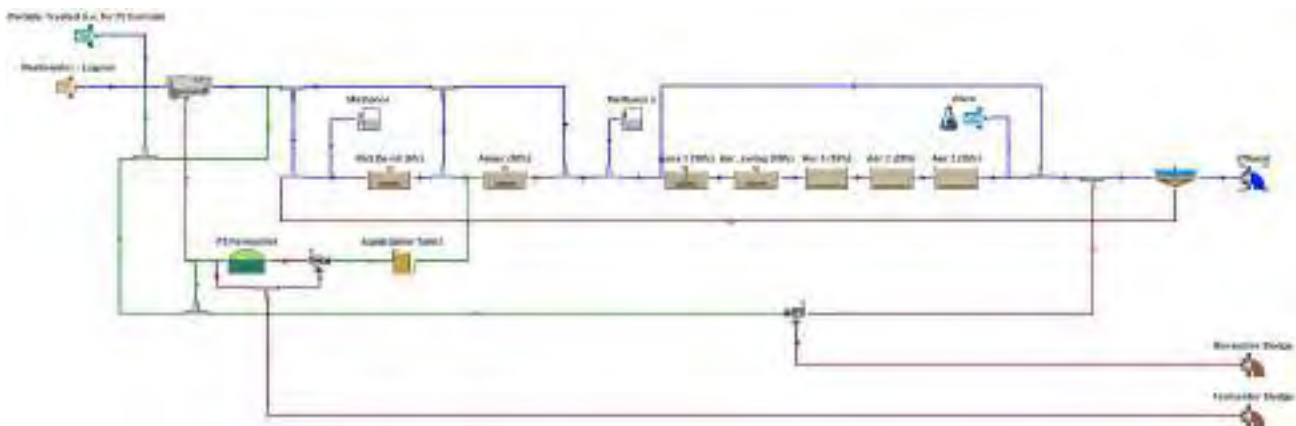
The remarkable aspect of the anammox reaction, from a wastewater treatment perspective, is that the conversion of ammonia all the way to N_2 occurs without the need for molecular oxygen or carbon. But there is a catch of sorts and this is where partial nitrification comes in. Aerobic ammonia oxidizing bacteria (AOB), well-known to the wastewater industry, are needed to first convert one-half of the ammonia to nitrite using an aerobic process (Grady et al., 2011):



Thus partial nitrification provides the 50/50 blend of ammonia and nitrite needed to drive the anammox reaction. Overall, the combination of partial nitrification + anammox (i.e., deammonification) provides both ammonia and essentially complete total nitrogen removal using 63% less oxygen than conventional nitrification and there is no need for carbon to drive denitrification.

To explore these potential benefits of main-stream deammonification (MSD) consider a typical Canadian WWTF that uses a liquid-stream process configuration similar to that used at the Fort McMurray WWTF (Figure 4-5).

Figure 4-5
Liquid-stream Process Configuration of a Typical Canadian BNR WWTF

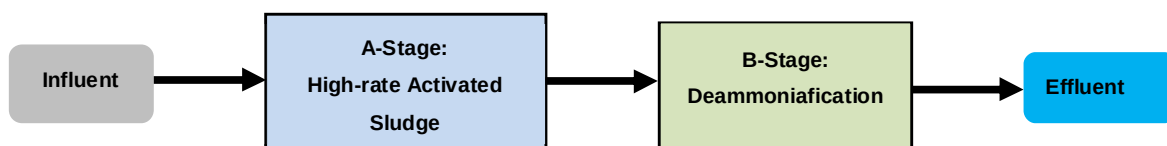


Process simulation work to support the analysis presented in Shiskowski (2013) found that the oxygen demand exerted by conventional nitrification was approximately 60% of the total oxygen demand required by the biomass for both carbon and nitrogen oxidation. Multiplying this value through by 0.63 (i.e., the efficiency noted above for deammoniafication vs. conventional nitrification) gives a value 38%. This value suggests that conducting ammonia removal via deammoniafication could reduce the total bioreactor oxygen requirement by 38% relative to a typical process that uses traditional nitrification pathways. This reduction in oxygen demand also translates into an approximate 38% savings in aeration-related energy. Analyses conducted by others (e.g. Caprariu, 2013) have reached similar conclusions. Furthermore, as will be discussed shortly, changes in the system to provide carbon oxidation (BOD removal) only, which was originally influenced by the requirements of conventional nitrification, could further reduce the oxygen demand and thus energy requirement by another 10%. Combined such efficiency gains could conceivably reduce aeration-related energy costs by an amount approaching 50%.

In addition, if external carbon (e.g. methanol) is needed to support conventional, heterotrophic denitrification to reach very low effluent total nitrogen levels, the benefits of deammoniafication become even more substantive. The savings in chemical costs can be in the same order as the total costs incurred in bioreactor aeration (e.g. Shiskowski, 2013). A similar conclusion was reached for DC Water's 1,400 ML/d Blue Plains WWTF, where its methanol costs run up to \$7M annually (e.g., Stinson et al., 2013).

Lastly, MSD has the potential to significantly reduce the facility tankage volume and area required relative to traditional suspended-growth biological systems. The implementation approach separates the secondary treatment / nutrient removal system into an 'A-stage' and 'B-stage'. Such "multiple-sludge" configurations were popular in the early days of nutrient removal when carbon (BOD) oxidation was provided in an initial system, followed by a second system to provide ammonia removal and total nitrogen removal via nitrification/denitrification. Figure 4-6 shows one configuration example, where a short SRT, high-rate activated sludge system (HRAS) provides BOD, and potentially P removal, in the A-stage and where its effluent is received by a B-stage deammoniafication system.

Figure 4-6
Conceptual A-Stage/B-Stage Configuration for Main-Stream Deammoniafication



How is volume/area reduction achieved?

- First, in a conventional system the SRT needed to support nitrification (e.g. 12 to 16 days) dictates in large part the bioreactor volume, which also has connection to secondary clarifier sizing. In the A-stage shown in Figure 4-6 the HRAS SRT can be very low (e.g. 2 days or less) for carbon oxidation only thus shrinking bioreactor volume markedly (e.g. Stinson et al., 2013). Although enhanced biological phosphorus removal (EBPR) systems require a longer SRT to ensure growth

and retention of P accumulating organisms (PAOs), it would still be much shorter than needed for a fully-nitrifying conventional system (e.g. Grady et al., 2011).

- Second, the B-stage deammonification system can be configured to grow anammox granules. Per the Section 4.2.1 discussion, use of granular biomass, as opposed to flocculent biomass, increases the biomass concentration that can be carried in the reactors while also allowing much higher settling velocities. Combined these two factors minimize the physical size of the B-stage.

This combination of benefits has generated considerable deammonification research and development in the past decade due to the potential advantages of this process over those traditionally used in wastewater treatment. TU Delft, Raboud University of Nijmegen, and the University of Innsbruck have figured prominently in development of the commercially available ANAMMOX® and DEMON® systems. Full-scale installations of these and other systems (e.g. Anita™ Mox) now surpass approximately 50 examples globally; spanning high-temperature, high-ammonia industrial wastewaters and municipal WWTF anaerobic digester / dewatering recycle *side-streams*. In this latter application the system currently in design for Blue Plains WWTF that serves the Washington, DC area represents the largest in the world.

But the leap to *main-stream* (i.e., full wastewater flow) deammonification (MSD) in a municipal wastewater application is a much bigger step. Key challenges include (Stinson et al., 2013):

- Slow growth of anammox organisms (i.e. cell doubling time in the order of 10 day compared to 10 hour for conventional nitrifying organisms) and associated biomass retention, which is further compounded at the low temperatures of main-stream wastewater.
- Suppression of nitrite oxidizing bacteria (NOB) to prevent full nitrification that at lower wastewater temperatures and nitrogen concentrations becomes harder to control because of kinetic rate differences between NOB and aerobic AOB.
- Wastewater carbon that results in competition of heterotrophic organisms with AOB and NOB for oxygen and nitrite, respectively, under the different biochemical environments required (Stinson et al., 2013) and which also impact the preceding point.

These points have been key drivers in the A-stage / B-stage thinking shown in Figure 4-6. But recent findings by Winkler et al. (2012b) set the stage for possibly replacing the A-stage biological system with a physical-chemical system (e.g. chemically-enhanced primary treatment, CEPT). The benefits of doing so would be a further reduction in A-stage tankage and space requirements, elimination of bioreactor aeration, and sending more primary sludge to anaerobic digesters for biogas generation. But CEPT systems leave some soluble carbon in their effluents and this material could negatively impact a downstream B-stage deammonification system. Capitalizing on the recognition that certain anammox organisms can oxidize volatile fatty acids with nitrate as an electron acceptor, Winkler et al. (2012b) demonstrated at bench-scale the potential to use an AGB system with integrated deammonification to treat a low C / N wastewater. While many uncertainties currently exist with such wastewaters (e.g., CEPT effluents), their work opens the door of possibility in A-stage/B-stage configurations.

On balance, the MSD challenges are significant, and unlike AGB discussed in Section 4.2, the technology has not yet made it to full-scale implementation. Much fundamental and bench-scale research continues at the academic level and large pilot-scale studies have been conducted at existing WWTFs in the Netherlands (e.g. Lotti et al., 2013) and the United States at the Blue Plains WWTF (e.g. Stinson et al., 2013). Limited full-scale demonstration studies have been executed at the Strass im Zillertal (200,000 pe) and Glarnerland (70,000 pe) WWTFs in Austria using some of their parallel trains (Caprariu, 2013; Borger and Geraats). Much of this effort involves cross-industry collaboration of universities, utilities, technology vendors, and industry research organizations such as the Water Environment Research Foundation.

Of particular note are the efforts centered on the Blue Plains WWTF (Figure 4-7). By chance this facility was originally conceived with an A-stage / B-stage configuration. It also sits on a very constrained site where space is at a premium. And, as noted earlier, it incurs very large methanol costs to meet its high quality effluent requirements. All these points incentivize MSD development. DC Water is attempting to secure grants to facilitate the transition to some extent of MSD implementation but the timeline remains uncertain (Murthy, 2013). Clearly, the sheer size of this WWTF and effort being expended on this topic at Blue Plains will have significant influence in the wastewater industry at-large.

4.3.2 Municipality Implications

Clearly the main-stream deammonification (MSD) benefits described in Section 4.3.1 are substantial and, relative to those reported earlier for aerobic granular biomass systems, are even more so from an energy perspective. However, compared to AGB, MSD in a municipal setting is still a distant goal given the technical hurdles that need to be overcome and assuming they can be overcome. Again the question is one of the implications of this technology development relative to the Municipality master planning.

As discussed previously, it is probable that the Municipality will need to make some important treatment capacity and greenfield technology decisions in potentially 10 years. On a shorter horizon (e.g., 2 to 3 years) it would seem improbable that MSD technology will be proven to the extent that a confident decision could be made for such immediate implementation. Alternately, the 10 year horizon might provide quite a different situation given current industry activity. The future uncertainty analysis approach discussed in Section 4.2.2 provides a framework to inform the MSD discussion. Relative to the AGB situation, where the purported AGB energy savings related to mechanical equipment may prove to be less substantial, the potential energy savings associated with MSD would feature much more prominently in the evaluation. Therefore, providing sufficient flexibility in the near-term to accommodate MSD implementation at a future date is recommended should the technology prove itself.

Figure 4-7
Blue Plains WWTF Aerial Photo Showing A-side HRAS Bioreactors (solid green box) and Clarifiers (dashed green box) and the B-Side Nitrification/Denitrification Bioreactors (solid red box) and Clarifiers (dashed red box) (adapted from Stinson et al., 2013)



Lastly, there are two further Municipality implications for consideration:

- One is that much of the MSD thinking, as well as full-scale demonstration trials, has involved the use of side-stream deammonification (i.e. applied to anaerobic digester/dewatering-related recycle streams) as a source of biomass to *bioaugment* an MSD system. The Fort McMurray WWTF does not currently stabilize solids using anaerobic digestion (AnD) and future plans for AnD at any RWMB facilities is uncertain at this time. But this situation would not necessarily preclude MSD. Pilot-scale research conducted at the Dokhaven-Sluisjesdijk WWTF in the Netherlands using actual A-side effluent, but without any bioaugmentation, found stable MSD performance and a system that could recover quickly to A-side process upsets (Lotti et al., 2013). The researchers concluded that proper system design, rather than relying on bioaugmentation, could likely provide a stable process.
- The Section 4.3.1 discussion identified various A-side options, including an HRAS or HRAS/EBPR system and potentially a solely CEPT system. Aerobic granular biomass, discussed in Section 4.2, could be added to this list of possibilities. The B-side MSD discussion cannot happen independently of the A-side and so the latter needs to factor into conceptual planning and evaluation.

take-away messages

- ✓ Main-stream deammonification (MSD) is another technology that the Municipality ought to consider earnestly for its potential benefits should it be successfully developed and implemented in a municipal setting.
- ✓ While the timeline where sufficient industry MSD information would be available to enable confident decision-making for the Municipality's WWTFs is likely in the order of a decade from now, if proven applicable, nearer-term WWTF decisions the Municipality needs to make should give consideration in terms of future adaptation or transition to MSD and other technology.
- ✓ Connected with "B-stage" MSD are complementary "A-stage" technologies such as high-rate activated sludge (HRAS), with potential integration of enhanced biological phosphorus removal (EBPR), and chemically-enhanced primary treatment (CEPT) that would further maximize the benefits of moving to MSD and simultaneously need to be considered with MSD.

5 Main-Stream Resource Recovery

5.1 OVERVIEW

Although resource recovery has long been part of wastewater management, through such measures as biogas generation/use and water reclamation/reuse, the topic has gained considerable profile in recent years. Editorial guidelines for the Water Environment Federation's (WEF) flagship research journal *Water Environment Research* provide an example of current industry attentiveness to the subject: the term "water resource recovery facility" is to be used in place of "wastewater treatment plant" in submitted manuscripts (www.wef.org/Publications). Furthermore, the diversity of research captured under the definition of resource recovery is impressive. For example, at its extreme, it includes topics such as the production of methanol, which would provide an easily distributed vehicle fuel, from methane contained in anaerobic digester biogas using ammonia oxidizing bacteria (e.g. Taher and Chandran, 2013).

However, as discussed in previous sections, nitrogen and phosphorus figure prominently in the effluent quality requirements set out in Approval 689-02-00. In turn, these constituents have driven the core technology decisions for the Fort McMurray WWTF in the past and will continue to do so in the future for this and other Municipality facilities. Therefore, likely most relevant for the Municipality in terms of implications for its WWTFs, and the technology they use in the foreseeable future, are nutrient recovery efforts that recognize the significant mass of the macro-nutrients phosphorus and nitrogen contained in municipal wastewater.

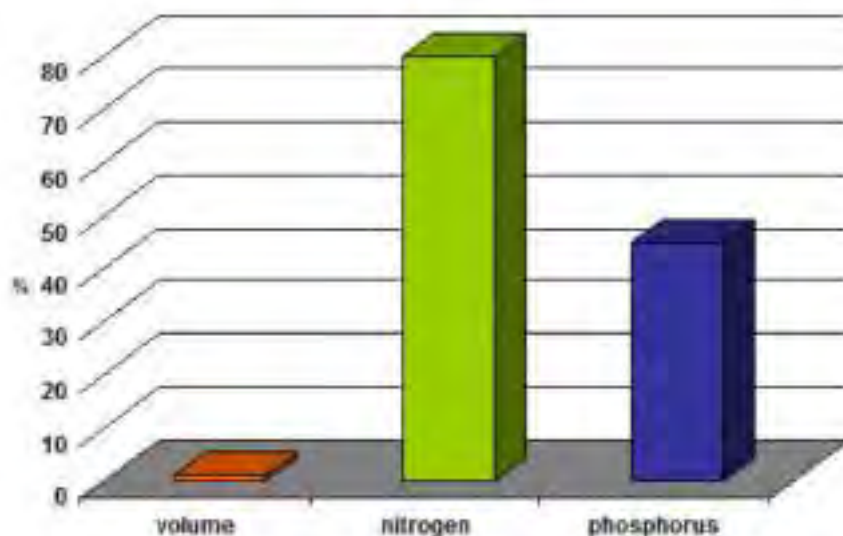
To this end, the following sub-sections discuss two specific approaches to nutrient recovery, and examples of associated technology, which could notably impact the Municipality facilities and technology decision-making.

5.2 AT-SOURCE

5.2.1 Management Description

As illustrated in Figure 5-1, while urine constituents in the order of only 1% of the volume of domestic wastewater, it typically contributes approximately 80% of the nitrogen and 50% of phosphorus. This reality makes at-source recovery of nutrients via urine separation attractive as a wastewater management strategy. Specific to the subject of this document and this section, at-source urine separation is one example of what has been termed *main-stream resource recovery* (i.e. nutrients recovered from the main-stream of wastewater flow) for the purpose of discussion.

Figure 5-1
Relative Contributions of Urine to the Volume, Nitrogen and Phosphorus Content
of Municipal Wastewater (adapted from Wilsenach and van Loosdrecht, 2006)



Many people working in wastewater management today have some familiarity with the concept of urine separation or urine diversion. In simple terms, implementing urine separation requires:

- i) Collecting urine separately at the source through dual-compartment toilets and waterless urinals.
- ii) “Transporting” urine by some means to potentially very near or more distance locations.
- iii) Using urine either as a fertilizer, subsequent to varying degrees of stabilization or pre-processing, or treating it for disposal. Countries such as Sweden and Switzerland have expended notable effort to date on the topic and pilot projects have been conducted in countries in Africa and Asia as well as Europe (Shiskowski, 2012). First in the United States, the Hampton Roads Sanitation District has implemented urine separation in its new Operations Center Complex, where the collected urine will be truck-hauled to their Nansemond WWTF side-stream struvite crystallization-based nutrient recovery facility.

For the interested reader the recent Water Environment Research Foundation (WERF) study by LeMonde Fewless et al. (2011) provides an excellent summary of the global state of knowledge and experience regarding urine separation, largely from a wastewater management-centric perspective. Others (e.g. Shiskowski, 2012) take the conversation more broadly in terms of the potential role and benefits of urine separation in managing the global reactive nitrogen cycle.

5.2.2 Municipality Implications

If the Municipality implemented urine separation as a wastewater management strategy over time, what are the implications on WWTF technology?

First consider nitrogen:

- At its extreme, assuming urine provides 80% of the wastewater nitrogen content and in consideration of typical unit nitrogen requirements for carbon oxidation, complete (i.e. 100%) urine separation could reduce wastewater nitrogen concentrations to a point that would negate the need for further main-stream ammonia removal at a WWTF (e.g. greenfield South Regional sewer system and WWTF) via conventional nitrification, MSD, etc. As discussed previously, regardless of the technology used at a WWTF (i.e. flocculent vs. granular biomass), the energy and tankage savings would be substantial relative to the current Municipality situation.
- Alternatively, consider the other end of possibility, say 25% urine separation. Such a scenario would still leave a substantial amount of nitrogen in the wastewater. For the technology currently used at the Fort McMurray WWTF the lower nitrogen loads would marginally reduce the aeration-related energy requirements. However, since effluent ammonia levels are generally a function of SRT and not ammonia load in such systems, the SRT would need to remain at existing levels to provide the level of performance required. Thus this scenario would offer no meaningful benefit in terms reduced tankage volume and area, etc.

Now consider phosphorus:

- The 100% urine separation scenario, assuming urine provides 50% of the wastewater phosphorus content, would also substantially reduce wastewater phosphorus levels but likely not to the point where heterotrophic synthesis of phosphorus for carbon removal would on its own lower effluent concentrations to the level required. However, the reduction in EPBR activity needed to produce low effluent TP levels would in turn reduce the volatile fatty acid (VFA) demand to drive the process. This result would reduce the fermenter capacity required and potentially eliminate them entirely depending on the VFA content of the wastewater. This scenario would also marginally reduce the aeration-related energy requirements as carbon contained in the primary sludge that was originally destined for the fermenters and ultimately bioreactors would be wasted from the liquid-stream system as primary sludge.
- Similar to nitrogen, the 25% urine separation scenario would expectedly offer no material benefit relative to the existing Municipality situation in a phosphorus context.



The simple, theoretical, qualitative analysis presented above suggests that the existing Fort McMurray WWTF could be impacted significantly, from a nitrogen perspective, should a 100% urine separation scenario be achieved. But given the investment in existing building and collection system infrastructure associated with the existing WWTF, assuming all other technical hurdles with urine separation could be overcome, such a wastewater management strategy would practically take decades to implement in fullness, if at all. As a result, Fort McMurray WWTF technology-related decisions that the Municipality will need to make in the foreseeable future appear reasonably insensitive to the influences of urine separation should the Municipality wish to adopt such a wastewater management strategy.

At this time much uncertainty exists regarding the greenfield South Regional sewer system and WWTF, both in terms of its timing of implementation and the mix of its service population. But because it would be a new system it does provide an opportunity for the 100% separation scenario from the outset should the Municipality choose to take such a direction. If so, a decision to proceed in this manner could have a substantial impact on WWTF design.

take-away messages

- ✓ Urine separation as an at-source, main-stream resource recovery strategy can have a significant impact on WWTF design and operation depending on the extent of urine diversion achieved.
- ✓ Given the existing infrastructure associated with the Fort McMurray WWTF, technology-related decisions for this WWTF that the Municipality will need to make in the foreseeable future appear reasonably insensitive to the influences of urine separation should the Municipality wish to adopt such a wastewater management strategy.
- ✓ Conversely, urine separation could significantly influence the proposed South Regional WWTF technology decisions, because of its greenfield nature, depending on the extent of separation the Municipality might wish to pursue under such a strategy if so adopted.
- ✓ The Municipality can use a risk assessment-based future uncertainty analysis framework to inform such technology decisions.

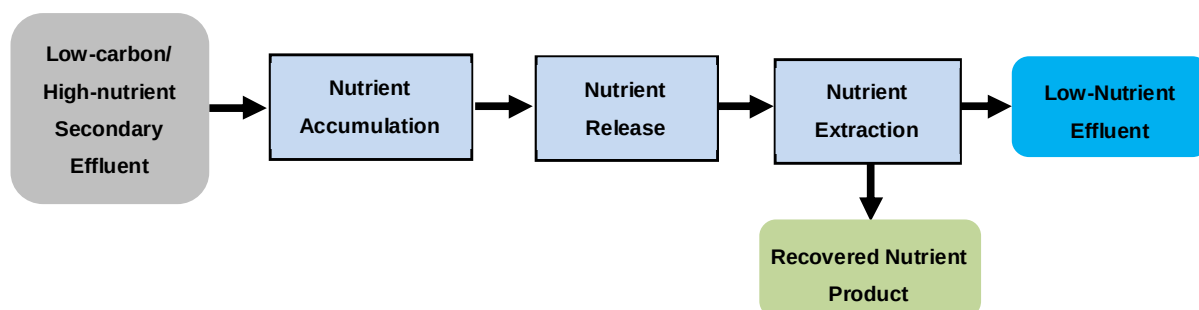
5.3 POST-TREATMENT

5.3.1 Technology Descriptions

For the purpose of this discussion post-treatment nutrient recovery refers to nitrogen and phosphorus capture from the *main-stream wastewater flow* after basic secondary treatment that provides carbon removal. This approach is distinctly different from nutrient recovery from anaerobic digestion (AnD) and dewatering recycle *side-streams* using processes such as magnesium-ammonium-phosphate (MAP) crystallization (e.g. Pearl® Process, Phosnix®). As indicated in Section 4.3.2, the Fort McMurray WWTF does not currently stabilize solids using AnD and future plans for AnD at any RWMB facilities is uncertain at this time. Thus this discussion focuses on main-stream nutrient recovery approaches.

This form of nutrient recovery involves three general steps as illustrated in Figure 5-2:

Figure 5-2
Elements of Post-Treatment Extractive Nutrient Recovery (PTENR) from
the Main-Stream Wastewater Flow (adapted from Khunjar et al., 2013)



One example of PTENR is using secondary effluents to drive microalgae production via the nitrogen and phosphorus it contains. Algae processes have gained considerable attention lately in part because the high lipid content of algal cells can be converted to biodiesel (Lu et al., 2013). While wastewater-derived nutrients could potentially offer a substantial reduction in the energy inputs needed for such biodiesel production (i.e. growth of microalgae), another key input is carbon dioxide (CO₂). And generated biogas from a WWTF is one source; coal-fired power plants could also supply the needed CO₂ (Lu et al., 2013). Simply the nutrient accumulation aspect of microalgae growth has been described by Khunjar et al. (2013) as at an embryonic stage of development, using the embryonic / innovative / established definitions used by WERF.

Looking solely to phosphorus recovery, use of metal oxide / polymer mixture media as adsorbents, which have ion exchange properties, has gained attention as a means to recover phosphorus from effluent while simultaneously producing effluent that contains extremely low phosphorus concentrations. Key to this concept development is a new media manufacturing technique that provides high porosity with high selectivity for phosphorus over other anions (deBarbadillo, 2011). The process described in deBarbadillo (2011) includes:

- Filtration of secondary effluent;
- Adsorption of phosphorus in media-filled towers;
- Desorption of the adsorption towers in an alkaline aqueous solution;
- Recovery of phosphorus in a precipitation/clarification reactor using calcium hydroxide to form an apatite-type calcium phosphate; and
- Refining of the recovered phosphate via drying/granulation to provide a commercial-grade product.

Pilot-scale trials have been conducted at the Tochigi WWTF in Japan and Lawrence WWTF in Kansas and have demonstrated 50th percentile effluent TP values in the range of 0.03 to 0.05 mg P/L while producing recovered solids that compared favourably to fertilizer standards for metals.

A variety of technical approaches to effluent nitrogen recovery are conceptually available (e.g., stripping (air, steam), adsorption (sorption, ion exchange), vacuum distillation and co-precipitation with phosphorus recovery via MAP crystallization) (Reardon and Machado, 2011). Of these, only adsorption/ion exchange is categorized by the WERF *Nutrient Recovery Challenge* as nitrogen accumulation technologies “suitable” for full-scale WWTFs (Khunjar et al., 2013). At the same time, they are currently classified as innovative technologies with limited full-scale application.

5.3.2 Municipality Implications

The feasibility of using PTENR for the purposes of microalgae and ultimately biodiesel production in the Municipality, or surrounding area, appears at this time to be extremely limited. Sunlight is a key element in algae production and the geographic location of the region is not favourable in this regard. Therefore, this form of PTENR will seemingly have no impact on Municipality WWTF-related decision-making at least for the foreseeable future.

Moving on to phosphorus and nitrogen commercial products, as clearly noted by Khunjar et al. (2013), the feasibility of PTENR in this light is dependent on the need to produce chemical products for use in a secondary market and the pricing for comparable products in a specific regional market. The Municipality's geographical location again would seem to preclude the practicality of PTENR for the purposes of producing nitrogen and phosphorus fertilizers for traditional agricultural uses. At the same time, one could ponder the potential for their use in oil sand-related reclamation activities.

Even if feasible in this latter market, the addition of the adsorption/desorption technology required for only phosphorus recovery and simultaneous removal from effluent impacts the current business-as-usual Fort McMurray WWTF technology in a limited way as described in Section 5.2.2: primarily, possible elimination of the need for primary sludge fermentation. It could also potentially negate the need for future tertiary effluent filtration as discussed in Section 2.2. The upside is possibly a revenue stream for the Municipality should this market actually exist. A 100 ML/d WWTF, assuming 5 mg P/L in secondary effluent, would generate approximately 180 t P/year. At a current North American market value of \$700/t P (Khunjar et al., 2013) this revenue stream would be \$126,000/year excluding production costs.

Nitrogen is a bit of a different story. On the revenue side, assuming secondary effluent contained 25 mg/L of ammonia at a flow rate of 100 ML/d and a market price of \$2,000/t N (Khunjar et al., 2013), nitrogen recovery could provide \$1,800,000/year in revenue independent of production costs. Plus, as discussed for nitrogen in Section 5.2.2, the implications for Municipality WWTF technology could be substantial if it is not needed on its own to provide ammonia removal for effluent quality purposes.

These numbers show in some manner the potential upside of nitrogen- and phosphorus-related PTENR. However, the commercial market for such products in the region is currently unknown. In addition, the technologies required are still early in their development. These points create a situation similar to that of main-stream deammonification discussed in Section 4.3.2: it is unlikely that the Municipality could confidently make a positive decision on implementation, as it relates to WWTF implementation, in the short-term but that position might change in the 10 year horizon where the Municipality will expectedly need to

make WWTF technology decisions. Again, use of the previously discussed future uncertainty analysis as a tool to inform decision-making would be beneficial.

take-away messages

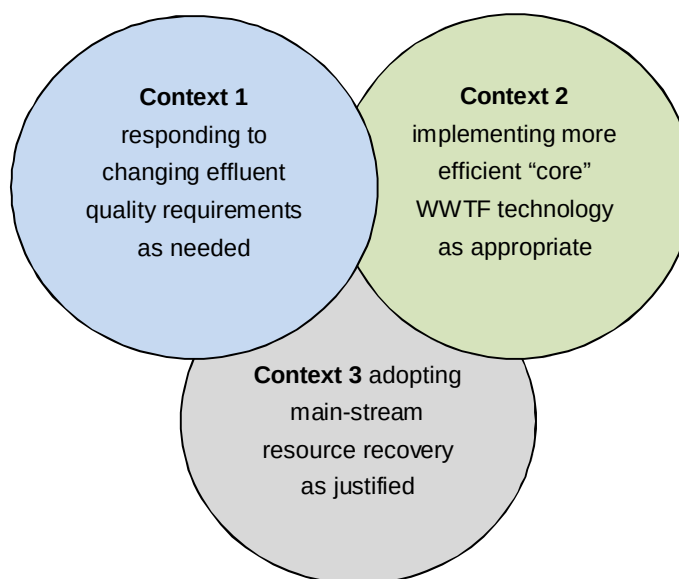
- ✓ Post-treatment extractive nutrient recovery (PTENR) technologies are still very early in their development stages and, perhaps more importantly, the commercial market (i.e. oil sand-related reclamation activities) for the resultant products is presumably largely unknown at this time.
- ✓ This situation may change over time and, given the range of potential PTENR benefits, it would be prudent for the Municipality to consider it in its WWTF decision-making.

6 Moving Forward: Summary & Recommendations

6.1 SUMMARY

As noted in the Introduction (Section 1), master planning work necessarily considers long-term horizons (25 yr +) and this technical memorandum (TM) raises the question of how treatment technology is changing, or may change, over such a horizon in response to three key dimensions or contexts that are summarized in Figure 6-1.

Figure 6-1
Interrelation Between WWTF Technology Change Contexts



Such potential change has implications on technology decisions already made by the Municipality and those that it will need to make in both the relative near-term and longer horizons. The following discussion summarizes key findings of this TM. The reader is directed to the “take-away message” boxes throughout the document for more detail.

Historical master planning has always grappled with contexts 1 and 2 highlighted in Figure 6-1 but the current place in time of the wastewater industry provides new complexities, as summarized below:

- In terms of **Context 1**, accommodating the potential future addition of trace organic compounds (TOC) as a newly added class of regulated effluent constituents in the longer-term will likely be the most significant challenge for the Municipality. This situation may drive a need for add-on unit processes to complement the core technologies currently used at the Fort McMurray WWTF and are planned for the proposed South Regional WWTF that provide secondary treatment and nutrient removal.

For currently regulated effluent constituents, a future lowering of their concentration-based limits, should it occur, would most likely impact the Municipality from an operations perspective rather than requiring capital-intensive outright technology change or addition. Minor capital works improvements might be needed. These conclusions are predicated on the assumption, which remains to be confirmed, that effluent filtration will be needed to meet the Year 2015 TP limits in Approval 689-02-00.

- The **Context 2** technology decisions made by the Municipality for the Fort McMurray WWTF in the mid-2000s were in part informed by the state of technology development at that time. The secondary treatment and nutrient removal technologies ultimately implemented have their origins in Canada from the early 1980s (i.e. 30 years ago) and reflected the technology evolution over the subsequent decades. At that point the technology was well-established and could be justifiably described as mature in terms of development life-cycle. Today, a decade following those decisions, finds the industry on the cusp of some dramatic step changes in biological system technology in the years ahead. Although the Municipality is well-advised to continually monitor technology development in terms of its existing and planned WWTFs, two specific examples stand out:

Aerobic granular biomass (ASB) technology has already seen full-scale implementation in both the municipal and industrial sectors and its purported advantages are difficult to ignore. At the time (e.g., 10 years from now), the Municipality needs to confirm technology choices for the existing Fort McMurray WWTF, and potentially a new South Regional WWTF, it is likely that sufficient industry experience will exist to make confident decisions on the technology.

Main-stream deammonification (MSD) is another technology that the Municipality ought to consider earnestly for its potential benefits should it be successfully developed and implemented in a municipal setting. While this timeline is likely in the order of a decade from now, nearer-term WWTF decisions the Municipality needs to make should give MSD consideration in terms of future adaptation or transition to this technology. Connected with “B-stage” MSD are complementary “A-stage” technologies such as high-rate activated sludge (HRAS), with potential integration of enhanced biological phosphorus removal (EBPR), and chemically-enhanced primary treatment (CEPT) that would further maximize the benefits of moving to MSD and simultaneously need to be considered with MSD.

- **Context 3** is essentially new for the Municipality and it is shown in Figure 6-1 as inter-related with the other contexts because of the significant influence it could have on them in terms of effluent nutrient removal simultaneous with nutrient recovery. Fort McMurray WWTF technology-related decisions that the Municipality will need to make in the foreseeable future appear reasonably insensitive to the influences of *at-source urine separation* should the Municipality wish to adopt such a wastewater management strategy. Alternatively, the greenfield nature of the proposed South Regional system and WWTF means technology decisions could be significantly influenced if urine separation was pursued. *Post-treatment extractive nutrient recovery* (PTENR) technologies are still very early in their development stages and, perhaps more importantly, the commercial market (i.e. oil sand-related reclamation activities) for the resultant products is presumably largely unknown at this time. But this may change over time and, given the range of potential PTENR benefits, it would be prudent for the Municipality to consider it in its WWTF decision-making.
- Lastly, regarding these contexts, it is important for the Municipality to maintain an awareness of their inter-relatedness beyond the nutrient removal drivers that have been and will continue to be central to its WWTF technology decisions. For example, how effective will AGB systems be for engineered nanomaterials (ENMs) removal, relative to flocculent biomass systems such as that used at the Fort McMurray WWTF, should it become a regulated effluent constituent in the longer-term? Similarly, how effective will A-side / B-side process configurations with integrated MSD be for TOC removal given the difference in the microbial communities such systems will have relative to those such as that currently used by the Municipality? The answers to these questions are essentially unknown at this time but this will change in the future.

6.2 RECOMMENDATIONS

Practically, what do these points mean for the Municipality? On the basis of the findings discussed in the TM, we offer the following strategy to guide the Municipality in its ongoing planning and decision-making in light of technology change:

1. Develop a **conservative plan** for cash flow and land area requirements.

One of the purposes of a master plan, at least where WWTFs are concerned, is to provide an understanding of the cash flow requirements over time to ensure future capital, operations and maintenance costs are adequately funded. Similarly, WWTFs require land area and master planning ensures sufficient space for long-term needs gets secured. Both ends can be accomplished reasonably using business-as-usual WWTF technology assumptions as they are a known commodity in many ways. For example, the information presented in Technical Memoranda #11 (Primary Treatment Screening, South Regional Wastewater

2. Formulate a **future uncertainty analysis** that can be integrated with a TBL evaluation.

Treatment Facility) (Associated Engineering, 2013c) and #12 (Secondary Treatment Screening, South Regional Wastewater Treatment Facility) (Associated Engineering, 2013d) can be used to this end. These assumptions will end up being conservative – the promise of the kinds of technology change discussed in this TM are less expensive, more compact, less energy use, etc.; thus, they will help to future-proof the cost and land area topics.

If such a master plan is a conservative, high-level road map for future cash flow and land area requirements, it is important to separate from it more detailed, WWTF/situation-specific efforts and decisions that are best made at a time nearer their point of implementation. Two points are relevant to this topic. This TM has described the role of a methodology termed future uncertainty analysis can have in WWTF technology decision-making. The complexities described in the three contexts above elevate the importance of using such methodologies now relative to what may have been done in the past. Furthermore, integrating the future uncertainty analysis with a broader triple-bottom-line evaluation methodology can beneficially inform decision-making. Proactively developing these methodologies in advance of when they are needed avoids project time-pressure and ensures Municipality staff is comfortable in their intent and design.

3. Regularly review **technology developments**.

Aerobic granular biomass and main-stream deammonification process technologies, and others, continue to develop and industry experience gained will inform future Municipality decision-making. The Municipality needs to remain abreast of technical advances so that it is fully informed at the time when it needs to make final technology choices. Related to this point is information needed to inform the aforementioned future uncertainty analysis that, given some of the technologies under deliberation, may require facility tours and meetings with their operations staff. The Municipality should allow schedule and budget in projects to this end.

4. Plan and design **WWTFs for adaptation**.

The Municipality should plan and design its WWTFs for adaptation. Arguably more so now than at any other time in wastewater management the need to plan for and accommodate core technology change / transition is critical, as is providing footprint and hydraulic gradeline space for add-on technology that may be needed to meet future effluent quality requirements or support main-stream resource recovery initiatives.

TECHNICAL MEMORANDUM A.2.2.4

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to identify key technical drivers that could significantly influence the Municipality's near- and longer-term decision-making as related to its wastewater treatment facilities and their associated technologies, and to outline a practical strategy that the Municipality can implement to assist in ongoing planning and decision-making in light of technology change.

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



Edith Asselin, M.Eng., P.Eng., LEED AP
Project Manager



Dean Shiskowski, P.Eng., Ph.D.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF	
Signature:	
Date:	Feb 10, 2014
APEGA Permit to Practice P 3979	

TECHNICAL MEMORANDUM A.2.2.4

References

- Anderson, P.D. 2008. Technical Brief: Trace Organic Compounds and Implications for Wastewater Treatment. WERF CEC3R07. Water Environment Research Foundation, Alexandria, VA.
- Associated Engineering, 2013a. DRAFT Technical Memorandum A.2.3.2: Regulatory Review, Wastewater Management Plan. Regional Municipality of Wood Buffalo, June 2013.
- Associated Engineering, 2013b. DRAFT Technical Memorandum A.2.2.3: Existing Treatment System Capacity, Fort McMurray Wastewater Treatment Facility. Regional Municipality of Wood Buffalo, June 2013.
- Associated Engineering, 2013c. Technical Memorandum #11: Primary Treatment Screening, South Regional Wastewater Treatment Facility. Regional Municipality of Wood Buffalo and confidential industrial client, April 2013.
- Associated Engineering, 2013d. Technical Memorandum #12: Secondary Treatment Screening, South Regional Wastewater Treatment Facility. Regional Municipality of Wood Buffalo and confidential industrial client, April 2013.
- Borger, A. and Garaats, B. EssDe®-Process: Introduction in Full Scale Experience. Grontmij.
- Caprariu, M. 2013. What can a DEMON do? What about two DEMONS? Proceedings of the 42nd Annual Water Environment Association of Ontario Technical Conference, April 7-9, 2013, Toronto, ON.
- deBarbadillo, C. 2011. Phosphorus Recovery with New Ultra-Low Adsorption Process. Workshop: Current State of Knowledge on Nitrogen and Phosphorus Recovery Technologies; Preparing Our Industry for the Next Paradigm Shift – Nutrient Recovery, Annual Water Environment Federation Technical Exhibition and Conference, October 15-19, 2011, Los Angeles, CA,
- De Bruin, L.M.M., van der Roest, H.F., van Loosdrecht, M.C.M. 2010. Overview of the Applied Research with Nereda®-Technology in the Netherlands. Proceedings of the Biofilms 2010 Conference of the Water Environment Federation, 103-111.
- Earth Tech, 2004. Final Predesign Report: Fort McMurray Tertiary Wastewater Treatment Plant. Regional Municipality of Wood Buffalo, November 2004.
- Giesen, A., Niermans, R., and van Loosdrecht, M. 2012. Aerobic Granular Biomass: the New Standard for Domestic and Industrial Wastewater Treatment? Water 21, April 2012: 28-30.
- Grady Jr., C.P.L., Daigger, G.T., Love, N.G., and Filipe, C.D.M. (2011). Biological Wastewater Treatment, 3rd Edition, CRC Press: Boca Raton, FL.
- Hu, Z. 2010. Impact of Silver Nanoparticles on Wastewater Treatment. WERF U3R07. Water Environment Research Foundation, Alexandria, VA.
- Hunter, G., Klierwer, A., Kobylinski, E., Klinger, C. and Carrera, M. 2011. Application of UV Disinfection to Achieve *Enterococci* Removal at a Trickling Filter Plant. IUVA News, 13(2): 15-17.

Regional Municipality of Wood Buffalo

Inocencio, P., Coelho, F., van Loosdrecht, M. and Giesen, A. 2013. The Future of Sewage Treatment: Nereda Technology Exceeds High Expectations. *Water* 21, April 2013: 28-29.

Khunjar, W.O., Latimer, R., Mehta, C., Batstone, D. and Jeyanayagam, S. 2013. Assessing Extractive Nutrient Recovery as a Viable Nutrient Control Alternative. *Proceedings of the Water Environment Federation/International Water Association Nutrient Removal and Recovery Conference*, July 28-31, 2013, Vancouver, BC.

Landers, J. 2012. Dutch Wastewater Plant First to Use New Process. *ASCE Civil Engineering*, June 19, 2012.

LeMonde Fewless, K., Sharvelle, S. and Roesner, L.A. 2011. Source Separation and Treatment of Anthropogenic Urine. WERF INFR4SG09b. *Water Environment Research Foundation*, Alexandria, VA.

Lotti, T., Kleerebezem, R., Kartal, B., de Kreuk, M.K., van Erp Taalman Kip, C., Kruit, J., Hendrickx, T.L.G. and van Loosdrecht, M.C.M. 2013. Pilot Scale Evaluation Of Anammox Based Main-Stream Nitrogen Removal from Municipal Wastewater. *Proceedings of the Water Environment Federation/International Water Association Nutrient Removal and Recovery Conference*, July 28-31, 2013, Vancouver, BC.

Lu, T., Kim, J., Lee, J.-Y., Dunlap, P., Shaw, A., Barnard, J., George, B., Parrott, J. and Metz, D. 2013. Investigation of Synergistic Relationship Between Nutrient Removal and Algae Growth in Municipal Wastewater Treatment Plants. *Proceedings of the Water Environment Federation/International Water Association Nutrient Removal and Recovery Conference*, July 28-31, 2013, Vancouver, BC.

Murthy, S. 2013. Personal Communication with D. Shiskowski, August 22-23, 2013.

Olaniczuk-Neyman, K., Stosik-Fleszar, H. and Mikolajski, S. 2001. Evaluation of Indicator Bacteria Removal in Wastewater Treatment Processes. *Polish Journal of Environmental Studies*, 10(6): 457-461.

Oldham, W.K. and Rabinowitz, B. 2002. Development of Biological Nutrient Removal Technology in Western Canada. *NRC Journal of Environmental Engineering and Science*, 1: 33-43.

Pagilla, K.R. and Urgan-Demirtas, M. 2009. Sustainable Technology for Achieving Very Low Nitrogen and Phosphorus Effluent Levels. WERF 02-CTS-1. *Water Environment Research Foundation*, Alexandria, VA.

Reardon, R. and Machado, C. Current State Of Knowledge on Nitrogen and Phosphorus Recovery Technologies. *Workshop: Current State of Knowledge on Nitrogen and Phosphorus Recovery Technologies; Preparing Our Industry for the Next Paradigm Shift – Nutrient Recovery*, Annual Water Environment Federation Technical Exhibition and Conference, October 15-19, 2011, Los Angeles, CA,

Scruggs, C., Hunter, G., Snyder, E., Long, B. and Snyder, S. 2004. EDCs in Wastewater: What's the Next Step? *Proceedings of the 77th Annual Water Environment Federation Technical Exhibition and Conference*, October 2-6, 2004, New Orleans, LA,

Shiskowski, D.M. 2013. Becoming Energy-Neutral or Beyond: A Perspective on the Role of Anammox Systems in Canadian WWTFs. *Proceedings of the 42nd Annual Water Environment Association of Ontario Technical Conference*, April 7-9, 2013, Toronto, ON.

Shiskowski, D.M. 2012. Urine Separation – Benefits Beyond Wastewater Management? *WEAO Influents*, Spring 2012, 61-63.

- Stinson, B., Murthy, S., Bott, C., Wett, B., Al-Omari, A., Bowden, G., Mokhyerie, Y. and De Clipperleir, H. 2013. Roadmap Toward Energy Neutrality & Chemical Optimization at Enhanced Nutrient Removal Facilities. Proceedings of the Water Environment Federation/International Water Association Nutrient Removal and Recovery Conference, July 28-31, 2013, Vancouver, BC.
- Taher, E. and Chandran, K. 2013. High-Rate, High-Yield Production of Methanol by Ammonia-Oxidizing Bacteria. Environmental Science & Technology, In-Press.
- Westerhoff, P.K., Kiser, M.A. and Hristovski, K. 2013. Nanomaterial Removal and Transformation during Biological Wastewater Treatment. Environmental Engineering Science, 30(3): 109-117.
- van Loosdrecht, M. and van der Roest, H. 2011. Purely Based On Character. Delft Outlook – magazine of the Delft University of Technology, 3: 4-11.
- Wedge, J. 2003. A Redundant Approach To Drought-Proof Water Supplies – California's Case Study. Water Conditioning & Purification, December 2003: 8-10.
- Whalley, M., Laidlaw, S., Steel, P. and Shiskowski, D.M. 2013. Meeting Ultra-Low Effluent Phosphorus In Small, Cold-Climate WWTFs. Proceedings of the Water Environment Federation/International Water Association Nutrient Removal and Recovery Conference, July 28-31, 2013, Vancouver, BC.
- Wilsenach, J.A. and van Loosdrecht, M.C.M. 2006. Integration of Processes to Treat Wastewater and Source-Separated Urine. ASCE Journal of Environmental Engineering, 132(3): 331.
- Winkler, M.-K.H. 2012a. Magic Granules. Ph.D. Thesis, Technical University of Delft, the Netherlands, September 5, 2012.
- Winkler, M.-K.h., Kleerebezem, R. and van Loosdrecht, M.C.M. 2012b. Integration of Anammox into Aerobic Granular Sludge Process for Main Stream Wastewater Treatment at Ambient Temperatures. Water Research, 46: 136-144.

TECHNICAL MEMORANDUM A.2.3.2

Regional Municipality of Wood Buffalo

Regulatory Upgrade Requirements



February 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE

This technical memorandum (TM) explores potential, more distant effluent quality requirements beyond the Year 2015 obligations contained in the Municipalities existing Alberta Environment and Sustainable Resource Development (AESRD) Approval 689-02-00. The objective of the TM is to identify key viewpoints to capture in the Wastewater Master Plan (WWMP) that the Municipality can review during future conceptual studies of its wastewater treatment facilities (WWTFs). The TM is not intended to provide an exhaustive global review of future directions. Rather, it provides perspective for the general trends being observed in the wastewater industry at this time.

2 MAIN FINDINGS

For the currently regulated constituents that apply or will apply to the Municipalities WWTFs, it is likely that the Provinces effluent *E. coli* requirements will become more stringent in the future with increased wastewater industry transition from fecal coliform to *E. coli* as the disinfection efficiency indicator organism of choice. It is likely that the horizon of such a change could be within a decade.

For the remaining currently regulated constituents, today's technology can already produce effluent concentrations lower than those shown in Approval 689-02-00. However, the increasingly recognized diminishing returns, from an broader sustainability perspective, in achieving lower levels suggests a lesser likelihood of regulators continuing to tighten their definition of best practicable technology (BPT) as may have been the historic past approach. That said, specific to the Municipalities WWTFs, should water quality based effluent limits (WQBEL) initiatives indicate further reductions are needed in effluent constituent loadings, AESRD may adopt the philosophy presented in the Water Management Framework (WMF) for the Industrial Heartland and Capital Region. Here the WMF calls for a watershed-based, cumulative effects approach that requires continuous improvement in the quality of effluent returned to the environment to meet the desired end.

In terms of currently unregulated constituents, it would be reasonable to assume that AESRD will expand the Approval 689-02-00 list of regulated effluent constituents at some point to include Enterococci as a microbiological indicator, and total nitrogen in an eutrophication context, and such a change could plausibly be expected within a decade. Along a similar timeline is a realistic basis for a monitoring requirement, initiated provincially and/or federally, for effluent trace organic compounds that includes, but may not be limited to, compounds that are associated with organism endocrine function disruption.

Likely more distant (e.g. decade plus) are actual regulatory requirements, either end-of-pipe or in-stream, for a limited or broader suite of trace organic compounds. Given the current state of knowledge and relative infancy of it, total nitrogen, from a greenhouse gas emission perspective, and engineered nanomaterials may well have an even longer timeline, if at all, before a regulatory requirement comes into place that may affect the Municipalities WWTFs.

3 RECOMMENDATIONS

Integral to future WWTF and WQBEL studies conducted by the Municipality will be its ongoing, industry-at-large global reviews to monitor the type and pace of potential regulatory changes discussed in this document. Similarly, the Municipality needs to remain abreast of the national perspective captured in Canadian Council of Ministers of Environment (CCME) and Environment Canada initiatives as they will be important in future planning activities.

AESRD is a key regulator of the Municipalities WWTFs and the Municipality will be served well by maintaining an intentional line of communication with its staff in terms of the general topics discussed in this document. Concurrently, the Municipality should be proactive in bringing broader sustainability aspects to AESRD to inform its Approval discussions.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	iv
1 Introduction	1-1
2 Current Approval	2-1
3 Drivers for Change	3-2
4 Potential Changes in Currently Regulated Effluent Constituents	4-3
4.1 Overview	4-3
4.2 Total Phosphorus	4-3
4.3 Ammonia	4-4
4.4 Carbonaceous Biochemical Oxygen Demand and Total Suspended Solids	4-4
4.5 E. coli	4-4
5 Potential Future Addition of Currently Un-Regulated Effluent Constituents	5-5
5.1 Overview	5-5
5.2 Microbiological Indicators	5-5
5.3 Trace Organic Compounds	5-6
5.4 Total Nitrogen	5-7
5.5 Engineered Nanomaterials	5-9
6 Summary	6-9
7 Recommendation	7-10
Closure	
References	

List of Tables

	PAGE NO.
Table 2-1 AESRD Approval 689-02-00 Effluent Quality Requirements	2-2
Table 6-1 Potential Horizon of Future Regulatory Requirements	6-10

1 Introduction

The Regional Municipality of Wood Buffalo (Municipality) is developing a Wastewater Master Plan (WWMP) to allow the strategic planning and operation of its entire wastewater system and is doing so in consideration of related “green” initiatives, stormwater management, and asset management capital planning. Master planning work necessarily considers long-term horizons and, specific to the subject of this document, raises the question of how regulatory requirements for those effluents discharged to the aquatic environment may evolve and/or change outright in the future.

In general terms, wastewater treatment facilities (WWTF) are designed to meet a minimum treatment standard measured by meeting maximum stipulated effluent constituent levels. The constituent levels are typically assigned either through federal, provincial, or municipal legislation, or a combination of the three regulatory jurisdictions. For a new WWTF within the Municipality, additional regulations need to be addressed as part of the Alberta Environment and Sustainable Resource Development (AESRD) construction and Approval-to-Operate procedure. A “road map” for doing so has been established for the planned South Regional Wastewater Treatment Facility (SRWWTF) (Associated Engineering, 2012a) and this map is relevant for other new WWTFs within the Municipality.

This technical memorandum (TM) explores potential, more distant effluent quality requirements with the objective of identifying key viewpoints to capture in the WWMP that the Municipality can review during future conceptual studies of its WWTFs. The TM is not intended to provide an exhaustive global review of future directions. Rather, it provides perspective for the general trends being observed in the wastewater industry at this time. It speaks to these trends independent of specific technology considerations. The subsequent TM 2.2.4 – Treatment Technology Review – will address the implications of potential regulatory changes on WWTF technology and that used in the Municipality facilities.

Starting with the Municipality's existing Approval 689-02-00 issued by AESRD, Section 2 summarizes current effluent quality requirements and the Approval requirements due to come into effect in Year 2015. Section 3 speaks briefly to the water quality based effluent limits (WQBEL) and best practicable technology (BTP) regulatory approaches for defining effluent quality requirements. Launching from this point, Section 4 explores potential future changes in currently regulated effluent constituents with Section 5 doing the same for currently un-regulated effluent constituents. Section 6 and Section 7 provide a summary of findings and recommendations for moving forward, respectively.

2 Current Approval

Table 2-1 summarizes the existing AESRD Approval 689-02-00 effluent quality requirements that came into effect in February 2009. Table 2-1 also shows stricter requirements for several constituents that will come into effect in July 2015.

Table 2-1
AESRD Approval 689-02-00 Effluent Quality Requirements

Parameter	Limit
CBOD	≤ 20 mg/L monthly arithmetic mean of daily composite samples
CBOD (Effective July 1, 2015)	≤ 10 mg/L monthly arithmetic mean of daily composite samples
TSS	≤ 20 mg/L monthly arithmetic mean of daily composite samples
TSS (Effective July 1, 2015)	≤ 10 mg/L monthly arithmetic mean of daily composite samples
Total Phosphorus	< 1.0 mg/L monthly arithmetic mean of daily composite samples
Total Phosphorus (Effective July 1, 2015)	< 0.50 mg/L monthly arithmetic mean of daily composite samples
Ammonia-Nitrogen (October 1 to June 30)	< 10 mg/L monthly arithmetic mean of daily composite samples
Ammonia-Nitrogen (July 1 to September 30)	< 5.0 mg/L monthly arithmetic mean of daily composite samples
Ammonia-Nitrogen (October 1 to June 30) (Effective October 1, 2015)	< 6.0 mg/L monthly arithmetic mean of daily composite samples
Ammonia-Nitrogen (July 1 to September 30) (Effective July 1, 2015)	< 3.0 mg/L monthly arithmetic mean of daily composite samples
<i>E. coli</i>	≤ 200 per 100 ml monthly geometric mean
pH	6.5-9.5 pH unit

3 Drivers for Change

Future changes, beyond those shown in Table 2-1, in regulated effluent constituents will be due to either:

- A scientific reason that is identified from site-specific “water quality based effluent limits” (WQBEL) initiatives; or
- The advance of wastewater industry “best practicable technology” (BPT) as adopted-in-principal by a regulator(s).

In general terms, the WQBEL approach recognizes the site-specific nuances of a receiving water body and considers the allowable end-of-pipe effluent constituent concentrations and/or effluent mass loadings. The definition of what is allowable is based in part on surface water quality standards and objectives, potential cumulative effects, and other water uses and effluent discharges within the watershed.

Alternatively, the BPT approach is more of a philosophy and one that establishes end-of-pipe effluent quality requirements based on established and proven treatment technologies. Obviously, the definition of such terms is subjective.

AESRD, via various provincial acts, regulations and guidelines, will stipulate the more stringent of the requirements yielded by these two approaches for a given situation. To this end, for example, the Municipality has initiated WQBEL work for the new SRWWTF (AE 2012a, b).

This TM does not speak to WQBEL context given its site-specific nature. Rather the TM focuses on BPT drivers that may influence future regulatory philosophy and requirements.

4 Potential Changes in Currently Regulated Effluent Constituents

4.1 OVERVIEW

AESRD has prepared what amounts to be generic to 20,000 plus population communities, BPT-type standards for the existing Fort McMurray WWTF (Table 2-1). The constituent concentrations shown in Table 2-1 provide the starting point of discussion in a BPT context. The question, in such a setting, becomes – for any one of these constituents, what is the evolving wastewater industry capability and its influencers, and how might they affect regulations that are BPT-based?

4.2 TOTAL PHOSPHORUS

Of the currently regulated constituents shown in Table 2-1, total phosphorus (TP) is likely of most importance to the Municipality. Already the TP value of 0.5 mg P/L shown in Table 2-1 has been replaced as a BPT value in British Columbia, where the current Municipal Wastewater Regulation (2012) requires effluents discharged to various geographic-centric waters to contain average annual TP levels of ≤ 0.25 mg P/L. As described in Oldham and Rabinowitz (2002), the demonstrated performance of the region's WWTFs led the Province to tighten its effluent TP limits over time in this generic regard.

Lower still is the Parks Canada Leadership Target, which is a BPT-type philosophy, for WWTFs that is set at 0.15 mg P/L for facilities, located in Banff, Lake Louise, and Field. Although using different combinations of technology, these WWTFs have in general demonstrated their ability to consistently produce such effluent. Looking further away in Canada to various facilities in Ontario, for example Schomberg, Ridgetown and Tottenham, that discharge effluents to very sensitive receiving bodies, the Ministry of Environment has set even lower effluent TP levels of ≤ 0.10 mg P/L. Again, there is demonstrated ability to produce such high-quality effluent on a consistent basis.

Recent research commissioned by the Water Environment Research Foundation (WERF) (Pagilla and Urgun-Demirtas, 2009) has also confirmed that TP levels of 0.10 mg P/L and lower are achievable with technology available today. But in essence it asks the question – just because we can should we? The level of performance that can be achieved today is, one could argue, at that point of diminishing returns where using "... chemically-intensive, resource-intensive, high sludge production and costly technologies to remove small amounts of P ..." is at odds with the overall sustainability of the intent. As the authors note, this point is particularly relevant in the context of point and non-point sources in watersheds. The

application of Life Cycle Assessment (LCA), such as that done by de Haas et al (2008) that examined the trade-off in WWTF greenhouse gas inventories with nutrient removal in Australia, is further calling into question governmental policy directions and regulations in the context of sustainability.

The arguments presented above suggest the wastewater industry, or at least some portion of it, is starting to challenge the traditional approach of continuous, incremental redefinition of BPT as technology advances are made. What might this mean for the Municipality? Unless future scientific arguments (i.e., WQBEL-based) dictate a clear site-specific need for effluent TP levels lower than those shown in Table 2-1, the Municipality should consider broader sustainability aspects in its approval negotiations with regulators.

4.3 AMMONIA

Many of the points discussed for TP are relevant for ammonia as well in a BPT context – today's technology can produce substantially lower effluent ammonia levels relative to those shown in Table 2-1. More complex is effluent total nitrogen, of which ammonia contributes, but is not a currently regulated parameter. Section 3 speaks to the total nitrogen topic.

4.4 CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND AND TOTAL SUSPENDED SOLIDS

The Year 2015 carbonaceous biochemical oxygen demand (CBOD) and total suspended solids (TSS) levels shown in Table 2-1 are low and at a level stipulated for some forms of reclaimed water use, including stream flow augmentation and maintaining wetlands and marshes (e.g. British Columbia Municipal Wastewater Regulation (2012)). Similar to nutrients, current technology can produce lower effluent levels but at this point it would seem that defining BPT to lower levels in the future would be unlikely. Part of this argument relates to the TP value and its relationship to TSS; if the BPT TP level does not change it would be unlikely for the BPT TSS concentration to be reduced on its own.

4.5 E. COLI

The use of E. coli as a disinfection efficiency indicator organism reflects a wastewater industry shift from the traditional use of fecal coliform. This change recognizes the sometimes poor correlation with the presence of fecal coliform and incidence of disease (Warrington, 2001). The 200 cfu/100 mL value shown in Table 2-1 is consistent with the recreational water use standard used historically in many jurisdictions for fecal coliform. However, some jurisdictions have proposed or implemented lower values for E. coli. For example, in British Columbia, the primary contact recreation values (geometric mean) are 77cfu/100 mL and 200 cfu/100 mL for E. coli and fecal coliform, respectively, as listed in Water Quality Criteria for Microbiological Indicators (Warrington, 2001). However, the current Municipal Wastewater Regulation continues to use fecal coliform as the indicator organism with a geometric mean value of 200 cfu/100 mL and thus this change in indicator organism and concentration has not yet been adopted in the regulation.

Looking more broadly and recently, the United States Environmental Protection Agency issued in December 2012 its 2012 Recreational Water Quality Criteria (USEPA, 2012). It presents two recommended freshwater E. coli values (100 cfu/100 mL and 126 cfu/100 mL) that are based on slightly different

Un-Regulated Effluent Constituents

estimated illness rates but are indicated to "... protect the public from exposure to harmful levels of pathogens". Fecal coliform are no longer a listed indicator organism. Such changes are reflected, as an example, in the California Environmental Protection Agency State Water Resources Control Board, which has replaced the 200 cfu/100 mL geometric mean fecal coliform value for limited contact recreation fresh waters with an *E. coli* value 126 cfu/100 mL (www.waterboards.ca.gov).

These examples suggest a probable future reduction in effluent *E. coli* levels relative to what is shown in Table 2-1. Such a reduction would not be BPT-related but one of better aligning the numeric requirement with its intent as scientific understanding and confidence improves. In terms of potential timing, it is feasible that AESRD might implement such a regulatory change within a decade.

5 Potential Future Addition of Currently Un-Regulated Effluent Constituents

5.1 OVERVIEW

The history of the wastewater industry has been one that has seen a growing list of regulated effluent constituents as human health and ecosystem science understanding has progressed, in part due to improvements in analytical methodologies, along with treatment technology development. Clearly, the list will continue to grow in the future. The question is how, which the following sub-sections explore.

5.2 MICROBIOLOGICAL INDICATORS

Carrying on from Section 4, the subject of effluent microbiological indicators is a good starting point. In British Columbia Warrington (2001) included Enterococci along with *E. coli* as an indicator of gastrointestinal disease. *Pseudomonas aeruginosa* is included as an indicator for non-gastrointestinal infections associated with water contact recreation, which is noted to have a high correlation with ear and skin infections. Numeric limits have been set for both organisms but again they have not yet made their way into British Columbia's Municipal Wastewater Regulation (2012). However, the stated implication is they will at some point.

Again looking to the United States, USEPA (2012) has added Enterococci to its recommended freshwater recreational contact criteria. The values presented range from 30 cfu/100 mL and 35 cfu/100 mL, based on different estimated illness rates. Recreational water protection has been a contentious issue in the United States that has invoked acts of Congress and legal action in arriving at this point (Boyd et al., 2011). So while these newly released federal criteria do not impose any new requirements on their own, the intent is that individual States will use them in setting their own standards and requirements. Boyd et al. (2011) anticipates the recent USEPA changes will be reviewed every five years to track their implementation and assess new issues.

Overall, in light of the above information, it would be reasonable to assume that AESRD will expand the Table 2-1 list of regulated effluent constituents at some point to include Enterococci as a microbiological indicator. The timing of such change is more uncertain, but given regulatory movements elsewhere it is not difficult to imagine such change happening within a decade.

5.3 TRACE ORGANIC COMPOUNDS

Undoubtedly the broad category of wastewater and thus effluent constituents that has garnered the most attention in recent years is trace organic compounds (TOrc). This TM uses the term “trace organic compounds” that has been adopted by WERF and where Anderson (2008) provides explicit definition of those constituent categories that fall under the definition of TOrc. Here TOrc replaces terms such as “emerging contaminants”, “micro-constituents” and others that have been used in the wastewater industry in recent years.

Included in this category are pharmaceuticals and personal care products (PPCPs) that have been the source of much media reporting, generally in recognition of their potential to disrupt endocrine function in organisms. However, the list of potential endocrine disrupting compounds (EDCs) extends beyond these products to include pesticides, surfactants, plasticizers and naturally occurring and synthetic hormones among others (Anderson, 2008). Furthermore, not all compounds classified as TOrcs are considered EDCs in terms of human health effects; glycol ether is one example. An additional complication is that many compounds that are considered EDCs are already defined, in the United States for example, as Priority Pollutants where water quality standards have been set previously (Reeve and Littlehat, 2010). The issue is that such numeric standards were set to “protect from toxic effects” rather than endocrine disrupting effects that may occur at lower concentrations.

With this introduction it is safe to say that the amount of effort dedicated to the TOrc topic globally has been and continues to be very substantial from both research and governmental policy perspectives. Starting provincially, AESRD has taken a first step in assessing the occurrence and extent of 105 EDC compounds and mixtures in municipal WWTF effluents (7 facilities) and associated receiving water sites (Bow River, North and South Saskatchewan Rivers, Oldman River, Red Deer River) around the province (Sosiak and Hebben, 2005). Another provincial example is in British Columbia, which has gone a step further and developed a recommended water quality guideline for 17 alpha-ethinylestradiol (Nagpal and Meays, 2009).

Nationally, the TOrc topic has received the attention of both the Canadian Council of Ministers of the Environment (CCME) and Environment Canada. The CCME Canada-wide Strategy for the Management of Municipal Wastewater Effluent (2009) calls for initial characterization of effluents from larger facilities to include various compounds that fit within the definition of TOrc used in this TM (e.g. pesticides, surfactants, etc.). Subsequently, the March 30, 2010 draft of the Wastewater Systems Effluent Regulation (WSER), issued under the federal Fisheries Act, contained in its environmental effects monitoring (EEM) a requirement to collect in-stream information for the TOrcs alkylphenol ethoxylates, ethinylestradiol, 17 β -estradiol and estrone.

Un-Regulated Effluent Constituents

As explained in the July 2012 enacted version of the WSER, such EEM requirements were subsequently removed due to, among other reasons, stakeholder concerns related to the timing of the CCME Strategy and lack of guidance on applying the criterion. However, the WSER also notes "... the intent to include them at a later date as a regulatory amendment in consultation with stakeholders and interested parties." The information cited above points to the interest in the TORC subject, from at least a data collection perspective, by both the provinces and Canadian federal government. However, nothing yet has made its way into a regulatory requirement in terms of end-of-pipe effluent quality or an in-stream requirement.

A similar situation appears to exist in the United States. Reeves and Littlehat (2010) note that the USEPA is currently focusing on establishing the EDC levels of impacts for 67 specific compounds and presumably whatever criteria the USEPA develop as a result may be adopted by the States. Interestingly, they also note that while only a few States appear to be developing EDC standards, it appears those that are most likely to be regulated in this context include nonylphenol, diazinon, tributyltin and polychlorinated biphenyls. Regardless, the authors conclude that implementation of standards for EDCs, which could show up in effluent discharge permits, "... is not imminent."

The European Commission functions in a role similar to the USEPA in the United States – it initiates and defines new environmental legislation in collaboration with the European Union member states and ensures they are put into practice. It recently proposed the addition of 15 additional compounds to its priority substances list, including three pharmaceutical substances (17 alpha-ethinylestradiol, 17 beta-estradiol and Diclofenac) that represent a first in terms of this specific class of substances (European Commission, 2012a, b). The implication of these proposed inclusions is one of data collection, initially, where "... monitoring data would be obtained to provide feedback on the effectiveness of existing legislation".

From this discussion it is clear that TORCs are a topic of interest of potential regulators provincially, nationally and internationally. To date the focus of regulatory bodies in the nearer-term appears to be one of monitoring; gathering data to inform policy development and potentially, in the longer-term, regulatory requirements. For the Municipality it is reasonable to suppose that either AESRD and/or Environment Canada, through an appropriate regulatory instrument, might implement some kind of TORC monitoring requirement in the relative near-term and within a decade. Since there is both environmental health and human health elements to the topic, the human health aspect from potable water and reclaimed water use (i.e. indirect potable reuse) contexts will further influence the wastewater perspective and timeline. In terms of an end-of-pipe or in-stream regulatory requirement that may dictate in part the Municipality's WWTF performance, the horizon appears more distance and likely beyond a decade.

5.4 TOTAL NITROGEN

Total nitrogen (TN) is typically defined as the aggregate measure of the [organic nitrogen + ammonia/ammonium + nitrite + nitrate] forms of nitrogen (Tchobanoglous et al., 2003). The traditional need for effluent TN control is site-specific and depends on the trophic status of the receiving water. In this context WQBEL-approaches are often used to establish effluent concentration and/or loading limits to control in-situ eutrophication. However, with more recent concerns surrounding greenhouse gas (GHG) emissions and climate change emerges a new effluent quality issue – the transformation of effluent-containing nitrogen in

the receiving environment to nitrous oxide (N_2O) via various microbial pathways (e.g. Shiskowski, 2008). N_2O is a powerful GHG with a global warming potential approximately 300 x that of carbon dioxide. While other trace gases (i.e. not carbon dioxide) such as methane and tropospheric ozone are recognized to be larger GHG forcings on the global climate system relative to N_2O , Hansen et al. (2007) for example suggest N_2O should too be a focus of mitigation efforts.

The N_2O question in wastewater treatment is complex. Imagine drawing a spatial boundary around a WWTF, including its energy and mass inputs, and its effluent receiving environment and accounting for all direct and indirect GHG emissions. Is it better to provide nitrogen transformations “completely” within the confines of a WWTF such that most of the nitrogen leaving the facility is inert di-nitrogen gas (N_2) emitted from bioreactors? Or are fewer GHGs emitted if more nitrogen leaves the WWTF in the effluent (i.e., lesser treatment provided) but accounting for some conversion of effluent nitrogen to N_2O in the receiving environment?

The idea of effluent receiving water bodies being an N_2O source has been captured in emission protocols developed by the Intergovernmental Panel on Climate Change (IPCC) but only in a manner that at present could be described as a crude approximation. A paper published by Naqvi et al. (2000) in the esteemed journal *Nature* revealed large areas off the Indian continental shelf where marine waters were supersaturated with N_2O at times due to the point and non-point nitrogen loadings from the continent. Although little research in river systems in developed countries where wastewater treatment is well established had been conducted in previous decades, recent years have seen notable N_2O research efforts in river systems in Canada (e.g. Grand River in Ontario, Rosamond et al., 2010), the United States (e.g., the Ohio River, Beaulieu et al., 2010) and Europe (e.g. lower Seine River in France, Garnier et al., 2008). Findings from such studies are being used to critically examine the IPCC emission protocols and improve upon them. Presumably what is learned will also inform regulatory policy at local, national, and international levels.

In the end, the Municipality effluent receiving waters are not in highly urbanized and/or intensively agricultural watersheds such as those examples highlighted above. And the infancy of the N_2O topic suggests the wastewater industry as-a-whole is a long way from establishing regulatory policy and requirements for effluent TN in a GHG emission setting. Furthermore, Canadian federal and provincial government policy on the GHG subject in general continues to induce much debate. These combined factors imply that total nitrogen regulation, explicitly set in a GHG context, by either AESRD or Environment Canada for the Municipality WWTFs would be quite distant and possibly of a horizon beyond that of trace organic compounds (e.g., several decades) if at all.

Coming back to the more traditional context for effluent TN control (i.e., eutrophication), we are aware that AESRD is considering a 15 mg N/L limit for larger municipalities. In addition, the Approval currently held by the City of Grande Prairie/Aquatera Utilities Inc. includes a TN monitoring requirement. These actions suggest that AESRD may implement such a TN limit within a decade time frame.

5.5 ENGINEERED NANOMATERIALS

Engineered nanomaterials (ENMs) are a class of constituents that is gaining the attraction of the wastewater industry from their potential toxicity effects. Defined as being less than 100 nm in size in at least one dimension, the “... most commonly used ENMs are variants of TiO_2 , Ag0, Fe0, CeO, ZnO, quantum dots and carbon based materials (e.g. fullerenes, nanotubes)” that see application in consumer products, foods and industrial applications such as inks, paints and coatings (Weisterhoff, 2013). The USEPA is currently evaluating its position on regulating one class of ENMs, nano-silver, but the US National Toxicology Program has not yet listed ENMs as a class of hazardous material (Weisterhoff, 2013).

The ongoing WERF-sponsored research conducted by Weisterhoff (2013), which focuses on biosolids, supports the recognition that wastewater-containing nano-silver particles are mostly adsorbed to biomass in secondary treatment systems (e.g., Hu, 2010). This nuance suggests that future wastewater-related ENM regulation may be more inclined to biosolids quality rather than effluent quality. In terms of nano-silver particles specifically, which appear to be the most commonly used ENMs, Hu (2010) also notes that their environmental and public health risk has yet to be evaluated adequately.

Similar to the effluent TN topic as related to GHG emissions, this combination of points for ENMs suggest future wastewater regulation of effluent quality in this context will likely be in a long-term, several decades horizon, if any.

6 Summary

For the currently regulated constituents that apply or will apply to the Municipality's WWTFs (Table 2-1), it is likely that the Provinces effluent E. coli requirements will become more stringent in the future with increased wastewater industry transition from fecal coliform to E. coli as the disinfection efficiency indicator organism of choice. It is likely that the horizon of such a change could be within a decade.

For the remaining currently regulated constituents, today's technology can already produce effluent concentrations lower than those shown in Table 2-1. However, the increasingly recognized diminishing returns, from a broader sustainability perspective, in achieving lower levels suggests a lesser likelihood of regulators continuing to tighten their definition of BPT as may have been the historic past approach. That said, specific to the Municipality's WWTFs, should WQBEL initiatives indicate further reductions are needed in effluent constituent loadings, AESRD may adopt the philosophy presented in the Water Management Framework (WMF) for the Industrial Heartland and Capital Region (Alberta Environment, 2013). Here the WMF calls for a watershed-based, cumulative effects approach that requires continuous improvement in the quality of effluent returned to the environment to meet the desired end.

In terms of currently unregulated constituents, it would be reasonable to assume that AESRD will expand the Table 2-1 list of regulated effluent constituents at some point to include Enterococci as a microbiological indicator, and total nitrogen in an eutrophication context, and such a change could plausibly be expected within a decade. Along a similar timeline is a realistic basis for a monitoring requirement, initiated

provincially and/or federally, for effluent trace organic compounds that includes, but may not be limited to, compounds that are associated with organism endocrine function disruption.

Likely more distant (e.g. decade plus) are actual regulatory requirements, either end-of-pipe or in-stream, for a limited or broader suite of trace organic compounds. Given the current state of knowledge and relative infancy of it, total nitrogen, from a greenhouse gas emission perspective, and engineered nanomaterials may well have an even longer timeline before a regulatory requirement comes into place that may affect the Municipality's WWTFs.

Table 6-1 summarizes the potential timelines noted above.

Table 6-1
Potential Horizon of Future Regulatory Requirements

Effluent Constituent	Horizon Within 10 Years	Horizon Beyond 10 Years
<i>E. coli</i>	Lower effluent limit	
<i>Enterococci</i>	Addition as a regulated constituent	
Trace Organic Compounds	Constituent(s) monitoring requirement	Addition as a regulated constituent(s)
Total Nitrogen (GHG context)		Addition as a regulated constituent
Total Nitrogen (eutrophication context)	Addition as a regulated constituent	Addition as a regulated constituent
Engineered Nanomaterials		Addition as a regulated constituent(s)

7 Recommendation

As noted in Section 1, this TM explored potential, more distant effluent quality requirements with the objective of identifying key viewpoints to capture in the WWMP that the Municipality can review during future conceptual studies of its (WWTF). Integral to these studies conducted by the Municipality will be its ongoing, industry-at-large global reviews to monitor the type and pace of potential changes discussed in this document. Similarly, remaining abreast of the national perspective captured in CCME and Environment Canada initiatives will also be important to inform planning activities.

AESRD is a key regulator of the Municipality's WWTFs and the Municipality will be served well by maintaining an intentional line of communication with its staff in terms of the general topics discussed in this document. Concurrently, the Municipality should be proactive in bringing broader sustainability aspects to AESRD to inform its Approval discussions.

TECHNICAL MEMORANDUM A.2.3.2

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to explore potential, more distant effluent quality requirements with the objective of identifying key viewpoints to capture in the Wastewater Master Plan that the Municipality can review during future conceptual studies of its wastewater treatment facilities.

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.



Edith Asselin, M.Eng., P.Eng., LEED AP
Project Manager



Dean Shiskowski, P.Eng., Ph.D.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF	
Signature:	
Date:	Feb 10, 2014
APEGA Permit to Practice P 3979	



Associated
Engineering

WASTEWATER
ENGINEERING

References

Anderson, P.D. 2008. Technical Brief: Trace Organic Compounds and Implications for Wastewater Treatment. WERF CEC3R07. Water Environment Research Foundation, Alexandria, VA.

Alberta Environment, 2013. The Water Management Framework for the Industrial Heartland and Capital Region: Five Years of Implementation (2007-2012). Alberta Environment and Sustainable Resource Development, Edmonton, AB.

Associated Engineering, 2012a. Technical Memorandum #3: South Regional Wastewater Treatment Facility – Regulatory Road Map. Regional Municipality of Wood Buffalo and Athabasca Oil Corporation, December 2012.

Associated Engineering, 2012b. Conceptual Design Report: South Regional Wastewater Management Concept. Regional Municipality of Wood Buffalo, August 2012.

Beaulieu, J.J., Shuster, W.D. and Rebholz, J.A. 2010. Nitrous Oxide Emissions From a Large, Impounded River: the Ohio River. Environ. Sci. Technol. 44(19): 7527-7533.

Boyd, G., Bibler, B., Kranz, R. and Toranzos, G.A. 2011. Microbial Contaminants in Recreational Waters: A Primer for 2012. WERF PATH8R11. Water Environment Research Foundation, Alexandria, VA.

CCME. 2002. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nonylphenol and Its Ethoxylates. Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment.

de Haas, D., Foley, J. and Barr, K. 2008. Greenhouse Gas Inventories from WWTPs: the Trade-off with Nutrient Removal. Proceedings of the Sustainability 2008 Conference of the Water Environment Federation, National Harbour, MD.

European Commission. 2012a. Press Release Environment and Water: Proposal to Reduce Water Pollution Risks. IP-12-88_EN.

European Commission. 2012b. Proposal for a Revised Directive of the European Parliament and of the Council on Priority Substances in the Field of Water Quality. MEMO-12-59_EN.

Garnier, J., Billen, G. and Cebon, A. 2007. Modelling Nitrogen Transformations in the Lower Seine River and Estuary (France): Impact of Wastewater Release on Oxygenation and N₂O Emission. Hydrobiologia 588(1): 291-302.

Hansen, J., Sato, M., Kharecha, P., Russell, G., Lea, D.W. and Siddall, M. 2007. Climate Change and Trace Gases. Phil. Trans. R. Soc. A. 365: 1925-1954.

Hu, Z. 2010. Impact of Silver Nanoparticles on Wastewater Treatment. WERF U3R07. Water Environment Research Foundation, Alexandria, VA.

- Reeves, S. and Littlehat, P. 2010. Microconstituents: What to Expect in Your Permit. Proceedings of the 83rd Annual Water Environment Federation Technical Exhibition and Conference, New Orleans, LA, 2251-2266.
- Nagpal, N.K. and Meays, C.L., 2009. Technical Appendix: Water Quality Guidelines for Pharmaceutically-Active-Compounds (PhACs): 17 Alpha-ethinylestradiol (EE@). British Columbia Ministry of Environment, September 2009.
- Naqvi, S.W.A., Jayakumar, D.A., Narvekar, P.V., Naik, H., Sarma, V.S., D'Souza, W. and George, M.D. 2000. Increased Marine Production of N₂O Due to Intensifying Anoxia of the Indian Continental Shelf. *Nature*: 405: 346
- Oldham, W.K. and Rabinowitz, B. 2002. Development of Biological Nutrient Removal Technology in Western Canada. *J. Environ. Eng. Sci.* 1: 33-43.
- Pagilla, K.R. and Urgan-Demirtas, M. 2009. Sustainable Technology for Achieving Very Low Nitrogen and Phosphorus Effluent Levels. WERF 02-CTS-1. Water Environment Research Foundation, Alexandria, VA.
- Rosamond, M.S., Thuss, S.J., Schiff, S.L. and Elgood, R.J. 2010. Coupled Cycles of Dissolved Oxygen and Nitrous Oxide in Rivers Along a Trophic Gradient in Southern Ontario, Canada. *J. Environ. Qual.* 40.
- Shiskowski, D.M. 2008. Change – More Than Just The Climate. *Wat. Env. Res.* 80(2): 99-100.
- Tchobanoglous, G., Burton, F.L., and Stensel, H.D. 2003. Wastewater Engineering: Treatment and Reuse. 4th edition. McGraw-Hill, Boston, MD.
- USEPA. 2012. 2012 Recreational Water Quality Criteria. EPA-820-F-12-061, Washington, DC.
- Warrington, P.D. 2001. Water Quality Criteria for Microbiological Indicators – Overview Report. British Columbia Ministry of Environment.
- Westerhoff, P. 2013. Fate of Engineered Nanomaterials in Wastewater Biosolid, Land Application and Incineration. WERF U1R10. Water Environment Research Foundation, Alexandria, VA.

TECHNICAL MEMORANDUM A.3.1.4

Regional Municipality of Wood Buffalo

South Utility Corridor



May 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Table of Contents

SECTION	PAGE NO.
Table of Contents	i
1 Introduction	1
1.1 Scope	1
1.2 Objective	1
1.3 Conceptual Alignment Study Area	2
2 South Utility “Customers”	2
3 Background Data Collection	2
4 Alignment Options	3
4.1 Option 1	3
4.2 Option 2	4
4.3 Option 3	5
5 Constructability Evaluation	9
5.1 Overview	9
5.2 Evaluation Criteria	9
5.3 Preliminary Criteria Weight Allocations	11
5.4 Concept Evaluation	11
5.5 Summary	16
6 Cost Estimate	21
6.1 Pipeline Cost Breakdowns	21
7 Conclusions and Recommendations	23
7.1 Conclusions	23
7.2 Recommendations	23
Closure	
Appendix A – Criteria Sheet	

1 Introduction

The Regional Municipality of Wood Buffalo (the Municipality) is currently updating the Wastewater Master Plan for the Urban Service Area, which includes a concept evaluation of a South Utility Corridor for the possible conveyance of treated effluent, wastewater, purple water, district heating, potable water supply (redundant and in addition to existing water supply to Anzac) and/or similar utilities to the areas southeast of Fort McMurray. This Technical Memorandum will analyse the alignment options to provide a utility corridor to service the following areas:

- Gregoire Lake Estates;
- Gregoire Lake First Nation;
- Hamlet of Anzac; and
- Future industrial clients in the Anzac area.

1.1 SCOPE

The scope of work included in this technical memorandum is as follows:

1. Review of work done as part of the following projects:
 - Recycle Water Supply Line Design Basis Memorandum (Associated Engineering, 2013);
 - South Regional Wastewater Treatment Facility predesign (Associated Engineering, Ongoing);
 - Southwest Water Supply Line Conceptual Design Report (Associated Engineering, 2012);
 - Draft Technical Memorandum A.3.2.2/A.3.2.3: Reuse Water Definition and Strategy (Associated Engineering, Ongoing); and
 - Southeast Regional Water Supply Line Technical Memorandums (Associated Engineering, 2003).
2. Define South Utility "Customers" and Service Area.
3. Document "Customer" effluent reuse potential and quality requirements.
4. Define a South Utility Network.
5. Review alignment options.
6. Review constructability of a South Utility Service, e.g. a utility corridor adjacent to Highway 63 and/or Highway 881.
7. Rate and rank developed utility alignment options.
8. Summarize findings and recommendations in a Technical Memorandum.
9. Facilitate Tech Memo A.3.1.4 review meeting with the Municipality.

1.2 OBJECTIVE

The primary objective of this South Utility Corridor Technical Memorandum is to summarize data and determine potential South Utility Corridor conceptual alignment options, based on the needs of customers and the Municipality. Information used to determine alignment options was provided by aerial photographs, as well as previously completed reports and projects within the study area, as outlined in Section 1.1.

1.3 CONCEPTUAL ALIGNMENT STUDY AREA

The conceptual alignment for the South Utility Corridor has been defined to commence at the location of the future South Regional Wastewater Treatment Facility, where the current Southwest Utility Corridor currently ends and will terminate at the Hamlet of Anzac.

2 South Utility “Customers”

Currently, the number and size of pipes has not yet been determined by the Municipality. The Municipality solicited industrial operations southeast of Fort McMurray for their interest in being supplied potable water and reuse water. To date, no customers have been defined other than a potential industrial customer approximately 25 kms south of Fort McMurray. Therefore, customer effluents re-use and south utility network tasks have not been included in the scope of services and the primary focus will be on identifying a conceptual corridor between the Municipality and Anzac.

3 Background Data Collection

Previous reports from which the information (geotechnical reports, concept alignments, and existing/future utilities) was collected from the following:

- Southeast Regional Water Supply Line Technical Memorandums (Associated Engineering, 2003): Multiple Technical Memorandums were completed for the Municipality throughout the course of the Southeast Regional Water Supply Line project to determine an alignment to supply the Hamlet of Anzac with potable water. The chosen alignment provides water from the SE Reservoir and Pump house extends south through undeveloped land, parallel to Highway 881 (servicing Gregoire Lake Estates and Gregoire lake First Nation) and ultimately servicing the Hamlet of Anzac.
- Southwest Water Supply Line Conceptual Design Report (Associated Engineering, 2012): This conceptual design report was completed for the Municipality and established utility corridor right-of-way from the Fort McMurray Water Treatment Facility (WTF) to the southwest development areas of Fort McMurray including the proposed South Regional Wastewater Treatment Facility and (SRWWTF) and Southlands Area 1A.
- Recycle Water Supply Line Design Basis Memorandum (Associated Engineering, 2013): This design basis memorandum was completed for the Municipality and a potential recycle water customer to define the supply of recycled wastewater from the Fort McMurray Wastewater Treatment Facility (FMWWTF) to the future industrial facility approximately 25 kms south of the Fort McMurray urban service area. Right-of-way was defined up to the SRWWTF where the majority of the alignment follows the Southwest Utility Corridor. An alignment from the SRWWTF to the Hangingstone Facility has been conceptually outlined, however, not finalized.
- Draft Technical Memorandum A.3.2.2/A.3.2.3: Reuse Water Definition and Strategy (Associated Engineering, 2013): This is an all-encompassing document that assisted the Municipality in determining an application and review process for outside industrial customers who request to be supplied with purple water.

The document did not mention specific customers, however, recommended that the Municipality prepare a comprehensive Water Reuse Master Plan with participation by key stakeholders.

The above listed studies will be considered for the purpose of identifying and reviewing the constructability and determination of a South Utility Corridor from the SRWWTF to the Hamlet of Anzac. The options presented require a desktop geotechnical investigation and environmental review.

4 Alignment Options

The conceptual corridor will consider the following piping for a total approximate ROW width of 50 m:

- Treated effluent
- Wastewater
- Purple water
- District heating
- Allowance for shallow utilities
- Access for maintenance

Three utility corridor alignment options have been developed based on existing reports, review of existing development, constructability, air photo analysis, and understanding of the Municipality's requirements. The Municipality's focal start point for establishing the South Utility Corridor is at the current landfill and is common for all options. The current landfill site will be home to the Municipality's future development of a South Regional Wastewater Treatment Facility and is the current end point for the Municipality's SWSL Utility corridor.

The following are the proposed South Utility Corridor options developed and presented in Figure 4-1:

- Option 1: Follow proposed Conceptual Recycle Water Supply Line ROW up to the potential industrial client facility and then east towards Anzac (53 km).
- Option 2a: Parallel Highway 63, Stoney Mountain Road, and Highway 881 Route (50 km).
- Option 2b: Parallel Highway 63 and Highway 881 (39 km).
- Option 3: Parallel Highway 63, parallel existing pipeline right-of-way, parallel southeast regional water supply line, and parallel Highway 881 (38 km).

4.1 OPTION 1

Associated Engineering (2012) completed the conceptual design for the Southwest Water Supply Line (SWSL) Corridor from the Fort McMurray WTF to the Southlands Area 1A. Included within the SWSL Corridor are:

- Future water supply lines;
- Gravity collection for Hangingstone Development;

- Force mains for the development of the Horse and Hangingstone;
- Future shallow utility provisions; and
- The proposed 600 mm recycle water supply line.

The proposed 600 mm recycle water supply line will continue south and supply treated effluent to the potential/future industrial client, approximately 25 km south of the SRWWTF. The alignment between the SRWWTF and the future industrial client facility has not been determined; however, a conceptual alignment has been developed, as shown in Figure 4-1.

Option 1 has been developed largely based on the conceptual alignment for the recycle water supply line between the SRWWTF and the potential/future industrial client's facility. This conceptual alignment follows an existing oil and gas pipeline alignment that parallels the western bank of the Hangingstone River. The proposed option shows the corridor continuing south past the potential industrial client, where it will then be directed east following another pipeline's ROW towards Highway 63. After crossing Highway 63, the corridor will run parallel with Stoney Mountain Road to the intersection of Stoney Mountain Road and Highway 881, at the Gregoire Lake First Nation. The Corridor will then follow the existing South Regional Water Supply Line's ROW by running parallel along Highway 881 to Anzac. The conceptual alignment for Option 1 is shown in Figure 4-1.

4.2 OPTION 2

The conceptual alignment for Option 2 is also shown in Figure 4-1. The corridor is envisioned to begin at the future SRWWTF and continue east towards Highway 63, before traversing south through an undeveloped area west of Highway 63. The proposed corridor option will then follow an existing pipeline's ROW and cross Highway 63 before paralleling the east side Highway 63 to the south until Highway 881 is encountered. A minimum offset distance of 30 m will be maintained from Highways 63 and 881 to avoid conflicts with future expansion of the highways. The intersection of Highways 63 and 881 is populated with private land development, and therefore, may need to be avoided. Option 2 then separates into two sub-options: Option 2a and Option 2b.

4.2.1 Option 2a

Option 2a crosses Highway 881 and continues south paralleling Highway 63 before turning east to parallel Stoney Mountain Road. Similar to Option 1, Option 2a will parallel the south side of Stoney Mountain Road and Highway 881 to Anzac.

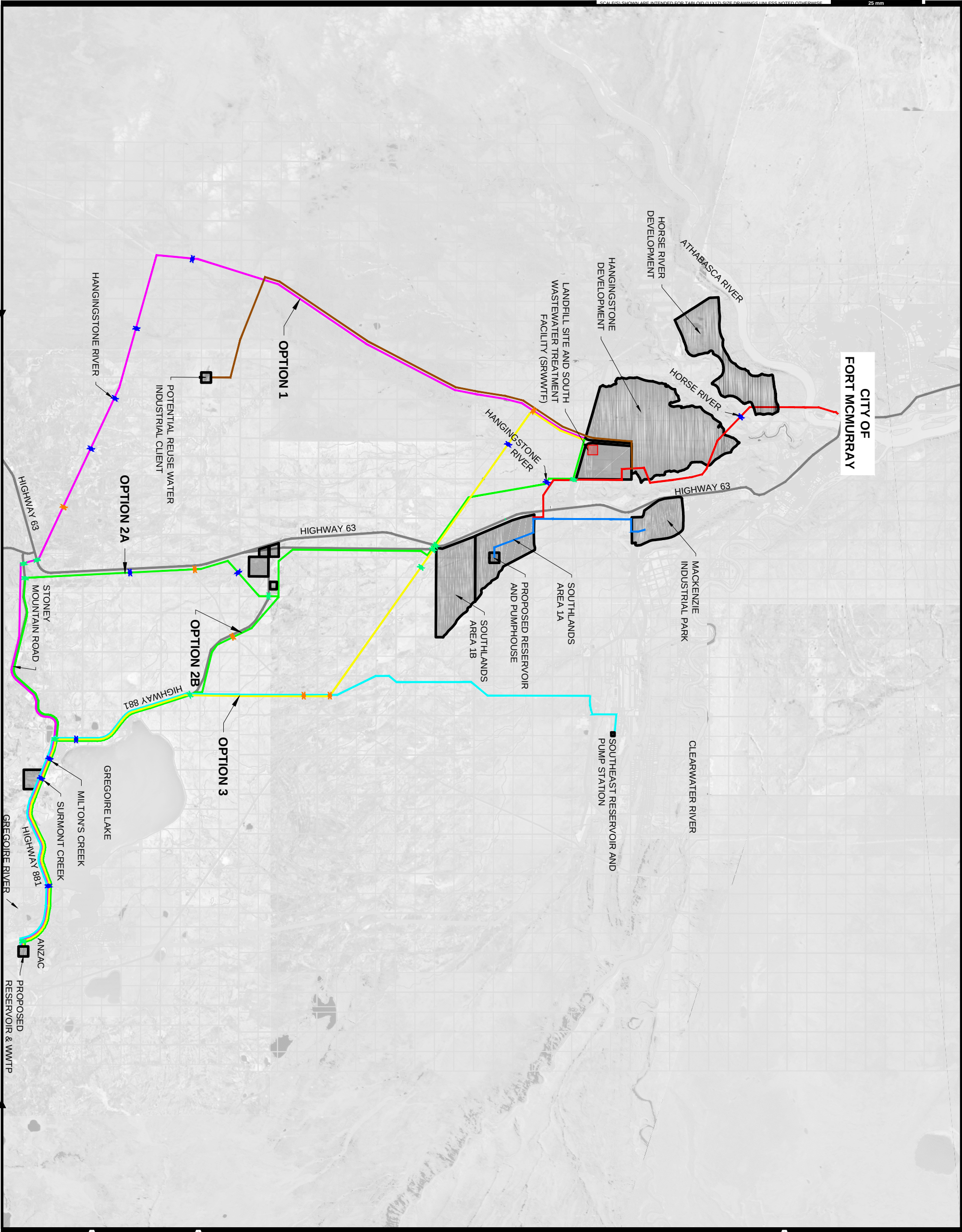
4.2.2 Option 2b

Option 2b differs from Option 2a after the intersection of Highways 63 and 881. Instead of continuing to travel south along Highway 63, the corridor parallels Highway 881 to Anzac. An offset distance of 30 m will be maintained along Highway 881, to avoid conflict with future expansion of the highway.

4.3 OPTION 3

The conceptual alignment for Option 3 is shown in Figure 4-1. This option parallels the existing oil and gas pipeline alignment south of the landfill site until it intersects ATCO Electric overhead power lines' right-of-way. The proposed alignment follows the ATCO ROW up until the intersection of the existing Southeast Regional Water Supply Line's ROW, where the proposed corridor turns south paralleling the existing Southeast Regional Water Supply Line's ROW, crosses Highway 881, and further parallels the south side of Highway 881 to Anzac.





- LEGEND:**
- OPTION 1
 - OPTION 2
 - OPTION 3
 - PROPOSED SOUTHWEST CORRIDOR
 - EX. ANZAC WATER SUPPLY LINE
 - CONCEPTUAL INTERIM WATER SUPPLY TO SOUTHLANDS AREA 1A AND 1B
 - PRIVATE PROPERTY
 - HIGHWAY
 - PROPOSED AOC RECYCLE WATER CORRIDOR
 - RIVER/CREEK CROSSING
 - PIPELINE / POWER LINE CROSSING
 - ROADWAY CROSSING



FIGURE NO 4-1

SOUTH WEST UTILITY CORRIDOR
TECHNICAL MEMORANDUM

SUMMARY OF ALL OPTIONS

AE PROJECT NO.	20123694-01
SCALE	1:1500
APPROVED	O. MIERKE
DATE	2014MAY09
REV	1
DESCRIPTION	

5 Constructability Evaluation

5.1 OVERVIEW

This section of the report evaluates the potential alignment constructability based on defined evaluation criteria. A set of proposed evaluation criteria has been developed based on the understanding of the Municipality's utility corridor requirements with the evaluation conducted utilizing a weighted criteria evaluation matrix.

5.2 EVALUATION CRITERIA

The constructability of a pipeline (or other infrastructure) can be affected by many aspects including pipe material, pipe coatings, construction techniques, schedules, and other construction costs. Consideration should be given to how constructible a pipeline is regards to, but not limited to, the following potential criteria below.

5.2.1 Congested/Developed Areas

Congested areas are crowded with gas lines, water mains, forcemains, and shallow underground utilities (gas, power, cable, telephone). Developed areas include urban or industrial areas with paved roads, sidewalks, curbs, gutters, etc. Key considerations when constructing in these areas include:

- Consultation with the land owner (Municipality/Industry) and Alberta Transportation;
- Consultation with Alberta Government (Current Leases, Crown Land);
- Pipeline proximity agreements and crossing approvals;
- Roadside development permits and highway crossing approvals;
- Relocation of existing utilities may be required;
- Traffic interruption/closure; and
- Slow construction process, low production, high cost.

5.2.2 River/Creek Crossings

Crossing of several water-bodies, including the Hangingstone River, as well as various creeks and wetlands, will be encountered. Crossing of these water bodies can be completed by trenchless installation methods. Key design considerations include:

- Consultation with the Municipality, Alberta Environment and Sustainable Resources Development (AESRD) and Department of Fisheries and Oceans (DFO);
- Geotechnical investigation (determine no drill zones, avoid bedrock and the Fort McMurray Formation bearing oil sand);
- Limited access to site in undeveloped areas and therefore seasonal construction;
- Disposal of drilling fluids; and
- High water tables.

5.2.3 Highway/Roadway/Pipeline/Power Line Crossings

All of the proposed alignments include the crossing of Highway 63. Other roadways and pipeline crossings will be encountered along all alignments options. Trenchless installation method will most likely be required. Key design considerations include:

- Consultation with the Municipality and Alberta Transportation;
- Pipeline proximity agreements and crossing approvals;
- Roadside development permits and highway crossing approvals;
- Traffic interruption/closure and need for Traffic Accommodation Plan; and
- Slow construction process, low production, high cost.

5.2.4 Accessibility (Construction and Maintenance)

Several sections along the alignment options are located though undeveloped lands along existing oil and gas pipeline ROWs. Constructability considerations include:

- Consultation with the Municipality and AESRD;
- Geotechnical investigation (potential for high groundwater, depth of muskeg/peat as well as consideration for concrete weights on pipe in these sections);
- High production rate in dry areas;
- Limited accessibility (construction and maintenance) in certain seasons; and
- Potential to build an access road along ROW.

5.2.5 Land Acquisition/Requirements

Most sections of the alignment follow existing pipeline ROWs in undeveloped land and/or parallel highways. To provide adequate ROW for the above mentioned utilities, as well as space for additional development requirements and shallow utilities, a ROW width of 50 m is suggested to accommodate multiple municipal pipes within the corridor. Constructability considerations with respect to land acquisition/requirements for the alignment options include:

- Consultation with the Municipality and AESRD;
- Consultation with Alberta Government (current leases, crown land);
- Challenges securing ROW from leaseholders;
- Dissecting potential developable lands; and
- Future highway expansion (overpass and roadway width).

5.3 PRELIMINARY CRITERIA WEIGHT ALLOCATIONS

Preliminary criteria weights were calculated, using a pairwise analysis matrix, based on the principles of the analytical hierarchy process. This allows for the assignment of weights based on the relative importance of the criteria. Accessibility for construction and maintenance was determined to be the most important when considering the constructability of the corridor. As a result, the accessibility of each option will have the most weight, followed by the “congested/developed areas criterion” and “land acquisition/requirements”. A lower weight was given to river/creek crossings as well as highway/roadway/pipeline/ power line crossings, whose weightings were determined insignificant when compared to other criterion. Crossings of existing highway/roadway/pipeline/power lines were determined negligible, as they could not be considered more important than any other criterion. Table 5-1 outlines the criteria weightings utilized in the concept evaluation as determined from the pairwise analysis matrix, based on anticipated utility corridor requirements. The Criteria Analysis Matrix used to determine the criteria weighting factors can be found in Appendix A. Confirmation of Criteria Weights with the Municipality was completed as part of the Wastewater Master Plan Workshop No.6 on March 20, 2014.

**Table 5-1
Criteria Weighting Factor**

Constructability Criteria	Weight
Congested/Developed Areas	30
River/Creek Crossings	5
Highway/Roadway/Pipeline/Power line Crossings	0
Accessibility (Construction and Maintenance)	40
Land Acquisition/Requirements	25

5.4 CONCEPT EVALUATION

A weighted evaluation score for each alignment option will be developed to determine the most suitable option to carry forward for further analysis. The following Sections, 5.4.1 to 5.4.5, provide rational and explanation as to how ratings are determined for each option. The rating scores range between 1 and 10, with 10 being the most favorable rating for the criterion being considered.

5.4.1 Congested/Developed Areas

Highly congested areas are not anticipated along the alignment options. Typically, congested areas are built up and crowded with gas lines, water mains, forcemains, and shallow underground utilities. Few developed areas are also likely to be encountered along the alignment options. Special consideration for each option is summarized in Table 5-2.

Table 5-2
Alignment Considerations for Congested/Developed Areas

Option	Discussion	Rating
Option 1	- The majority of the alignment follows an existing oil and gas pipeline ROW west of Highway 63 along the Hangingstone River top of bank. - The alignment is almost fully through undeveloped lands with the exception of a short distance paralleling Highway 881 between the Gregoire Lake First Nations and Anzac. - Option 1 avoids developed areas along Highway 63 and Highway 881. Initial review of land ownership along Highway 881 may cause rerouting (i.e. Private Land - Surmont Creek) which is consistent for all alignment options.	10
Option 2	- Option 2 will be the most congested due to the proximity of construction to Highway 63 and Highway 881. The alignment is more heavily congested with utilities as compared to the other options which will require additional research into existing utilities and potential for rerouting with further study. - Special considerations will be required when working along roadways (i.e., planned area for Southlands Area 1A Overpass) and a minimum 30 m offset distances will be required when paralleling Provincial Highways. In addition, roadside Development permit approval is required when working in close proximity to an existing Alberta Highway right of way.	
	Option 2a - Stoney Mountain Road is a less developed roadway as compared to Highway 881 and therefore has less potential for existing utilities/driveways/developments. - Potential re-routing around private land will be required (Intersection of Highway 63 and Highway 881).	7
	Option 2b Option 2b will be the most congested due to the proximity of construction to Highway 63 and Highway 881. Highway 881 is considerably more congested as compared to Stoney Mountain Road in Option 2a.	5
Option 3	- Option 3 is nearly entirely through undeveloped lands as it parallels existing pipeline/power line ROWs. - Option 3 parallels the existing Southeast Regional Water Supply Line and Highway 881 and is through primarily undeveloped lands.	8

5.4.2 River/Creek Crossings

All alignment options will require the crossing of the Hangingstone River which will be completed by trenchless methods, likely HDD, to minimize land disturbance. Installation by trenchless methods can increase the risk, cost, and schedule of a project. The amount of small creek and wetland crossings by trenchless methods will vary depending of the chosen alignment. The estimated amount of crossings for each option is summarized in Table 5-3 and shown in Figure 4-1.

Table 5-3
Quantity of River and Creek Crossings per Alignment Option

Option	Hangingstone River Crossing	Misc. Creek Crossings	Total	Rating (1-10)
Option 1	1	5	6	4
Option 2a	1	4	5	5
Option 2b	1	2	8	7
Option 3	1	2	3	7

Option 1 includes the most crossings by trenchless method. Option 2b includes a lesser number of crossings as compared to Option 1 but greater than Option 2a. Option 3 has the least amount of crossings as well as the greatest distance of installation though undeveloped land. This is important in the constructability analysis as winter construction may be required in order to access remote areas with drilling equipment. Scoring of this criterion is based on the number and estimated difficulty of the water course crossings presented under each option.

Further geotechnical investigation will be required to verify values in Table 5-3 and determine additional wetland crossings. Further investigation will also clarify setback from watercourses, “no drill zones”, and therefore lengths of each trenchless crossing.

5.4.3 Highway/Roadway/Pipeline Crossings

All of the alignment options include a single crossing of Highway 63. Construction method will be by means of auguring with steel casing insertion, HDD, or other similar trenchless methods. The amount of existing oil and gas pipeline/power line crossings is estimated at two and is consistent with all alignments. The number of Highway 881 and rural roadway crossing vary depending on alignment option selected. A summary of estimated crossings for each alignment option is provided in Table 5-4.

**Table 5-4
Quantity of Highway/Roadway/Pipeline/Power Line Crossings per Alignment Option**

Option	Highway 63	Highway 881	Other Rural Roadways	Pipeline/Power Line	Total	Rating (1-10)
Option 1	1	1	1	2	5	5
Option 2a	1	2	1	2	6	4
Option 2b	1	2	1	2	6	4
Option 3	1	2	1	2	6	4

As seen in Figure 4-1 and summarized in Table 5-4, the options located in mostly undeveloped areas (Options 1 and 3) have less rural roadway and pipeline/power line crossings.

5.4.4 Accessibility (Construction and Maintenance)

The proposed utility corridor alignment options greatly vary in portion of lengths through undeveloped land. This is an important constructability consideration as access for construction and maintenance to these areas can be limited. Analysis of air photos and geotechnical reports of previous studies demonstrate the following for all alignment options:

- Relatively flat forested areas.
- Large areas of muskeg/organic deposits.
- Potential high water table.
- Trenchless crossings required (Including Hangingstone River Crossing).
- Roadway crossings required (Including Highway 63).

A significant concern and future design consideration is the un-favored alignment of the existing Southeast Regional Water Supply Line due to its limited ROW access in boreal areas. Pipe breaks and leakage as a result of soft ground conditions are understood to be common and have limited access for repair. Preliminary consideration for each alignment option is shown in Table 5-5 as follows:

Table 5-5
Alignment Option Considerations for Accessibility

Option	Discussion	Rating
Option 1	As seen in Figure 4-1, alignment Option 1 follows an existing pipeline ROW through boreal forest. Aerial photographs show various areas of muskeg, organics, and high water table which limit access to remote areas of the ROW.	3
Option 2	- Option 2 allows the most accessibility for construction and maintenance as a large percentage of the utility ROW would parallel an existing highway/roadway. The difference between Option 2a and 2b are as follows and shown in Figure 4-1. Option 2a - Option 2a is the most accessible due to the continual proximity to Highway 63 and Highway 881. This allows access for construction, regular maintenance, and repairs. Option 2b - A benefit of Option 2b as compared to Option 2a is the use of Stoney Mountain Road. A 30 m offset may not be required for Option 2a as it is not a provincial highway. This may allow easier access to the Utility Corridor.	10 10
Option 3	Similar to that of Option 1, Option 3 has long lengths of piping through undeveloped land that will limit accessibility for construction and maintenance. To allow access to these areas, there is potential to build a ROW access road to otherwise inaccessible sections.	5

5.4.5 Land Acquisition/Requirements

Initial investigation into land ownership, along the alignment options, indicated that a majority of the land within the study area is Crown Land; however, Municipal owned and private land also exists. On sections of crown land, various leases are held for both private and municipal use. It is recommended that a land surveying company, who specializes in land survey geomatics, be commissioned to create an overall profile of land ownership and verify potential alignment conflicts on the chosen alignment.

As the Municipality is currently in the planning process of identifying a utility corridor from Fort McMurray to Anzac, the quantity of pipes and pipe sizes for the conveyance of treated effluent, wastewater, district heating, purple water, etc. has yet to be determined. To provision enough space for the aforementioned utilities, as well as space for additional development requirements and shallow utilities, a ROW width of 50 m is suggested. This suggested width was chosen to allow flexibility in future utilities and servicing within the same ROW. Figure 5-1 provides an illustrative typical cross section of how the 50 m ROW is derived.

Generally, Option 1 and Option 3 have the least potential to be limited by land ownership, as the majority of the alignments are through undeveloped crown lands. Options 2a and 2b, which parallel major highways, will be the most effected by land ownership constraints.

5.5 SUMMARY

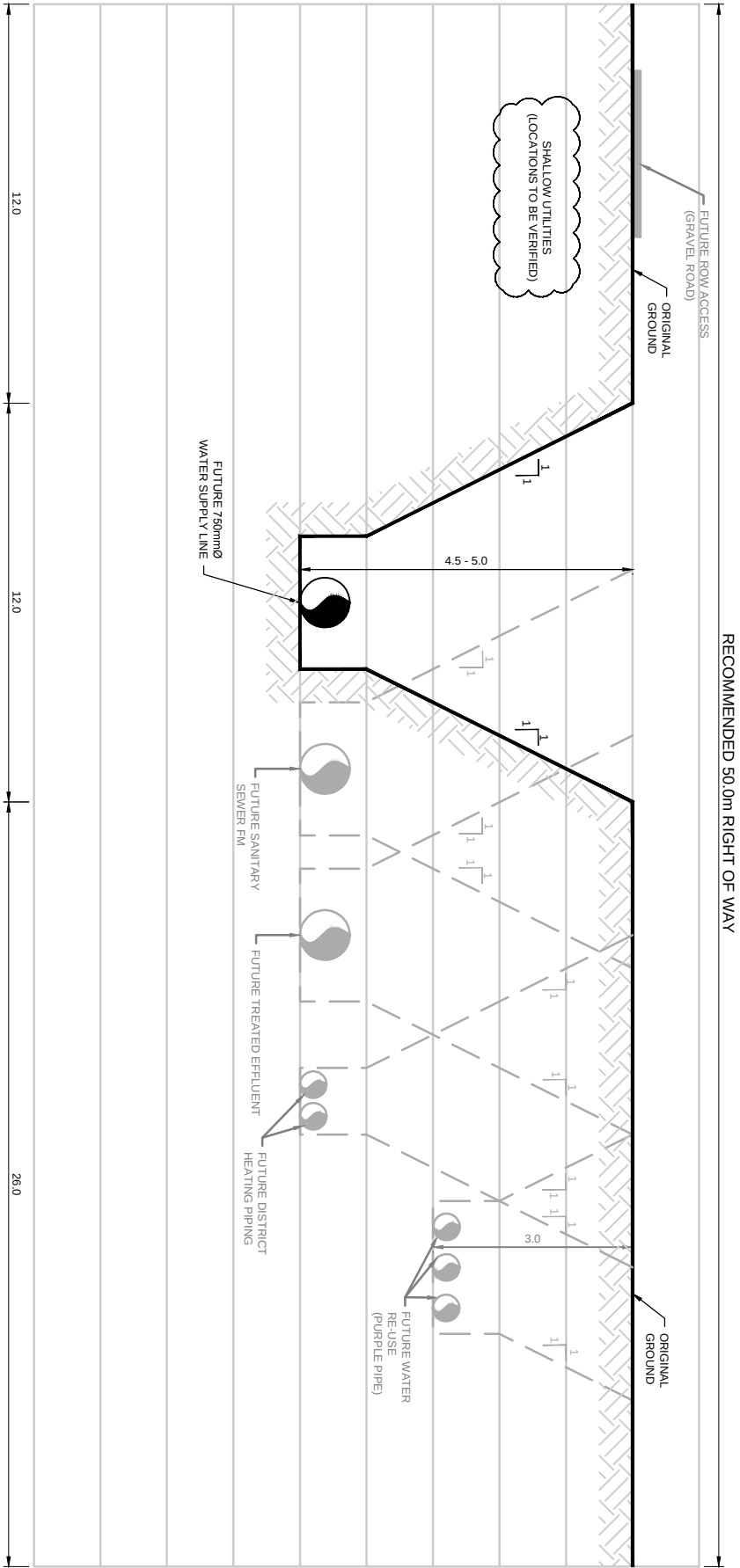
A weighted (WGT) evaluation score for each alignment option was developed to determine the most suitable option to carry forward for further analysis. For each criterion, a score was determined by multiplying the weighted factor by a rating determined though comparing the various options. The rating scores ranged between 1 and 10, with 10 being the highest favourable rating for the criterion being considered. These scores were totalled for each option to obtain the total weighted criterion score. The option with the highest weighted criteria score is considered the most optimal option, based on the developed evaluation criteria. The estimated construction costs, based on assumptions listed in Section 6, were then utilized to obtain a Value Ratio for each option. The results of this evaluation are summarized in Table 5-6.

**Table 5-6
Evaluation Matrix**

Constructability Criteria	WGT	Option 1		Option 2a		Option 2b		Option 3	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score
Congested/Developed Areas	30	10	300	7	210	5	150	8	240
River/Creek Crossings	5	4	20	5	25	7	35	7	35
Highway/Roadway/Pipeline/ Power Line Crossings	0	5	0	4	0	4	0	4	0
Accessibility (Construction/ Maintenance)	40	3	120	10	400	10	400	5	200
Land Acquisition/Requirements	25	7	175	6	150	5	125	7	175
Total Weighted Criteria Score		615		785		710		650	
Estimated Construction Costs		\$71,410,000		\$68,970,000		\$56,505,000		\$55,670,000	
Value Ratio (Cost/Criteria Score)		116,114		87,860		78,944		85,646	

The evaluation of the crossing options, utilizing the weighted ranking system, determined that alignment Option 2a was the most favourable. However, when considering the value ratio (the estimated cost divided by the weighted criteria score), alignment Option 2b is perceived to have the best value, as a result of the lower cost.





**REGIONAL MUNICIPALITY
OF WOOD BUFFALO**

FIGURE NO 5-1

**SOUTH WEST UTILITY CORRIDOR
TECHNICAL MEMORANDUM**

**TYPICAL CROSS SECTION
50.0m R.O.W.**

AE PROJECT NO.	20123694-01
SCALE	AS NOTED
APPROVED	O. MIERKE
DATE	2014MAY09
REV	0
DESCRIPTION	

6 Cost Estimate

6.1 PIPELINE COST BREAKDOWNS

Cost Estimates have been developed and include an allowance for engineering (10%) and contingency (30%). Assumptions used in developing a preliminary cost estimate include:

- One (1) 400 mm steel pipeline throughout the entire alignment length with minimum 3.5 m cover.
- Quantities of muskeg construction are based on conceptual analysis of air photos.
- Crossings of all Rivers and Creeks will be completed by HDD.
- Installation of multiple pipes at one time would present cost efficiencies that could be further considered once the number of pipelines as well as timelines are determined.

Costs have been developed for all five alignment options, as detailed and summarized in Table 6-1.

Table 6-1
Cost Estimate

Item	Unit	Unit Price (\$/m)	Option 1		Option 2a		Option 2b		Option 3	
			Quantity (m)	Amount	Quantity (m)	Amount	Quantity (m)	Amount	Quantity (m)	Amount
Open Cut	lm	1,000	34,200	\$34,200,000	29,500	\$29,500,000	21,100	\$21,100,000	18,500	\$18,500,000
Open Cut – Muskeg/Peat	lm	1,800	15,700	\$28,260,000	17,400	\$31,320,000	15,500	\$27,900,000	16,900	\$30,420,000
River/Creek Crossing (HDD)	lm	3,500	2,300	\$8,050,000	1,900	\$6,650,000	1,500	\$5,250,000	1,500	\$5,250,000
Highway/Pipeline Crossing (Auger/HDD)	lm	3,000	300	\$900,000	500	\$1,500,000	600	\$1,800,000	500	\$1,500,000
Total Construction			52,500	\$71,410,000	49,300	\$68,970,000	38,700	\$56,050,000	37,400	\$55,670,000
Contingency 30%				\$21,423,000		\$20,691,000		\$16,815,000		\$16,701,000
Engineering 5%				\$3,570,500		\$3,448,500		\$2,802,500		\$2,783,500
Total Project				\$96,403,500		\$93,109,500		\$75,667,500		\$75,154,500
Cost per Metre Installed				\$1,836		\$1,889		\$1,955		\$2,009

7 Conclusions and Recommendations

7.1 CONCLUSIONS

- Air photo analysis, as well as previous reports and projects completed for the subject areas, generated a total of four alignment options for consideration of a proposed South Utility Corridor from Fort McMurray to Anzac.
- The concept options were analyzed using a Pairwise Comparison, weighted system, to determine the most favorable alignment option.
- Alignment options were evaluated considering congested/developed areas, river/creek crossing, highway/roadway/pipeline/power line crossings, and accessibility for construction and maintenance as well as land acquisition/requirements.
- Conceptual cost estimates were developed for each alignment options.
- Option 2a had the highest Total Weighted Criteria Score.
- Based on the analysis, Option 2b had the lowest Value Ratio.
- A workshop was conducted with the Municipality to confirm the criteria weightings and review the findings of the South Utility Corridor alignment analysis.
- Based on the analysis and review with the Municipality it was determined that Option 2b is most favourable.

7.2 RECOMMENDATIONS

- Option 2b: Parallel Highway 63 and Highway 881 (39 km) should be adopted as the preferred South Utility Corridor Alignment.
- The Municipality should complete a preliminary design for the preferred option and include the following:
 - Confirmation of number and type of utilities required in the corridor.
 - Determine the required demands for each of the proposed utilities.
 - Determine potential utility users along the alignment.
 - Hydraulic assessment.
 - Consultation with Stakeholders: including creation of overall profile indicating land ownership.
 - Geotechnical Assessment.
 - Environmental Review.

TECHNICAL MEMORANDUM A.3.1.4

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to summarize data and determine potential South Utility Corridor conceptual alignment options for the possible conveyance of treated effluent, wastewater, district heating, potable water supply, purple water, and or similar utilities to the areas southeast of Fort McMurray.

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.



Owen Mierke, P.Eng.
Project Manager

Carlie Jones, E.I.T.
Project Engineer

ASSOCIATED ENGINEERING	
QUALITY MANAGEMENT SIGN-OFF	
Signature:	
Date:	May 6, 2014
APEGA Permit to Practice P 3979	



Associated
Engineering

ADDITIONAL PROFESSIONAL
SUBSIDIARIES

Appendix A – Criteria Sheet

CRITERIA ANALYSIS MATRIX

PROJECT: RMWB South Utility Corridor																		
PROJECT ELEMENT: Alignment Options Constructibility																		
Configuration Options																		
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Evaluation Criteria	Score	Weighting factor	Weighting factor Rounded
A	a	3	a	3	d	2	e	2							Congested/Developed Areas	6	29	30
	b	1	d	2	e	2									River/Creek Crossings	1	5	5
C			d	2	e	2									Highway/Roadway/Pipeline Crossings	0	-1	0
			D	d	2										Accessibility (Construction and Maintenance)	8	38	40
E				E											Land Acquisition/Requirements	6	29	30
					F													
G					G													
						H												
I							I											
								J										
K										K								
											L							
L												M						
													N					
O														O				

KEY

Evaluation Criteria are the project elements or alternatives that need to be compared

Score is the total number of points for each attribute

Weighting factor is the relative numerical value of each attribute

Ranking

1 = Low preference for

2 = Medium preference for

3 = High - strong preference for

INSTRUCTIONS

Step 1: Compare each alternative with each other alternative at intersecting boxes.

Step 2: Select which alternative is better and to what degree, using the 1-3 ranking system.

Step 3: Enter the letter of the chosen alternative in the left side of the appropriate box and its numerical ranking in the right side of the box.

Step 4: Weighting factors are calculated for you.

TECHNICAL MEMORANDUM A.3.2.2/A.3.2.3

Regional Municipality of Wood Buffalo

Wastewater Master Plan

Reuse Water Definition and Strategy



March 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo Wastewater Master Plan. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE

The main objectives of Technical Memorandum A.3.2.2/A.3.2.3, Reuse Water Definition and Strategy, include:

- Review previous work that incorporated reuse water principles from the South Regional Wastewater Treatment Facility (SRWWTF) predesign;
- Review possible reuse water applications;
- Document reuse water opportunities for the Municipality;
- Update effluent reuse water balance for the affected catchment areas;
- Document effluent quality requirements for reuse;
- Determine the infrastructure needs to accomplish the identified applications;
- Conduct a feasibility for the infrastructure components;
- Develop an effluent reuse methodology framework;
- Document custody transfer requirements for effluent reuse;
- Review implications of the termination of an effluent reuse partnership on water balance and effluent treatment requirements; and
- Summary of findings and recommendations.

2 MAIN FINDINGS

The main findings of this work are summarized as follows:

- **Reuse Water Applications:** Water that is reclaimed for reuse may be categorized as consumptive or non-consumptive. Consumptive reuse applications (e.g., irrigation) do not return water back to the wastewater collection system for re-treatment. Non-consumptive re-use applications (e.g., toilet flushing) do return water back to the wastewater collection system for re-treatment.
- **Water Reuse Opportunities for Existing Potable Water Customers:** Currently there appear to be limited opportunities for significant water reuse by existing customers.
- **Water Reuse Opportunities for New Customers:** The most significant water reuse opportunities lie with new customers where a purple pipe system can be accommodated much more economically.
- **Non-consumptive Water Reuse:** Proportionately reduces the required potable water treatment and distribution, as well as the WWTF effluent discharge to the Athabasca River.
- **Consumptive Water Reuse:** Proportionately reduces the WWTF effluent discharge to the Athabasca River.

- **Water Balance:** For the Municipality to achieve its ultimate objective of 100% water reuse, any combination of consumptive and non-consumptive water reuses totalling 100% of the WWTF effluent volume will be required.
- **Water Reuse Quality:** With future filtration and chlorination, the existing WWTF can meet the generally accepted highest standards for reuse water quality, providing maximum flexibility for supply not only to one proposed industrial user, but other potential customers as well.
- **Reuse Water Infrastructure:** There are three main infrastructure components for reuse water systems: treatment, storage, and distribution. The degree of treatment, storage volumes, and distribution methods are all dependent on the reuse water application.
- **Reuse Water Distribution:** The Municipality must evaluate the feasibility of distributing reuse water to new and existing developments through a purple water pipe network, truck fill stations, or a combination thereof. This should be completed in a Reuse Water Master Plan.
- **Application and Review Process For Water Reuse:** The overall process may be similar for residential and for commercial/industrial customers within Fort McMurray. The process for outside industrial customers will be more complicated and will be situation-specific.
- **Water Reuse Master Plan:** A much more detailed plan is required.
- **Stakeholders:** The major stakeholders for a comprehensive water reuse plan include the Municipality, private developers (commercial and residential), commercial and residential water users (the public), truckfill users, external users outside of the City (remote industrial), and outside approval agencies. Each need to know their responsibilities and understand/mitigate risks associated with water reuse.
- **Total Loadings:** Water reuse will reduce the effluent discharge volumes and total loadings to the Athabasca River.

3 RECOMMENDATIONS

The main recommendation from this preliminary study is for the Municipality to prepare a comprehensive Reuse Water Master Plan with participation by key stakeholders including: the Municipality, private developers (commercial and residential), commercial and residential water users (the public), truckfill users, external users (remote industrial), and outside approval agencies. The plan should examine:

- Sources of reuse water
- Potential customers
- Their reuse water quantity and quality requirements
- Infrastructure requirements
- System reliability
- Costs
- Risks
- Implementation

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	v
List of Figures	vi
1 Introduction	1
1.1 Reuse Water Drivers	1
1.2 Reuse Water Tech Memo Scope of Work	1
2 Review of Previous Work	2
2.1 South Regional Conceptual Design	2
2.2 South Regional Preliminary Design	3
3 Reuse Water Applications	3
3.1 Potential Applications	3
3.2 Other Reuse Concepts	5
4 Fort McMurray Water Consumption Review	6
4.1 Trucked Reuse Water Opportunities	6
4.2 Piped Reuse Water Opportunities	7
4.3 Opportunities and Reality	8
5 Optimizing Effluent Reuse	8
6 Reuse Water Balance	9
7 Reuse Water Quality Requirements	12
7.1 California Title 22 Regulations	12
7.2 Canadian Guidelines	13
7.3 United States Environmental Protection Agency	15
7.4 Other Countries	16
7.5 Summary of Water Quality Standards and Guidelines	17
7.6 Recommended Reuse Water Qualities	18
8 Reuse Water Infrastructure Requirements	18
8.1 Treatment	19
8.2 Storage	19
8.3 Distribution	20

Regional Municipality of Wood Buffalo Wastewater Master Plan

9	Implementing Reuse Water Infrastructure	23
9.1	New Developments with UDSR	24
9.2	Existing Developments within UDSR	24
9.3	Long Distance Commercial/Industrial Developments	24
10	Reuse Methodology Framework	25
10.1	Existing Developed Areas	25
10.2	Proposed Development Areas	25
10.3	Remote Industrial Users	25
10.4	Application Process	25
10.5	Application Checklist	26
10.6	Reuse Water Master Plan	27
11	Custody Transfer Requirements	33
11.1	Introduction	33
11.2	Reuse Water Ownership – Municipal Customers	33
11.3	Reuse Water Ownership – External Customers	33
11.4	Responsibilities and Potential Liabilities	34
12	Implications of Reuse Agreement Termination	37
12.1	Water Balance Implications	37
12.2	Effluent Treatment Requirements	38
13	Summary & Conclusions	38
14	Recommendations	39
Closure		
Appendix A – CMHC Greywater Reuse Demonstration Project Reports		
Appendix B – Direct Potable Reuse Example		

List of Tables

	PAGE NO.
Table 3-1	Potential Reuse Water Applications 4
Table 4-1	Fort McMurray Potable Water Distribution Summary 2008-2013 6
Table 4-2	Summary of Fort McMurray's High Water Use 7
Table 4-3	Preliminary Assessment of Reuse Water Use Potential for the Top Piped Potable Water Customers in Fort McMurray 8
Table 6-1	Water Balances for Various Reuse Water Use Scenarios 10
Table 6-2	Water Balances for Various Reuse Water Use Scenarios 10
Table 7-1	BC Requirements for Reclaimed Water 14
Table 7-2	Guideline Values for Domestic Reuse Water Used In Toilet and Urinal Flushing 14
Table 7-3	Summary of Water Recycling Guidelines and Mandatory Standards in the United States and Other Countries 16
Table 7-4	Summary of Water Quality Guidelines and Standards 17
Table 8-1	Reuse Water Distribution Methods 22
Table 11-1	Reuse Water Stakeholder Responsibilities and Potential Liabilities 35

List of Figures

	PAGE NO.
Figure 6-1 Water Balance Scenarios	11
Figure 10-1 Reuse Water Application and Review Process	29
Figure 10-2 Reuse Water Framework	31

1 Introduction

With increasing populations and industrial development throughout the world, there is a large demand for water. Most high quality water sources, with significant yield, are already developed; therefore, future availability of high quality water sources is becoming exhausted. Using treated wastewater effluent, also known as reuse water, for industrial, urban, or agricultural irrigation purposes is one way of reducing the demand on the potable water system. AWWA defines reuse water as wastewater that has been treated and recovered for useful purposes.

According to AWWA, there are two factors that have accelerated the development of reuse water systems:

1. The need for water that does not need to be potable water quality; and
2. New requirements for costly, advanced wastewater treatment technologies to remove nutrients and organics for the protection of receiving streams.

1.1 REUSE WATER DRIVERS

There are many drivers that a community may be considering when evaluating implementation of a reuse water system, including:

- Conservation
- Limited water resources
- Limited water supplies
- Polluted sources
- Rigorous wastewater treatment
- Overall environmental benefits

The main drivers for the Regional Municipality of Wood Buffalo (Municipality) are conservation and overall environmental benefits. The Municipality has embarked on a water conservation program which will gradually reduce the average potable water per capita water demands. Water reuse is a form of water conservation in that it reduces the demands placed on the potable water treatment facility. Environmental benefits of water conservation for the Municipality include:

- Lower raw water withdrawal volumes from the Athabasca River;
- Maximized use of treated effluent as a resource rather than a waste; and
- Lower effluent loads discharged to the Athabasca River.

1.2 REUSE WATER TECH MEMO SCOPE OF WORK

The Wastewater Master Plan (WWMP) Effluent Reuse Definition and Strategy sub-tasks (A.3.2.2 and A.3.2.3) evaluate effluent reuse possibilities and effluent quality requirements for the existing and future wastewater treatment facilities (WWTF).

The main objectives of Tech Memo A.3.2.2/A.3.2.3 are to summarize effluent reuse opportunities, reuse quality requirements, implications to infrastructure, an overall reuse framework, and custody transfer of the reuse water. To accomplish these objectives, the scope of work for this combined Tech Memo includes the following:

- Review previous work that incorporated reuse water principles from the South Regional Wastewater Treatment Facility (SRWWTF) predesign;
- Review possible reuse water applications;
- Document reuse water opportunities for the Municipality;
- Update effluent reuse water balance for the affected catchment areas;
- Document effluent quality requirements for reuse;
- Determine the infrastructure needs to accomplish the identified applications;
- Conduct a feasibility for the infrastructure components;
- Develop an effluent reuse methodology framework;
- Document custody transfer requirements for effluent reuse;
- Review implications of the termination of an effluent reuse partnership on water balance and effluent treatment requirements; and
- Summarize the findings and recommendations.

2 Review of Previous Work

The Municipality started evaluating the concept of reuse water systems for the Urban Development Sub-Region (UDSR) at the same time as concepts were being evaluated to manage wastewater for the future south developments. Below are brief overviews of the two reports that have documented reuse water in the Municipality to date.

2.1 SOUTH REGIONAL CONCEPTUAL DESIGN

Associated Engineering's (AE) August 2012 Conceptual Design Report entitled, "South Regional Wastewater Management Concept", indicated that the goal¹ of the Municipality is to reuse 100% of the WWTF effluent through consumptive and non-consumptive means. The report identified at a high level various potential users/buyers of reuse water.

In this report, AE highlighted that the only Canadian guidelines currently available for reuse water are the "Canadian Guidelines for Domestic Reuse Water for Use in Toilet and Urinal Flushing"; however, the USEPA and the government of California provide more general guidelines that could be applied with modification to the future purple water distribution system.²

¹ With consumptive use (e.g., irrigation), the water does not return to the sanitary sewage collection system; with non-consumptive use (e.g., toilet flushing), the resulting wastewater discharges to the sanitary sewage collection system.

² Reuse water distributed through a completely separate system from potable water. The reuse water is distributed in lavender (light purple) pipes to distinguish it from potable water.

2.2 SOUTH REGIONAL PRELIMINARY DESIGN

As part of the preliminary design for a proposed SRWWTF, AE prepared Technical Memorandum #7 in January, 2013 entitled "Treated Wastewater Reuse and Disposal Targets". This Tech Memo focussed on reuse water volume and quality requirements for an industrial client.

Reuse water volume and quality requirements for other users (commercial and residential customers) were not specifically identified. However, the Tech Memo suggested that quality requirements for other users are not expected to be more stringent than recognized standards and guidelines from other jurisdictions, including California Title 22.

The Fort McMurray WWTF currently discharges average effluent flows in excess of 25 ML/d to the Athabasca River. An industrial customer is negotiating to receive up to 11 ML/d of the effluent flow for reuse, but its average requirements are estimated to be much lower, in the 4 to 7 ML/d range. Therefore, given sufficient storage to manage hourly flow variations, the remaining volume of water available for reuse in the Municipality could average between 72% and 84%, and not be less than 56%³, during a peak industrial demand period.

3 Reuse Water Applications

3.1 POTENTIAL APPLICATIONS

There are many applications for reuse water; however there are two main categories that reuse water applications fall into: consumptive or non-consumptive. Consumptive uses are defined as applications that would consume the water; in other words the water does not return back to the wastewater collection system. Non-consumptive applications are defined as those that return water back to the wastewater collection system for treatment. Table 2-1 highlights several reuse water applications available and indicates whether the application is consumptive (C) or non-consumptive (NC).

³ Example calculation: If total flow is 25 ML/d and industrial customer uses 11 ML/d, then the volume remaining for reuse by other customers is $(25-11)/25 \times 100\% = 56\%$.

**Table 3-1
Potential Reuse Water Applications**

Type of Use	Specific Type of Use	C/NC
Municipal	• Parks irrigation and water amenities (ex. fountains)	C
	• Recreational activities (ex. golf courses, tennis courts)	C
	• Cemeteries	C
	• Snow making	C
	• Road dust control	C
	• Construction (ex. concrete, soil compaction, dust control)	C
	• Fire protection	C
Residential	• Residential lawn watering	C
	• Toilet flushing	NC
	• Air conditioning	NC
	• Vehicle washing	NC
Commercial	• Vehicle and equipment washing	NC
	• Toilet flushing	NC
	• Product water (e.g. concrete)	C
	• Dust control	C
	• Irrigation	C
Industrial	• Cooling tower make up water	C
	• Boiler feed make up water	C
	• Oil sands facility make-up water	C
	• Stack gas scrubbers	C
	• Gasifier ash quenching	C
	• Other process waters	C
Agriculture	• Crops (food, soil, fiber, seed, etc.)	C
	• Nurseries	C
	• Livestock watering	C
Other	• Environmental Uses: Stream augmentation, marshes, wetlands, and fisheries	C
	• Groundwater Re-charge: Aquifer storage and recovery	C

Within the list of applications in Table 3-1, there are several that may not pertain to the Municipality due to the local environment. For instance, agriculture is not common; therefore, it may not be a viable reuse opportunity for the Municipality. In addition, the opportunities for reuse water use in existing residential developments are most probably nil, given the significant neighborhood disruptions and costs associated with installing purple pipe infrastructure in established communities.

The Fort McMurray area is generally covered by boreal forest and has a plant hardiness rating of zone 1a (meaning no agriculture is generally possible here).⁴ To address this limitation, perhaps an extensive greenhouse development could be considered as a means of providing a year-round agricultural growing season.

3.2 OTHER REUSE CONCEPTS

3.2.1 Decentralized Reuse of Greywater

An alternative approach to reuse water for larger customers (not single-family residential) would be separation of greywater followed by treatment and reuse for toilet flushing. Central Mortgage and Housing Corporation (CMHC) has reported on a number of such projects in Canada (refer to Appendix A). This type of approach would eliminate the extensive purple pipe transmission/distribution system that would be required with a centralized reuse water system. On the other hand it would place more responsibility on the property manager for proper operation and maintenance of the reuse water system.

3.2.2 Direct Potable Reuse

Direct potable reuse of reuse water involves blending of treated wastewater effluent with the raw water supply for potable water treatment and distribution to customers. This concept is practised to a very limited extent throughout the world, but is gaining some momentum in locations with inadequate raw water supply volumes. Recently (November 2013), Water Reuse Research and Water Reuse California sponsored a specialty conference devoted entirely to this subject. As well, some Texas communities faced with raw water supply shortages are in the process of implementing this concept. Treated wastewater will be blended with the raw water supply to potable water treatment plants (refer to Appendix B for more details).

Perhaps years from now, direct potable reuse (with technology advancements, extensive treatment, and regulatory and public acceptance) may emerge as another opportunity in Fort McMurray.

3.2.3 Indirect Potable Reuse

Indirect potable reuse of reuse water is somewhat similar to direct reuse. Two main differences distinguish indirect from direct potable water reuse. With indirect reuse, an environmental buffer is provided between the effluent and the reuse water discharge point(s). Also, the reuse water typically comprises a smaller percentage of the total raw water supply (greater dilution available).

The State of California is recognized for its extensive indirect potable reuse system. Reuse water is used to recharge groundwater so that withdrawals do not exceed supply. As the water flows through the aquifer to collection wells, it is further purified, reducing the treatment demands at the potable water treatment facilities.

⁴ <http://www.woodbuffalo.net/aboutStats.html>

The most common indirect potable reuse option is prevalent throughout the world. Communities discharge treated wastewater effluent to streams or lakes. The effluent is mixed in the receiving water and may be withdrawn by other downstream communities for treatment and distribution.

Indirect potable reuse within the boundaries of the UDSR may one day be viable. However, it is not considered practical at this time because the main driver for this concept, raw water supply limitations, does not apply to the UDSR.

4 Fort McMurray Water Consumption Review

There are many means to identify potential customers for reuse water. AE undertook a preliminary review of available trucked and piped water consumption records for Fort McMurray with the aim of identifying existing customers who may have the potential for utilizing significant amounts of reuse water. Table 4-1 summarizes the 2008-2013 water supply records reviewed for the Fort McMurray Water Treatment Plant (WTP).

**Table 4-1
Fort McMurray Potable Water Distribution Summary 2008-2013 (m³/d Average Day Flow)**

Location	2008	2009	2010	2011	2012	2013*
WTP Total Water Supply	25.81	26.04	27.11	28.72	29.38	30.61
Regional Piped Portion	—	—	0.39	0.44	0.47	0.59
Trucked Potable Portion	1.82	1.66	2.14	2.38	3.09	3.92
Trucked Non-Potable Portion	0.04	0.06	0.08	0.10	0.22	0.27
Piped within Fort McMurray	23.96	24.32	24.51	25.80	25.60	25.83

*Partial year's data for 2013.

Although the total amount of potable water supplied from the water treatment plant has increased at an average annual rate approaching 4%, the piped portion, within the City of Fort McMurray, appears to have increased at <2% per year.

4.1 TRUCKED REUSE WATER OPPORTUNITIES

The trucked non-potable portion of the water is actually potable water supplied from a separate fill point (separate from two potable water fill points) at the truck fill station adjacent to Fort McMurray WWTF. This may be a candidate for replacement with reuse water from the WWTF, however it represents <1% of the total potable water supply. On the other hand, it is conceivable that a portion of the trucked potable water supply is actually used for non-potable purposes. The trucked potable portion accounts for approximately 13% of the total water supply. An in depth survey and analysis would be required to better estimate the total portion of the potable water supply that could be served by reuse water from the WWTF.

4.2 PIPED REUSE WATER OPPORTUNITIES

The Municipality provided 2013 (partial year) metered potable water records for high water use customers served from Fort McMurray's potable water distribution system. AE reviewed the records with the aim of identifying in-City high water use customers (those who used $>2,000 \text{ m}^3/\text{month}$ or about $66 \text{ m}^3/\text{d}$ over the first half of 2013) that might be able to substitute a portion of their potable water supply with reuse water. Table 4-2 summarizes the review.

Table 4-2
Summary of Fort McMurray's High Water Use

Customer Rank	Avg Day Water Use (m^3/d)	Customer Rank	Avg Day Water Use (m^3/d)
1	494	17	100
2	412	18	100
3	335	19	100
4	180	20	100
5	178	21	90
6	168	22	90
7	165	23	89
8	161	24	89
9	155	25	86
10	129	26	81
11	114	27	80
12	112	28	76
13	107	29	76
14	106	30	67
15	105	31	66
16	103		
Total (Customer Ranks 1-31)			4,312

Further analysis of the data was completed to identify customer type and whether or not some customers might use reuse water, given the opportunity. This review appeared to show little potential for reuse water from existing customers. Commercial customers, such as trucking/rental companies, as well as a park, were considered to have some potential for water reuse. Condominium corporations, hotels and the like were considered to have no immediate potential for significant reuse water. The remaining customers were classified as "Unknown". Table 4-3 summarizes this analysis.

Table 4-3
Preliminary Assessment of Reuse Water Use Potential for the
Top Piped Potable Water Customers in Fort McMurray

Potential	Number of Top Customers	Average Day Potable Water Use (m ³ /d)
Some Potential	3	996*
Unknown Potential	9	1,233*
No Potential	19	2,083
Totals	31	4,312

* The portion of potable water consumption that might be displaced by reuse water use is not known at this time.

This preliminary analysis appeared to show low potential for significant reuse water use by existing piped customers.

4.3 OPPORTUNITIES AND REALITY

Sections 3.0 and 4.0 provide a preliminary assessment of reuse water opportunities in Fort McMurray. The next step in the analysis should be a customer survey to merge the gap between identified opportunities and on-the-mark reuse water estimates. This step is beyond the scope of this Tech Memo.

5 Optimizing Effluent Reuse

The Municipality's goal is to achieve 100% reuse of effluent. The degree to which this goal will be met depends on various factors, including:

- Major industrial users and their associated consumptive use demands
- Types and distribution of other customers
- Government regulations and requirements
- Municipal bylaws – mandatory or voluntary water reuse
- Legal advice
- Available reuse water qualities (e.g. very high quality may enable residential reuse)
- Public information programs and community awareness and support for reuse water programs
- Funding mechanisms
- Economics
- Cost recovery
 - Who pays upfront costs?
 - Mechanisms (e.g. development levies, agreements, taxes, incentives)?
 - Pricing?

- Full cost recovery?
- 50-75% of potable water cost to encourage reuse?

A detailed review of the above factors is beyond the scope of this technical memorandum.

6 Reuse Water Balance

Tables 6-1 and 6-2 show a range of water balance results with 12 possible reuse water scenarios. Figure 6-1 illustrates one of the scenarios, Scenario 6. The illustration shows the overall impacts on required potable water production, and effluent discharge for a reuse water scenario in which 10% of the wastewater effluent reuse is non-consumptive (e.g. toilet flushing, commercial car washes) and 25% is consumptive (e.g. irrigation and industrial make-up water supply).

The main conclusions from this analysis are as follows:

The Municipality's goal is to achieve 100% reuse water. To achieve this goal, the following combinations of non-consumptive/consumptive reuse water are necessary:

- 0% / 100% (non-consumptive / consumptive);
- 10% / 90%;
- 20% / 80%; and/or
- Any other combination of non-consumptive and consumptive reuse waters totaling 100%.

Non-consumptive water reuse impacts the required water treatment plant production, e.g., if the non-consumptive water reuse is 20%, the required potable water production will be reduced correspondingly (by 20%). Both non-consumptive and consumptive water reuse impact the effluent volumes returned to the Athabasca River, e.g., if the consumptive water reuse is 50%, the effluent flow discharged to the Athabasca River will be reduced correspondingly (by 50%); also if non-consumptive water reuse is 20%, the effluent flow discharged to the Athabasca River will be reduced by a further 20%. Refer to Scenario 11 in Tables 6-1 and 6-2 for details.

Table 6-1
Water Balances for Various Reuse Water Use Scenarios
(% of available wastewater effluent)

Item	Reuse Water Use Scenario											
	1	2	3	4	5	6	7	8	9	10	11	12
Wastewater Treatment Plant Effluent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Non-consumptive Reuse Water Use	0%	0%	0%	0%	10%	10%	10%	10%	20%	20%	20%	20%
Consumptive Reuse Water Use	0%	25%	50%	100%	0%	25%	50%	90%	0%	25%	50%	80%
Treated Effluent Discharge to Athabasca River	100%	75%	50%	0%	90%	65%	40%	0%	80%	55%	30%	0%
Water Treatment Plant Potable Water Supply	100%	100%	100%	100%	90%	90%*	90%	90%	80%	80%	80%	80%

* Refer to Figure 6-1.

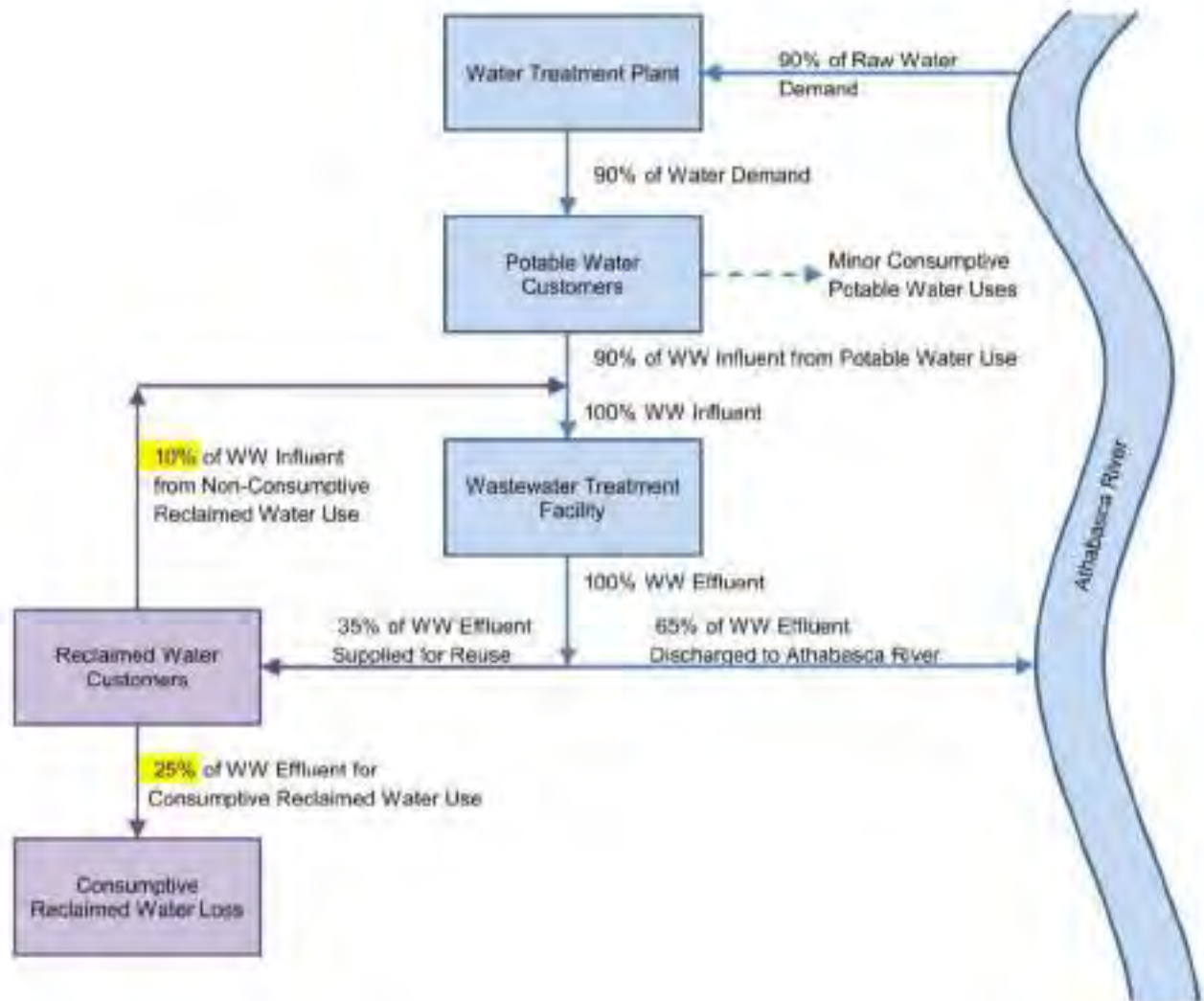
← Refer to Figure 6-1

Table 6-2
Water Balances for Various Reuse Water Use Scenarios
(based on 30 ML/d of available wastewater effluent)

Item	Reuse Water Use Scenario											
	1	2	3	4	5	6	7	8	9	10	11	12
Wastewater Treatment Plant Effluent	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Non-consumptive Reuse Water Use	—	—	—	—	3.0	3.0	3.0	3.0	6.0	6.0	6.0	6.0
Consumptive Reuse Water Use	—	7.5	15.0	30.0	—	7.5	15.0	27.0	—	7.5	15.0	24.0
Treated Effluent Discharge to Athabasca River	30.0	22.5	15.0	—	27.0	19.5	12.0	—	24.0	16.5	9.0	—
Water Treatment Plant Potable Water Supply	30.0	30.0	30.0	30.0	27.0	27.0	27.0	27.0	24.0	24.0	24.0	24.0

Note: Colours transition green-yellow-orange-red to illustrate highly favourable to less favourable water use or reuse.

Figure 6-1
Water Balance Scenarios



7 Reuse Water Quality Requirements

Sections 7.1 to 7.3 summarize reuse water quality standards and guidelines from other jurisdictions for consideration in Fort McMurray.

7.1 CALIFORNIA TITLE 22 REGULATIONS

The Government of California has provided water reuse regulations under the “California Health Laws Related to Recycled Water, Title 22: The Purple Book”, which outlines regulations related to recycled water, depending upon the application. For each level of treatment, a specific process or alternative processes must be used as defined in the regulations.

The standard lists various acceptable recycled water uses for various levels of treatment listed as follows in order of increasing degree of treatment (source: The Purple Book, California Health Laws Related to Recycled Water):

- Undisinfected secondary recycled water – oxidized wastewater.
- Disinfected secondary – 23 recycled water – median concentration of total coliforms (TC) not to exceed a most probable number (MPN) of 23 per 100 mL.
- Disinfected secondary – 2.2 recycled water – median Total Coliform (TC) concentration not to exceed MPN of 2.2 per 100 mL.
- Disinfected tertiary recycled water (DTRW) - notes follow.

Disinfected Tertiary Recycled Water is the highest quality water, approved for the largest number of applications. For example, it can be used as irrigation in the following scenarios:

1. Food crops, including all edible root crops where the recycled water comes into contact with the edible portion of the crop.
2. Parks and playgrounds.
3. School yards.
4. Residential landscaping.
5. Unrestricted access golf courses.
6. Any other irrigation use not specified and not prohibited by other sections of the California Code of Regulations.

It also has any other approved uses including cooling tower water and for industrial process water that may come into contact with workers.

The “disinfection” component of the regulations requires that the wastewater meets the following criteria:

- “1) A chlorine disinfection process following filtration that provides a CT (the product of total chlorine residual and modal contact time measured at the same point) value of not less than 450 milligram-minutes per litre at all times with a modal contact time of at least 90 minutes, based on peak dry weather design flow; or

- 2) A disinfection process that when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999% (5-log) of the plaque forming units of F-specific bacteria – phage MS2, or polio virus in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of the demonstration.
- 3) The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed an MPN of 2.2/100 mL, utilizing the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23/100 mL in more than one (1) sample in any 30 day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.”

To qualify as “disinfected tertiary recycle water”, very specific filtration and coagulation processes must be provided in addition to disinfection.

It is assumed that a chlorine disinfection process will be required to meet the first of the disinfected tertiary criteria in theory, using the transfer pipeline to provide the required contact time. However, for future commercial and industrial users who may be located closer to the WWTF, a chlorine contact tank may be necessary.

7.2 CANADIAN GUIDELINES

7.2.1 Alberta

The current Alberta Plumbing Code under the Safety Codes Act does not permit the use of reclaimed water. A variation has to be acquired from Alberta Municipal Affairs on a case-by-case basis.

7.2.2 British Columbia

British Columbia recently updated its “Municipal Wastewater Regulation” (April 2012) to include “Reclaimed Water Requirements”. Table 7-1 summarizes the BC standards. In addition, the minimum total chlorine residual at the point of use is generally required to be maintained at 0.5 mg/L.

Four reuse water categories are indicated in BC’s regulations:

- **Indirect Potable Reuse:** Any use of reclaimed water to replenish a potential potable water source.
- **Greater Exposure Potential:** Uses for which public contact is likely or that present a risk to the receiving environment.
- **Moderate Exposure Potential:** Uses for which public contact is likely minimal, for which public access to the reclaimed water is restricted and users are educated as to the risks posed by the use of the reclaimed water, or that present a moderate risk to the receiving environment.
- **Lower Exposure Potential:** Uses for which public access to the reclaimed water is restricted and users are not likely to have contact with the reclaimed water, that are commercial or industrial in

nature and users are educated as to the risks posed by the use of the reclaimed water, or that present a low risk to the receiving environment.

**Table 7-1
BC Requirements for Reclaimed Water**

Parameters	Indirect Potable Reuse	Greater Exposure Potential	Moderate Exposure Potential	Lower Exposure Potential
pH	Site specific	6.5 to 9	6.5 to 9	6.5 to 9
BOD ₅ , TSS	BOD ₅ : 5 mg/L TSS: < 5 mg/L	10 mg/L	25 mg/L	45 mg/L
Turbidity	Maximum 1 NTU	Average: 2 NTU Maximum: 5 NTU	n/a	n/a
Fecal Coliform (/100 mL)	Median: < 1 CFU or < 2.2 MPN	Median: < 1 CFU or < 2.2 MPN Maximum: 14 CFU	Median: 100 CFU Maximum: 400 CFU	Median: 200 CFU Maximum: 1000 CFU

7.2.3 National

A Canadian national guideline has also been published, “*Canadian Guidelines for Domestic Reuse Water for Use in Toilet and Urinal Flushing*”. Table 7-2 summarizes the parameter limits.

**Table 7-2
Guideline Values for Domestic Reuse Water Used In Toilet and Urinal Flushing^a**

Parameter	Units	Median	Maximum
BOD ₅	mg/L	≤ 10	≤ 20
TSS ^b	mg/L	≤ 10	≤ 20
Turbidity ^b	NTU	≤ 2	≤ 5
<i>Escherichia coli</i> ^c (<i>E.coli</i>)	CFU/100 mL	Not detected	≤ 200
Thermotolerant coliforms ^c	CFU/100 mL	Not detected	≤ 200
Total chlorine residual ^d	mg/L	≥ 0.5	

^a Unless otherwise noted, recommended quality limits apply to the reuse water at the point of discharge from the treatment facility or treatment unit. BOD₅ = Five-day biochemical oxygen demand; TSS = Total suspended solids; NTU = Nephelometric turbidity unit; CFU = Colony-forming unit.

^b Measured prior to disinfection point. Only one of TSS and turbidity needs to be monitored in a given system.

^c Only one of *Escherichia coli* and thermotolerant coliforms needs to be monitored in a given system.

^d Measured at the point where the treated effluent enters the distribution/plumbing system.

7.3 UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

The USEPA (2012)⁵ summarized various reuse standards for several states on their website at: <http://www.epa.gov/nrmrl/wswrd/dw/smallsystems/pubs/625r04108.pdf>. Based on their review, they suggested reuse water quality guidelines for various potential uses:

- Urban reuse (including unrestricted and restricted reuse)
- Restricted access area irrigation
- Agricultural – Food crops not commercially processed
- Agricultural – Food crops commercially processed
- Agricultural – Non-food crops
- Recreational impoundments
- Landscape impoundments
- Construction use (e.g. dust control, making concrete)
- Industrial – Cooling
- Industrial – Other (depends on use)
- Environmental (e.g., wetlands, wildlife habitat)
- Groundwater recharge
- Indirect potable reuse

The suggested urban reuse water quality guidelines are at least as stringent as all of the other reuse water quality guidelines except for indirect potable water reuse which is not applicable to this project. The limits include:

- | | |
|---------------------|---------------------------------|
| • pH | 6-9 |
| • BOD ₅ | Average ≤10 mg/L |
| • Turbidity | Average ≤2 NTU (maximum ≤5 NTU) |
| • Fecal Coliforms | Non Detect (< 14/100 mL) |
| • Chlorine residual | ≥ 1 mg/L (30 min contact) |

BC's "Greater exposure potential" water quality requirements appear similar to the above limits.

Some states allow the use of reuse water for toilet and urinal flushing in buildings where unauthorized personnel including residents do not have access to the plumbing systems for repairs or modifications. The use of reuse water in single family residences is generally prohibited. In addition backflow preventers are usually required in areas that receive both potable and reuse water. An air gap is required where a potable water system is used to supplement a reuse water system.⁶

⁵ US EPA, 2012. Guidelines for Water Reuse, EPA/600/R-12/618.

⁶ AWWA, 2009. Planning for the Distribution of Reclaimed Water, Third Edition.

Regional Municipality of Wood Buffalo Wastewater Master Plan

7.4 OTHER COUNTRIES

The USEPA (2012) also summarized various reuse standards and guidelines for other countries. Table 7-3 is reproduced from that document to facilitate the readers' reference. More recent (2012) and more extensive numbers have been published by USEPA, but a comparative consolidation does not appear to be included.

Table 7-3
Summary of Water Recycling Guidelines and Mandatory Standards in the United States
and Other Countries (ref: US EPA, 2004, Guidelines for Water Reuse)

Country/Region	Fecal Coliforms (CFU/100ml)	Total coliforms (cfu/100 ml)	Helminth eggs (#/L)	BOD ₅ (ppm)	Turbidity (NTU)	TSS (ppm)	DO (%of Sat)	pH	Chlorine residual (ppm)
Australia (New South Wales)	<1	<2/50	--	>20	<2	--	--	--	--
Arizona	<1	--	--	--	1	--	--	4.5-9	--
California	--	2.2	--	--	2	--	--	--	--
Cyprus	50	--	--	10	--	10	--	--	--
EC bathing water	100 (g)	500 (g)	--	--	2 (g)	--	80-120	6-9	--
	2,000 (m)	10,000 (m)			1 (m)				
France	<1000	--	<1	--	--	--	--	--	--
Florida (m)	25 for any sample for 75%	--	--	20	--	5	--	--	1
Germany (g)	100(g)	500 (g)	--	20 (g)	1-2 (m)	30	80-120	6-9	--
Japan (m)	10	10	--	10	5	--	--	6-9	--
Israel	--	2.2 (50%) 12(80%)	--	15	--	15	0.5	--	0.5
Italy	--	--	--	--	--	--	--	--	--
Kuwait Crops not eaten raw	--	10,000	--	10	--	10	--	--	1
Kuwait Crops eaten raw		100		10		10			1
Oman 11A	<200	--	--	15	--	15	--	6-9	--
Oman 11B	<1000			20		30		6-9	
South Africa	0 (g)	--	--	--	--	--	--	--	--
Spain (Canary islands)	--	2.2	--	10	2	3	--	6.5-8.4	1
Texas (m)	75(m)	--	--	5	3	--	--	--	--
Tunisia	--	--	<1	30	--	30	7	6.5-8.5	--
UAE	--	<100	--	<10	--	<10	--	--	--
United Kingdom Bathing Water Criteria	100 (g)	500 (g)	--	--	2 (g)	--	80-120	6-9	--
	2000 (m)	10000 (m)			1 (m)				
US EPA (g)	14 for any sample, 0 for 90 %	--	--	10	2	--	--	6-9	1
WHO (lawn irrigation)	200 (g)	--	--	--	--	--	--	--	--
	1000 (m)								

Note: (g) signifies that the standard is a guideline and (m) signifies that the standard is a mandatory regulation
Source: Adapted from Cranfield University, 2001. Urban Water Recycling Information Pack, UK

7.5 SUMMARY OF WATER QUALITY STANDARDS AND GUIDELINES

Table 7-4 summarizes our review of the various water quality guidelines and standards. The 2015 Approval limits for effluent discharge to the Athabasca River are included for comparison purposes.

Table 7-4
Summary of Water Quality Guidelines and Standards

PARAMETER	UNITS	Effluent Approval Limit 2015	CA Title 22 "Disinfected Tertiary Recycled Water"	USEPA "Urban Reuse Water"	Canada "Toilet Flushing"
		Monthly Average	Median (Max)	Average (Max)	Median (Max)
pH		6.5-9.5		6-9	
BOD ₅	mg/L	≤ 10		≤ 10	≤ 10 (≤ 20)
TSS	mg/L	≤ 10			≤ 10 (≤ 20)
Turbidity	NTU		2 (5, ≤ 5% time) (10 max)	≤ 2 (5 max)	≤ 2 (≤ 5)
Total Phosphorus	mg/L	< 0.5			
Ammonia Nitrogen	mg/L	< 3 summer < 6 winter			
<i>E. coli</i>	CFU/100 mL	≤ 200			ND* (≤ 200)
Fecal Coliforms (Thermo-tolerant coliforms)	CFU/100 mL			ND (≤ 14)	ND (≤ 200)
Total Coliforms	CFU/100 mL		2.2 (23 1x/mo) (240 max)		
Total Chlorine Residual	mg/L			≥ 1	≥ 0.5
Chlorine Contact Time	minutes		CT ≥ 450 mg-min/L with T ≥ 90 min	30	

* None detected.

At this time, AE anticipates that the water quality from the FMWWTF, following filtration and chlorine disinfection will meet the applicable regulatory requirements and the specific needs of most users who may connect through a distribution network. Where water quality requirements of specific users may be more stringent, then the onus should be on the specific users to provide additional treatment.

7.6 RECOMMENDED REUSE WATER QUALITIES

Two potential water quality levels for consideration are as follows:

- **Quality 1:** Chlorine-disinfected, chemically coagulated, filtered effluent: This quality of effluent is currently proposed for the reuse water supply from the FMWWTF to an industrial client. This quality of effluent would be equivalent to California's Title 22 most stringent standard - disinfected tertiary recycled water. It should be noted that this standard is not considered adequate in California, or a number of other jurisdictions, for flushing of residential toilets. However, the achievable quality appears to meet the Canadian Guideline.
- **Quality 2:** Chlorine-disinfected, reverse osmosis (or equivalent) treatment of Quality 1 effluent. Assuming regulatory authorities do not approve Quality 1 effluent for residential use, or the Municipality does not want to take on the risk of supplying potentially contaminated effluent for non-potable indoor residential uses, then the higher water quality water that could be assured through RO treatment may mitigate the concerns/risks. Strategically located satellite RO treatment facilities could be supplied from Quality 1 reuse water supply pipelines.

AE suggests that the planning for possible Quality 2 treatment facilities be deferred. If such facilities are determined to be needed to enable the wider distribution of reuse water to residential areas, then individual developers should undertake the development and pass along the up-front costs and the deferred benefits to individual home owners. The Municipality may wish to consider making distribution systems mandatory in new developments rather than voluntary, if the overall benefits outweigh the economics.

8 Reuse Water Infrastructure Requirements

Implementing a reuse system within the Municipality varies depending upon the application; however there are three main infrastructure components to consider for reuse applications:

1. Treatment
2. Storage
3. Distribution

Depending upon the Municipality's preferred customers for reuse, the requirements for each of these three infrastructure components will change. The most significant infrastructure change between the different reuse applications is the means of distribution. Below is a brief summary of each of these infrastructure components and how they differ between the various reuse applications. Also it should be noted that, until Alberta clarifies specific requirements for reclaimed water systems, approval will have to be acquired from Alberta Municipal Affairs on a case-by-case basis.

8.1 TREATMENT

As outlined in Section 7.5, the treatment requirements vary between the different reuse applications, depending upon human exposure. AE recommends for the Municipality to plan for Reuse Water Quality 1, chlorine-disinfected, chemically coagulated, filtered effluent. The Municipality does not currently filter the FMWWTF effluent; however it has been identified that it will be necessary to filter all effluent to ensure the facility can reliably meet more stringent discharge limits set forth by AESRD for July, 2015. To prevent bio-film and bacterial growth in the treated effluent, chlorine must be provided to the filtered effluent. With this, the two major improvements to the FMWWTF that are required to provide reuse water are the addition of filtration and chlorine feed systems.

If a customer or regulatory authorities require a varying quality of water, the Municipality may have to re-evaluate the treatment system to ensure the required quality is satisfied. If it is a specific customer requesting a varying grade of reuse water, the Municipality must complete a cost analysis on the benefits of providing improved quality.

In addition to ensuring good quality reuse water for the end customer, the wastewater treatment system must be also ensure there is a reliable system to supply reuse water to the end customers at all times of demand. Reliability measures may include:

- Alarm systems for notification of a power failure or failure of an essential unit process;
- Automatic standby power supply;
- Standby treatment process units;
- Emergency storage;
- Flexible design; and
- Potable water supply as a backup.

8.2 STORAGE

Municipality's ultimate goal is to reuse 100% of the wastewater effluent; however this will take some time to achieve. Although 100% of the reuse water would eventually be distributed to industrial, commercial, and municipal use, some storage is still necessary to manage initial reuse excess and fluctuations in demand. The volume of storage necessary is dependent on diurnal trending of the wastewater system, as well as reuse customer demands. Some municipalities within the United States require a minimum storage volume, similar to potable water storage requirements; however, there are currently no standards for storage within Alberta. With this, the required storage volume for reuse water will have to be evaluated on a case by case basis depending on the reuse water demands and the available wastewater effluent volume. To evaluate the storage required for a specific application the Municipality must review:

- Customer demands from the storage reservoir: daily and hourly.
- Reuse water available from the WWTF: daily and hourly.

If there is an excess of reuse water available in storage, the WWTF will discharge filtered effluent (UV disinfected, not chlorinated) to the Athabasca River as per the current operating Approval.

8.3 DISTRIBUTION

The infrastructure required to distribute reuse water to the end customers is variable depending upon the reuse application. In general, distribution of reuse water includes the same infrastructure as a potable water system such as truck fills, pumping stations, and pipelines.

The similarities in infrastructure required relates to the term, dual distribution system. To distinguish between potable and reuse water distribution networks is it important for there to be color differential in the pipes. Potable water pipeline is typically blue and a common colour for reuse water pipeline is purple which correlates to the name purple water pipe network. To properly plan the purple water distribution network, inclusive of specific requirements to the Municipality, a Reuse Water Master Plan is recommended. The following sections provide an overview of the distribution infrastructure necessary based upon the various reuse application opportunities.

8.3.1 Municipal

Municipal reuse applications vary from simple irrigation to fire protection, which require very different infrastructure needs. For example, if the Municipality chooses to focus on utilizing reuse water for irrigation purposes, a dual distribution system may not be necessary; the Municipality may implement a reuse water pumping station complete with a truck fill to service irrigation trucks in this reuse water application. A pump station/truck fill system could also satisfy other Municipal reuse water applications including dust control, soil compaction during construction, and possibly even snow making.

On the other hand, if the Municipality decided to focus on implementing reuse water for fire protection, a distribution network would be necessary to feed the hydrants. A distribution system would also be applicable for concrete plants, water amenities such as fountains, and irrigation of golf courses.

8.3.2 Residential

The opportunities for reuse water use in new residential developments may range from minimal to significant. This will depend on the accepted water quality limits and several other factors. The residential reuse water use opportunities may include:

- Toilet flushing in multi-family buildings where there will be a limited number of qualified contractors.
- Toilet flushing and irrigation at single-family houses where the reuse water has been further treated, possibly to a potable water standard as a safeguard against system tampering by the residents.⁷

⁷ Reuse of reuse water in single family homes may be cost-prohibitive, if treatment to a potable water standard is required.

Implementing a reuse water network within the Municipality for residential purposes will necessitate implementing a full dual, purple pipe, distribution system if toilet flushing capabilities are priority. A dual distribution system consists of two separate water piping systems — one carrying potable water and one carrying reuse water. This is a costly addition to residential developments and would need to be incorporated into the Developer Charges. As previously mentioned, incorporating dual distribution networks into existing residential communities is not deemed to be feasible.

Although a dual distribution system would be convenient for all residential applications of reuse water, it is not necessary. If toilet flushing is not a priority, the Municipality could implement a bucket fill system within communities for residents to use for non-potable uses such as watering.

8.3.3 Commercial/Industrial

Commercial/industrial applications for reuse water typically require continuous supply and pressure; therefore a distribution network to the users is necessary. Commercial reuse water reuse opportunities will likely be limited to:

- Existing potable water customers located along a reuse water transmission line
- New commercial developments where the purple pipe infrastructure can be coordinated with the remainder of the infrastructure.

Supply of reuse water for industrial users outside of the UDSR is a near certainty. Potentially up to 100% of the treated wastewater effluent could be supplied for industrial use. The distribution of reuse water to industrial customers will likely comprise of north and south reuse water transmission lines.

Table 8-1 summarizes the various applications for reuse water, and the preferred distribution methods based on the discussion above.

**Table 8-1
Reuse Water Distribution Methods**

Type of Use	Specific Type of Use	Distribution
Municipal	• Parks irrigation • Recreational activities (i.e., tennis courts) • Cemeteries • Snow making • Road dust control • Construction (i.e., concrete, soil compaction, dust control)	
	• Fire protection • water amenities (i.e., fountains) • Golf Courses • Concrete	
Residential	• Residential lawn watering • Toilet flushing • Air conditioning • Vehicle washing	
Commercial	• Vehicle and equipment washing • Concrete	
Industrial	• Cooling tower make up water • Boiler feed make up water • Oil sands facility make-up water • Stack gas scrubbers • Gasifier ash quenching • Other process waters	
Other	• Environmental Uses • Groundwater Re-charge: Aquifer storage and recovery	 

9 Implementing Reuse Water Infrastructure

There is a great deal of information to consider when planning a reuse water distribution network, including:

- Potential customers and demands;
- Regulatory requirements specific to the intended use;
- Potential customer locations;
- Future development for the Municipality;
- Existing infrastructure that could be utilized; and
- Local expectations.

Planning a reuse water distribution network for the Municipality must take into consideration existing, established developments as well as new developments planned for the community.

As proposed in Tech Memo A.2.1.2, the Municipality's wastewater network is divided into two catchments, the north and south. To align with this, AE proposes that ultimately the Municipality's reuse water distribution network be divided into similar north and south areas. Reuse water produced from the existing FMWWTF will be supplied by the north developments and that from the future SRWWTF will be distributed to the south developments. Implementation of a reuse system in the north catchment is much different than the south reuse as the majority of existing development within the Municipality is situated in the north catchment. Until the SRWWTF is commissioned reuse water may be distributed to south customers through a transmission main from the FMWWTF.

To develop a detailed reuse water distribution plan it is necessary for the Municipality to complete a Reuse Water Master Plan to identify the needs and actions necessary for each catchment and development; as well as to assist the Municipality with identifying potential customers for reuse water. A Reuse Water Master Plan will incorporate:

- Source identification
- Customer identification and associated demand
- Hydraulic modeling of the distribution system
- Identifying costs
- Develop a Municipal standard for reuse system and
- Develop Municipal policies for reuse water system.

For the purpose of this Tech Memo, AE highlights the infrastructure consideration necessary for three broad reuse applications:

1. New residential or commercial/industrial developments within the UDSR.
2. Existing residential or commercial/industrial development within the UDSR.
3. Long distance commercial/industrial development outside of the UDSR.

9.1 NEW DEVELOPMENTS WITH UDSR

For new development areas, the Municipality has two options to implement a reuse water system:

- Purple water pipe network
- Reservoir and truck/bucket fill

Depending upon the customer application and demands, the type of reuse system implemented in a new development may vary. Before determining what system is best suited the reuse water demands of the development area must be evaluated. For example, the cost of implementing a purple water pipe network may not be necessary if there is not a high demand for reuse water in the development. It is difficult to determine the specific needs of a new development as the customers are unknown at this time.

For planning purposes, AE suggests that the Municipality considers constructing reuse reservoirs in major new development areas that would be fed by the FMWWTF or future SRWWTF. This allows the Municipality the flexibility to either implement full purple pipe networks or truck fills. The location of the future reservoirs should be identified in the Reuse Water Master Plan. Once new developments initiate planning stages, the Municipality should complete a full economic and non-economic benefit analysis to assess the social, environmental, and economic benefits of a purple pipe network or reservoir truck fill system.

9.2 EXISTING DEVELOPMENTS WITHIN UDSR

For existing developments, implementing a purple water pipe system is difficult as installation would require destruction of existing infrastructure. With this, the best suited reuse water system for an existing development area is a reservoir truck/bucket fill system for residents and commercial/industrial customers to use as desired. To gauge the size of the reservoir and truck fill station required for this system, an evaluation of the customer demands would be necessary. This could be accomplished by conducting a survey of the current customers in existing developments.

Placement of the reservoir and routing of reuse pipeline to feed to reservoir will take careful consideration for existing developments. The potential routing could be identified as part of the Reuse Water Master Plan.

9.3 LONG DISTANCE COMMERCIAL/INDUSTRIAL DEVELOPMENTS

Long distance commercial/industrial developments are possible all around the UDSR. Implementing the reuse system for these systems seems to be more straight-forward as the customer demands requirements will likely be well defined prior to implementing the system. Due to the long distance, these systems may require dedicated pump stations and pipelines, if an existing reuse pipeline is not available. Several commercial/industrial users are present to the north and south of the UDSR; and with this, AE suggests that the Municipality consider installing reuse water transmission main to north and south, based on customer needs.

10 Reuse Methodology Framework

This Tech Memo provides a high level framework towards developing a strategy for reuse water supply. This preliminary framework will require significant, further development and refinement prior to implementing the reuse water strategy. This should include:

- **Existing Developed Areas:** Review of customer database to evaluate the potential reuse water needs. This may be supplemented by a targeted market survey;
- **Proposed Development Areas:** water reuse potential for all practical uses;
- **Remote Users:** confirmed and potential major industrial users and their locations; and
- Water Reuse Master Plan tying the three areas together within an overall plan.

10.1 EXISTING DEVELOPED AREAS

- Preliminary review of existing customer database (this Tech memo).
- Targeted market survey (future).

10.2 PROPOSED DEVELOPMENT AREAS

- Existing developed areas: Review of customer database to evaluate the potential reuse water needs. This may be supplemented by a targeted market survey.

10.3 REMOTE INDUSTRIAL USERS

- Existing south customer (negotiations in progress).
- Additional south customer.
- Potential north industrial customers.

10.4 APPLICATION PROCESS

Figure 10-1 illustrates a suggested overall application process applicable to residential, commercial/industrial, and outside industrial customers. Major activities are colour-coded to identify the primary responsible parties at each step: proponent, Municipality, joint proponent-Municipality, and regulatory.

The residential and commercial/industrial application processes are similar but separately shown as the checklist criteria may be different. Refer to Section 10.5 for a suggested checklist. If the application does not fully comply with the checklist criteria, then the Municipality would either reject the application or request the proponent to revise and resubmit.

If the application complies with the checklist criteria, it would be forwarded to appropriate regulatory bodies with a letter from the Municipality requesting approval. In the longer term, once water reuse is more broadly accepted, this regulatory approval step might be omitted. At this time, AE envisages that regulatory

approval may be required from Alberta Environment and Sustainable Resource Development, as well as Alberta Labour, and Safety Codes Council.

Subject to regulatory approval, the Municipality would then issue a permit enabling the proponent to proceed with the project. The proponent would then be responsible for finalizing the design, submitting detailed plans for the Municipality's review and approval, construction, coordination of inspection requests by the Municipality, and commissioning of the system. Inspections would be concurrent with underground piping and interior plumbing system inspections.

After system commissioning, the Municipality would assume ownership of the system up to the property line of residential and commercial/industrial properties. With ownership, the Municipality will have the ongoing responsibilities of operation, maintenance, and billing. The property owner would have the responsibility of maintaining the system on his/her property and ensuring that any system maintenance is undertaken only by an approved contractor.

With respect to the application process for outside industrial customers, the process will be somewhat contingent on the specifics of each application. The figure suggests a generic process which should be generally applicable to outside industrial customers. For these applications, a legal agreement will be required between the Municipality and the industrial proponent before regulatory review.

10.5 APPLICATION CHECKLIST

The following is a preliminary checklist for water reuse applications from residential and commercial/industrial development proponents.

1. Complete
2. Application fee submitted
3. Complies with Municipal Development Plan
4. Complies with Area Structure Plan
5. Complies with Engineering Service Standards
6. Complies with Water Reuse Master Plan
7. Backflow preventer on potable supply
8. Lower pressure on reuse water supply (potential criterion)
9. No cross connections
10. Identified non-potable uses and volumes
11. Acceptable reuse water quality for identified uses
12. Dual (separate) pipe systems - potable and purple
13. Binding agreement - internal plumbing by qualified contractors

10.6 REUSE WATER MASTER PLAN

The preliminary water reuse strategy outlined in this Tech Memo should be further developed in a comprehensive Reuse Water Master Plan. The Master Plan should encompass:

- Sources of reuse water
- Matching available supply with demands
- Reuse water qualities
- Customers
 - Demand projections
 - Water quality requirements
 - Regulatory
 - Legal
 - Risks
 - Risk Mitigation
- Infrastructure
 - Collection
 - Pumping
 - Transmission
 - Additional treatment (where required)
 - Equalization storage
 - Distribution
 - End-use facilities
- Reuse supply vs. demand
 - Equalization storage
 - Provisions to manage supply shortfalls
- System reliability
- Cost evaluation
 - System costs
 - Cost savings from deferred WTP expansion
 - Funding
 - Pricing of reuse water
- Identification of responsible parties for plan implementation

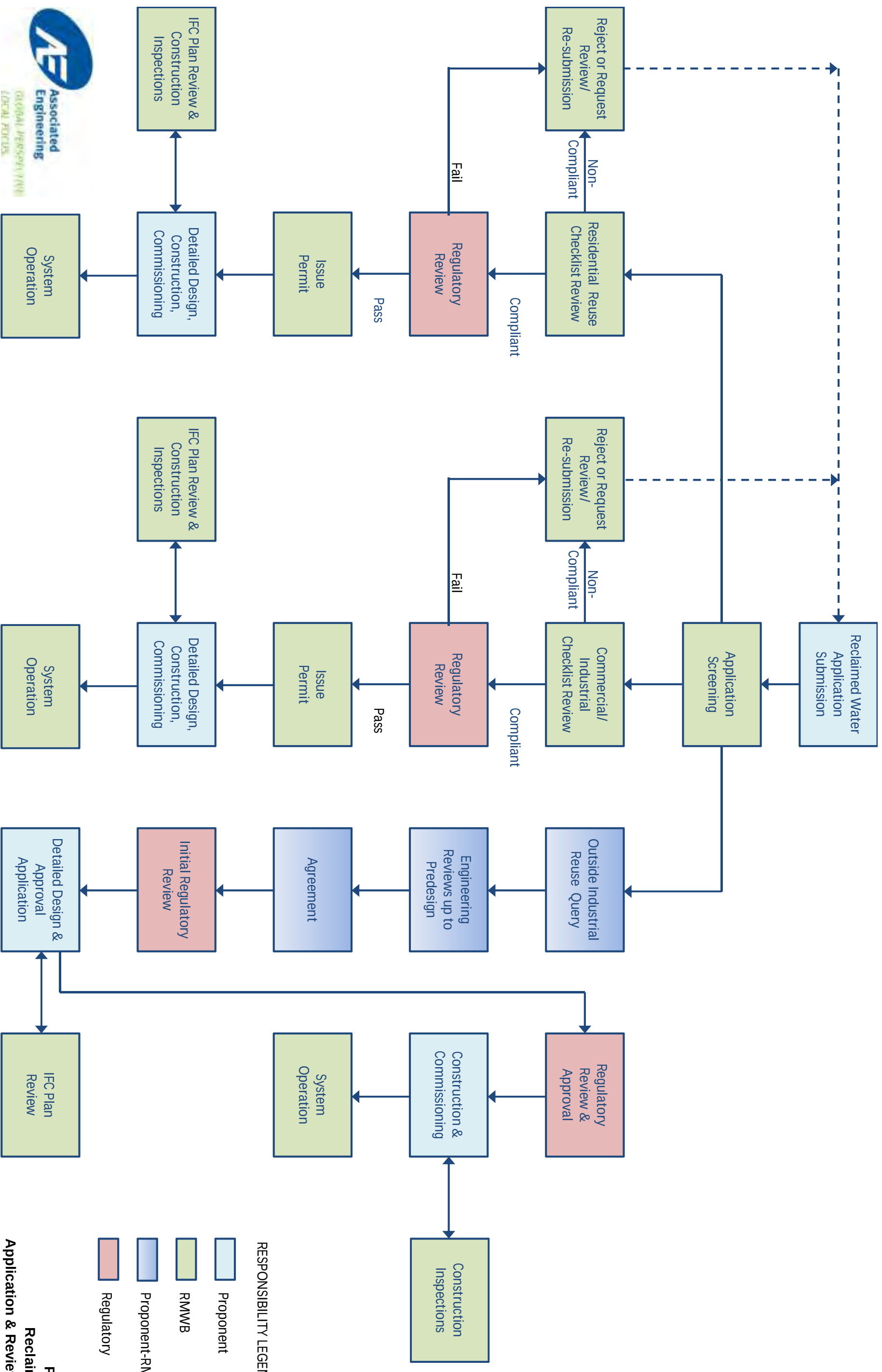
Figure 10-2 illustrates an overall framework for developing and implementing the Water Reuse Master Plan. The main framework areas include:

- Review of potential reuse water demands
- Review of factors impacting reuse water use
- Implementation process

Regional Municipality of Wood Buffalo Wastewater Master Plan



It should be noted that listed items are not necessarily undertaken in a linear fashion, since they will often be iterative with a subsequent evaluation necessitating revision of a previous conclusion. This technical memorandum covers portions of each framework area, extending into the implementation process only as far as identifying preliminary concepts.



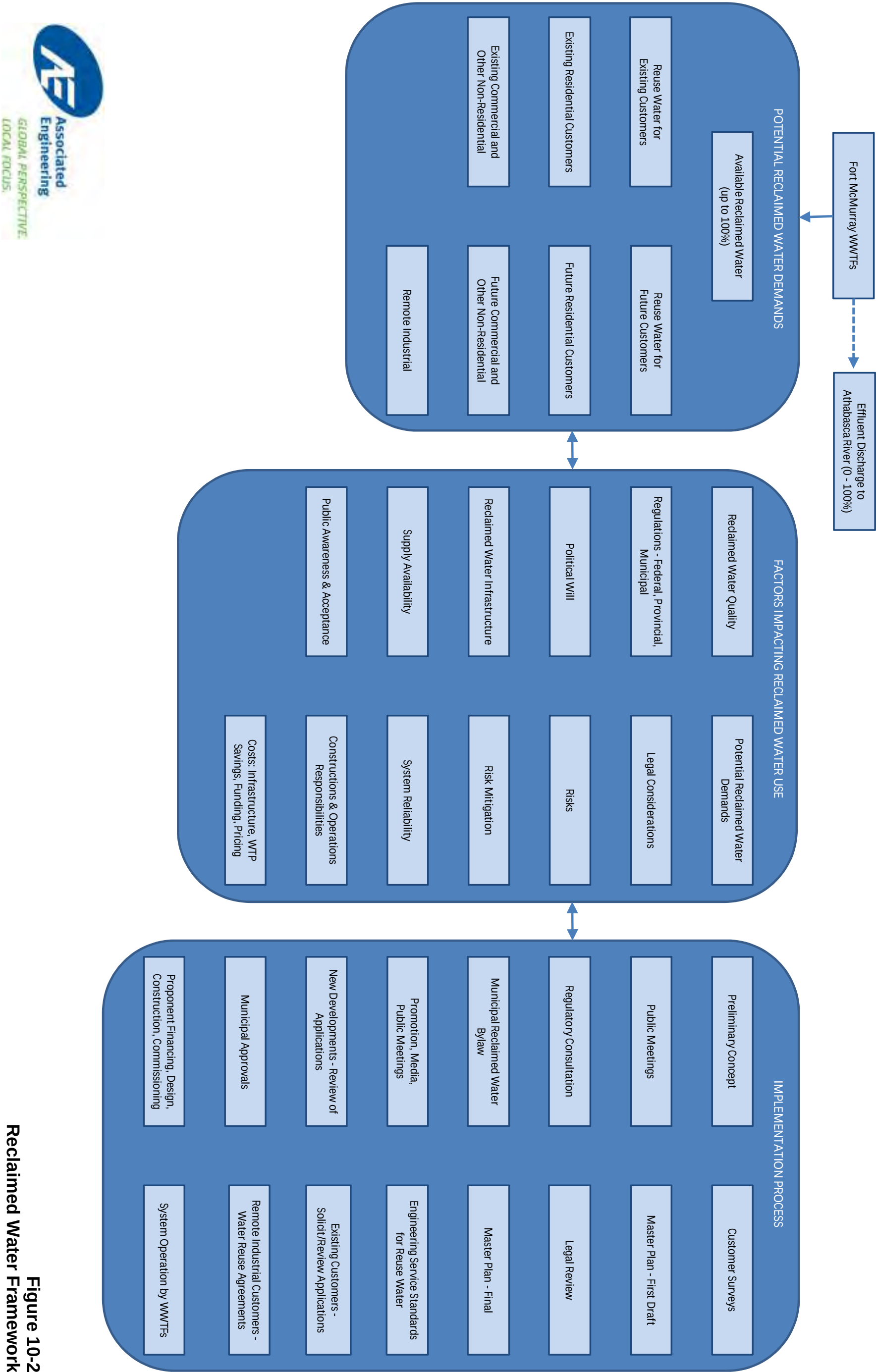


Figure 10-2
Reclaimed Water Framework

11 Custody Transfer Requirements

11.1 INTRODUCTION

This section addresses reuse water ownership, responsibilities, and liabilities. At what point is the ownership of the water transferred from the Municipality to the end user and possibly back to the Municipality following reuse? What are the responsibilities and potential liabilities of both parties?

11.2 REUSE WATER OWNERSHIP – MUNICIPAL CUSTOMERS

Potential end users of reuse water are focussed on their individual water needs and operations. The Municipality's utilities will be focussed on delivering reuse water and/or receiving wastewater for treatment/discharge or repeated reuse. Therefore, we suggest that the reuse water ownership should remain with the Municipality at least up to the customer property line, as would be consistent with potable water supply. The ownership of the reuse water would transfer to the customer at the property line. For truck fill facilities, the ownership would transfer at the point of delivery at the truck.

11.3 REUSE WATER OWNERSHIP – EXTERNAL CUSTOMERS

To provide reuse water to external customers (e.g. remote industrial users) within RMWB, the Municipality's existing Water Act Diversion License will require modification as the return flow to the Athabasca River will decrease. To adjust the estimated return flow to the Athabasca River, the Municipality is required to apply for an amendment to the existing license. As part of the license amendment, the Municipality must provide details where the water will be returned to the environment within the Athabasca River Basin. With this, details regarding pipelines and discharge of the reuse water from the FMWWTF to the external customers must be provided.

Recently (May 7, 2013), AESRD noted that the model applied to reuse projects has considered the reuse water pipeline as a tributary to the river that receives the return flow. In this case, the reuse water pipeline would be considered as a tributary to the Athabasca River. With this, the Municipality would apply for an amendment to the existing Water Act Diversion License to return flow back to the new Tributary.

To supply water to external customers, the end user is required to apply for a separate diversion license from the new Tributary. Although the process to apply for a new water diversion license is well established within AESRD, the process will likely take a minimum of one year due to the unique aspects of the new Tributary and the connection to other portions of the project.

The point where ownership of the water transfers from the Municipality to the external customer will depend on specifics of the agreement between the two parties. This may be at the inlet to the pumphouse, at the outlet of the pumphouse, or at the ultimate delivery point.

11.4 RESPONSIBILITIES AND POTENTIAL LIABILITIES

Table 11-1 provides a preliminary list of responsibilities and liabilities with respect to reuse water systems which may be developed within the Fort McMurray area. This information needs to be reviewed by all stakeholders before finalization.

**Table 11-1
Reuse Water Stakeholder Responsibilities and Potential Liabilities**

Stakeholder	Responsibilities	Potential Risks/Liabilities	Comments
Municipality	- Sourcing, treatment and transmission of reuse water meeting minimum acceptable standard. - Reuse water bylaw development and administration. - Update ESS to address reuse water. - Reliable supply. - Application review and approval. - Leadership through optimized use of reuse water at municipal facilities. - Agreement negotiations with external users. - System operation and monitoring (to point of transfer), billing.	- Failure of approval authority to amend water licence and/or WWTF approval. - Failure to meet terms of external water supply agreements – potential legal action or penalties. - Reliable supply may require potable water back-up. - Agreement termination (external user), lost revenue. - Inadequate cost recovery, placing a financial burden on the Municipality. - Lack of public acceptance. - Water quality (e.g. high chlorine, SAR, TDS) may be inappropriate for some irrigation uses.	- On-going communications with approval authorities necessary to avoid sudden surprises. - Consider phasing system investments to prove out concepts and ensure revenue expectations are realistic. - Master Plan development needs to be coordinated with public reviews. - Municipality should publish reuse water quality data and possible restrictions on some irrigation uses (if necessary).
Private Developer (commercial or residential)	- Planning, design, construction, and commissioning of additional reuse water treatment facilities (if required), equalization storage, and distribution to development customers. - ESS compliance for reuse water facilities.	- Failure to construct facilities compliant with new reuse water ESS. - Difficulty in recovering extra development costs for purple pipe system.	- Funding mechanisms and cost recovery need to be further explored. - Perhaps Municipality could assume some of the risk by front-ending a portion of the additional costs which would then be recovered through the water rate.
Commercial Users	- Proper operation and maintenance on on-site purple water pipe system. - Any modifications to purple pipe systems on user's property to be undertaken through permit by qualified, licenced plumber.	- Risk that some customers will undertake unapproved system alterations resulting in cross connections between purple pipe system and potable water system. - A cross connection could potentially result in contamination of the area's potable water system.	Relative to residential users, reduced risk of improper operation or cross connections (qualified plumbing contractors are much more likely to be utilized).

Stakeholder	Responsibilities	Potential Risks/Liabilities	Comments
Residential Users	• Proper operation and maintenance on on-site purple water pipe system. • Any modifications to purple pipe systems on user's property to be undertaken through permit by qualified, licenced plumber.	• Risk that some residential customers will undertake unapproved system alterations resulting in cross connections between purple pipe system and potable water system. • A cross connection could potentially result in contamination of the area's potable water system. • Potential legal suites against the Municipality for allowing a system that potentially could become contaminated.	• Although the existing Canadian standards allow use of lesser quality water for toilet flushing, we suggest that RO quality water be considered as the minimum requirement for residential purple pipe systems. • In view of the risk that one or more residential user may improperly use or cross-connect the purple pipe and potable water systems, the Municipality needs to weigh the benefits against the risks and liabilities, even if high quality RO water is used for residential systems.
Truckfill Users	• Ensure end use is non-potable. • Ensure separate use of non-potable trucks.	• Possible potable water contamination if dual use (potable and non-potable) trucks are used.	• Municipality may wish to monitor the system to help ensure safe operation.
External Users (remote industrial)	• Agreement negotiation with Municipality. • Planning, design, construction, and commissioning of additional treatment facilities (if required), equalization storage, and internal use/distribution. • Water licence for industrial use.	• Failure to meet terms of the agreement. • Agreement termination, lost revenue. • Failure to secure Water License. • Long pipelines may require high initial chlorine residuals necessitating dechlorination at intermediate points of withdrawal.	• Legal review required.
Outside Approval Agencies	• Water licence and WWTF approval amendments.	• Inconsistent and uncertain requirements. • Adverse public reaction if an approved system experiences problems.	• As experience is gained, approval and licence requirements should become more standardized.

* Abbreviations used in Table11-1: ESS - Engineering Service Standards; SAR – Sodium Adsorption Ratio
TDS – Total Dissolved Solids; WWTF – Wastewater Treatment Facility

12 Implications of Reuse Agreement Termination

This section reviews the implications of the possible termination of an effluent reuse partnership on water balance and effluent treatment requirements.

Currently, there is a pending agreement between an industrial client and the Regional Municipality of Wood Buffalo to supply treated wastewater effluent from Fort McMurray. In the near term, the intent is to supply the industrial client with reuse water from the existing Fort McMurray WWTF. At some future time, all or a portion of that water may be supplied from the SRWWTF, if and when it is constructed.

For purposes of this analysis, we will assume that other reuse water customers have insignificant water demands and the agreement being terminated would apply to a customer with a similar reuse water profile as for the industrial client, approximated as follows:

- Peak water demand 11,000 m³/d (5% frequency)
- Average water demand 4,000 to 7,000 m³/d
- Minimum water demand 400 m³/d (10% frequency)

Assuming the agreement is terminated prior to the construction of the proposed SRWWTF, the possible impacts of agreement termination may be as follows:

- Water licence and/or WWTF approvals may require amendments, depending on how they are worded.
- More water would be available for other possible reuse water customers.
- Total effluent loadings to the Athabasca River would increase as a result of the greater effluent volume being discharged. This may require revisions to the total effluent loading plan and may trigger more stringent effluent quality limits (to off-set the greater loads).

If the agreement is terminated after the proposed SRWWTF is commissioned, then:

- The portion of the reuse water supply line from FMWWTF as far as SRWWTF may have to be operated as an outfall, reversing the flow in the line (from SRWWTF to FMWWTF). This may require pumping modifications at SRWWTF as well as effluent receiving modifications at FMWWTF. These modifications may be required regardless of agreement termination since the possibility of such termination needs to be recognized in advance.

12.1 WATER BALANCE IMPLICATIONS

The water balance implication could be a transition from something similar to Scenario 2 to Scenario 1. The treated effluent discharge and loads to the Athabasca River could increase by about 33% (from 22.5 ML/d to 30 ML/d). Refer to Tables 6-1 and 6-2.

12.2 EFFLUENT TREATMENT REQUIREMENTS

Based on current planning, termination of a reuse agreement will have no impact on the effluent treatment requirements. AESRD's approval limits for Fort McMurray's discharge of treated effluent to the Athabasca are more stringent than the industrial client's requirements. Therefore, water that would have gone to the former reuse customer would be diverted to the outfall.

Should other major reuse water users require higher water quality in future, then the additional treatment requirements should most likely be the responsibility of the other users.

13 Summary & Conclusions

The main conclusions of this Tech Memo: Reuse Water Definition and Strategy are summarized as follows:

- **Reuse Water Applications:** There are two main categories that reuse water applications: consumptive or non-consumptive. Consumptive reuse water does not return to the wastewater collection system. Non-consumptive applications are those that return water back to the wastewater collection system.
- **Water Reuse Opportunities for Existing Customers:** Currently there appear to be limited opportunities for significant water reuse (>5% of the total potable water supply) by existing customers.
- **Water Reuse Opportunities for New Customers:** The most significant water reuse opportunities lie with new customers where a purple pipe system can be accommodated much more economically.
- **Non-consumptive Water Reuse:** Proportionately reduces the required potable water treatment and distribution, as well as the WWTF effluent discharge to the Athabasca River.
- **Consumptive Water Reuse:** Proportionately reduces the WWTF effluent discharge to the Athabasca River.
- **Water Balance:** For the Municipality to achieve its ultimate objective of 100% water reuse, any combination of consumptive and non-consumptive water reuses totalling 100% of the WWTF effluent volume will be required.
- **Water Reuse Quality:** With future filtration and chlorination, the existing WWTF can meet the generally accepted highest standards for reuse water quality, providing maximum flexibility for supply not only to one proposed industrial user, but other potential customers as well.
- **Reuse Water Infrastructure:** There are three main infrastructure components for reuse water systems: treatment, storage, and distribution. The degree of treatment, storage volumes, and distribution methods are all dependent on the reuse water application.
- **Reuse Water Distribution:** The Municipality must evaluate the feasibility of distributing reuse water to new and existing developments through a purple water pipe network, truck fill stations, or a combination thereof. This should be completed in a Reuse Water Master Plan.

- **Application and Review Process for Water Reuse:** The overall process may be similar for residential and for commercial/industrial customers within Fort McMurray, including:
 - Application submission (proponent)
 - Application screening (Municipality)
 - Checklist review (Municipality)
 - Regulatory review (AESRD and Alberta Municipal Affairs)
 - Permit if approved (Municipality)
 - Detailed design, construction and commissioning (proponent)
 - Plan review and construction inspections, final permit
 - System operation up to property line (Municipality)

The process for outside industrial customers will be more complicated and will be situation specific:

- **Water Reuse Master Plan:** A much more detailed plan is required.
- **Stakeholders:** The major stakeholders for a comprehensive water reuse plan include the Municipality, private developers (commercial and residential), commercial and residential water users (the public), truckfill users, external users outside of the City (remote industrial), and outside approval agencies. Each need to know their responsibilities and understand/mitigate risks associated with water reuse.
- **Total Loadings:** Water reuse will reduce effluent discharge volumes and total loadings to the Athabasca River.

14 Recommendations

The main recommendation from this preliminary study is for the Municipality to prepare a comprehensive Water Reuse Master Plan with participation by key stakeholders. The plan should examine:

- Sources of reuse water
- Potential customers
- Their reuse water quantity and quality requirements
- Infrastructure requirements
- System reliability
- Costs
- Risks
- Implementation

TECHNICAL MEMORANDUM A.3.2.2/A.3.2.3

Closure

This report was prepared for the Regional Municipality of Wood Buffalo Wastewater Master Plan to evaluate the effluent reuse possibilities and effluent quality requirements for the existing and future wastewater treatment facilities.

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.



Jacqueline Mykytiuk, P.Eng.
Process Engineer



Patrick W. Given, P.Eng.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF

Signature: [Signature]
Date: March 10, 2014

APEGA Permit to Practice P 3979



Associated
Engineering

10000 100th Ave.
Edmonton, AB T5A 0A6

Appendix A – CMHC Greywater Reuse Demonstration Project Reports

Commissioning Guide for the Toronto Healthy Houses Water Systems

INTRODUCTION

The Commissioning Guide for the Toronto Healthy Houses Water Systems is the culmination of a series of reports prepared for Canada Mortgage and Housing Corporation by Blue Heron Environmental Technology. The series deals with the selection, design, regulatory approval and monitoring of the potable water supply and wastewater renovation systems for the Toronto Healthy Houses.

CMHC's Healthy House in the heart of the city of Toronto is one of the winners of CMHC's national Healthy Housing Design Competition to promote environmentally responsible housing. This project resulted in the building of two adjoining houses—one completely independent of municipal servicing and the other connected only to the electrical power grid. Both houses have completely independent, on-site potable water supply, wastewater reclamation and ground disposal systems.

Both houses use treated rainwater and melted snow that fall on their roofs and ground patios for drinking, food preparation and dishwashing. Through a separate plumbing system, reclaimed renovated wastewater supplies water for toilet flushing, bathing, showering, clothes washing and hot water heating.

To achieve water and energy conservation, the houses use low-flow toilets, water-conserving showerheads, taps and faucets, efficient dishwashers and clothes washers, and greywater heat utilization. Depending on the house, solar panels with a back-up co-generator or electricity from the municipal service heat the hot water.

DESCRIPTION OF THE PUBLICATION

The Commissioning Guide for the Toronto Healthy Houses Water Systems consists of three parts:

Part 1: Description of the Toronto Healthy Houses Water Systems;

Part 2: Operational Maintenance Considerations for the Toronto Healthy Houses Water Systems; and

Part 3: Toronto Healthy Houses Occupant Guidelines.

Part 1: Description of the Toronto Healthy Houses Water Systems

Part 1 provides a detailed overview, with accompanying photographs and schematics, of each component of the potable water, wastewater and renovated water-treatment systems. It includes the associated water and energy conservation features.

■ Potable water treatment

Potable water for each house is obtained from a groundwater collection system consisting of three roof surfaces, two ground patios, collection piping and a 20 m³ (4,400 gal.) concrete cistern. In the cistern, limestone imparts alkalinity to the collected water.

The total catchment area is about 80 m² (860 sq. ft.). The total roof area of approximately 55 m² (590 sq. ft.) is divided into a top flat area of 24 m² (258 sq. ft.) a back sloping area of 22 m² (237 sq. ft.) and a front sloping area of 9 m² (97 sq. ft.). (Conversions to imperial measurements are rounded up.)

Two landscaped patio areas covered with a textured concrete collect ground-level rainwater. The north side of the upper patio wall has a wall drainage system that directs groundwater to a collection drain terminating in a sump in the front yard.

Rainwater collected from eavestroughs and upper and lower patios is carried by pipes to the respective cistern inlet catch basin. A small

pump then directs the stored water to a combined slow sand activated carbon adsorber for filtration and ultraviolet disinfection.

The treated water is stored in a concrete tank beneath the basement floor. From there, it is pumped out on demand by a Grundfos “three-in-one” wall-mounted JetpaQ pumping system and re-disinfected for use at the potable water taps and in the dishwasher.

On sunny days, the water is heated by two lower glycol circulating solar panels located on the south side of the roof. On dull days, a separate heat exchanger connected to the stand-by cogenerator heats the hot water tank in the off-grid house. In the other house, electricity from the power grid heats the water when required. The hot water tank is located under the counter in the second floor bathroom.

■ Greywater heat recovery

In each house, the plumbing system includes two greywater heat recovery units. One unit recovers heat from the wastewater leaving the bathrooms (bath, shower and clothes washer). The second unit captures heat from the wastewater leaving the kitchen (sink and dishwasher). Up to 70 per cent of the energy in the greywater can be transferred to the supply water.

■ Wastewater treatment

The wastewater treatment component of the system consists of a septic tank, recirculation tank with biofilter feed pump, Waterloo Biofilter™ and treated wastewater ground disposal gravel pack.

The 3,600 l (800 gal.) precast concrete septic tank serves as a trash tank to retain grease, grit, oil and other objects that could clog the piping and equipment. It also provides primary treatment by settling organic and inorganic solids.

The effluent from the septic tank flows to a 2,000 l (440 gal.) recirculation tank located under the ground floor in the solarium/office area. The recirculation tank also receives effluent from the Waterloo Biofilter™ through a downward flowing valved inlet pipe. The mixture of effluents from the septic tank and the Waterloo Biofilter™ is pumped as feed to the Waterloo Biofilter™.

The recirculating Waterloo Biofilter™ with forced air ventilation provides secondary treatment. This aerobic biological process removes organic matter and effects nitrification. Some of the treated effluent (approximately 120 l/day) is then wasted to the ground disposal gravel pack located outside of the front wall of each house, depending on the liquid level of the recirculation tank.

■ Renovated water treatment

The renovated water-treatment system consists of twin combined slow sand filters and activated carbon adsorbers, ultraviolet irradiation disinfection, treated renovated-water storage and a renovated-water pressure distribution pump.

The treated Waterloo Biofilter™ effluent flows by gravity through the slow sand filter and activated carbon adsorbers. A second Trojan Aqua Advantage 5 Sterilizer then disinfects this renovated water in the same manner as the potable water.

The renovated water storage tank is underneath the ground floor beside the potable water storage tank. From here, a second Grundfos JQ2 “three-in-one” wallmounted JetpaQ pumping system supplies the renovated water to the house through a separate piping system for toilet flushing, bathing and clothes washing. It also supplies the hot water radiant-heating system as required.

Part 2: Operational Maintenance Considerations for the Toronto Healthy Houses Water Systems

Part 2 deals with operational and maintenance requirements as the systems are put into service. It provides initial operating instructions as given by the equipment manufacturers, as well as maintenance instructions taken from equipment owner guides. It recommends that the homeowners use qualified professionals to service some of the equipment.

This section of the guide also describes the operating procedures for the potable water, wastewater treatment, and renovated water systems. These include maintaining the water-collection facilities, filtering and backwash operations, checking the ultraviolet sensors, inspecting the potable water storage tank, cleaning the Waterloo Biofilter™ and other procedures.

Troubleshooting guides for the effluent pump system, the water sterilizer and the potable water and renovated water distribution pumps are also provided.

Part 3: Toronto Healthy Houses Occupant Guidelines

Part 3 provides advice for occupants of the Toronto Healthy Houses with respect to water use and protection of the biological water-treatment systems. It presents critical information on the lifestyles and household maintenance habits appropriate for living with self-sufficient potable and reclaimed water systems.

This section also emphasizes that occupants will have to change their lifestyles to develop the habits of conserving water and using appliances efficiently. In addition to providing examples of water conservation practices, it deals with drinking water safety and protecting the water systems from occupant abuse.

The following is a sample of some of the recommendations provided:

- Boil drinking water if there is ever any doubt about its safety.
- Refrain from using chemical household cleaners and other products that are toxic to human health or to the environment, or can harm the beneficial microorganisms in the system.
- Direct as many kitchen wastes as possible to a composter or garbage rather than washing them down the kitchen sink.
- Do not dispose of non-biodegradable substances down any drains.

The guide also identifies which commercial cleaners to avoid, suggests others that are safe to use, and recommends various homemade cleaning compounds. For outdoors, it recommends that the homeowners not use chemical sprays and pesticides to maintain the lawn and garden, and offers a list of non-chemical, environmentally friendly alternatives.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The Commissioning Guide for the Toronto Healthy Houses Water Systems offers a detailed technical examination of the operation and maintenance of the potable water supply and wastewater renovation systems for the Toronto Healthy Houses.

It will be useful to architects and mechanical and plumbing contractors interested in understanding or developing innovative approaches to conserving water supplies, reducing contamination of waterways and eliminating the need for urban infrastructure in the form of water and sewer systems.

CMHC Project Manager: Christopher Ives

CMHC contact: Cate Soroczan

Consultant: A. R. Townshend, Blue Heron Environmental Technology

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642

Fax: 1-800-245-9274

©2001, Canada Mortgage and Housing Corporation
Printed in Canada
Produced by CMHC
Revised: 2007

26-10-2007

Although this information product reflects housing experts' current knowledge, it is provided for general information purposes only. Any reliance or action taken based on the information, materials and techniques described are the responsibility of the user. Readers are advised to consult appropriate professional resources to determine what is safe and suitable in their particular case. Canada Mortgage and Housing Corporation assumes no responsibility for any consequence arising from use of the information, materials and techniques described.

Final Assessment of Conservation Co-op's Greywater System

INTRODUCTION

Before greywater treatment systems can become a common feature in residential buildings, field testing is essential. In fact, the National Building Code currently prohibits the use of these systems in residential buildings, except on an experimental basis. Their installation requires special permits and rigorous monitoring.

Conservation Co-op, centrally located in Ottawa, agreed to participate as a pilot demonstration site for a Canada Mortgage and Housing Corporation (CMHC) greywater treatment project. CMHC is interested in researching these systems to gain a better understanding of design and operational and maintenance needs, in order to encourage the adoption of water conservation technologies and practices in the residential sector. In addition to CMHC, the Municipality of Ottawa, the Ontario Ministry of Environment and Conservation Co-op staff and residents contributed to the project's undertaking.

Conservation Co-op, built in 1995, is a four-storey, 84-unit housing co-operative where residents are committed to environmentally sustainable practices. The co-op incorporated some unique features, such as a greywater treatment system and its monitoring equipment.

Greywater for this demonstration site is defined as water collected from the shower and bathtub. The building design allowed for eight units to be dual plumbed, which added separate greywater effluent pipes to deliver the greywater for treatment to the system in the basement. Return supply lines from the treatment system,

redirected the water back to the eight units as the water supply for toilet flushing. The water reuse plumbing system was active only when connected to the greywater treatment system. Otherwise, the toilets were supplied with water from the city.

In the summer of 1996, water meters were installed on the city water supply lines to the toilets to monitor water consumption for two months. This data and a literature review of greywater treatment technologies were used to select two treatment options—slow sand filter and rapid sand filter—for testing. The treatment facility was installed the following summer.

The pilot study was not as successful as anticipated. In 1999, a new treatment process was designed using a rapid pressure filter system, replacing the two filtration technologies tested in 1997. The treatment system was completed and commissioned for use in August 1999, but it immediately ran into a series of problems including failure of system pumps and a valve. The system was shut down, resulting in odour problems, scum and accidental ozone release. A review of the operation and treatment system was undertaken in December 2001 by NovaTec Consulting in order to recommend corrective action. The work included 1) a review of documentation, 2) interviews with key individuals involved in the design, installation and operation of the treatment system, and 3) site inspection of the treatment system. NovaTec Consulting's recommendations are reported in subsequent sections of this highlight.

THE GREYWATER TREATMENT SYSTEM AT CONSERVATION CO-OP

Residential wastewater is commonly grouped into three classifications:

1. blackwater—from toilets;
2. dark greywater—from kitchen sinks, clothes washers and dishwashers;
3. light greywater—from showers, tubs and bathroom sinks.

In designing or selecting effective treatment processes for any of these, it is important to recognize that all three contain significant quantities of contaminants. They therefore require all of the following treatments:

1. screening and settling to remove solids;
2. flotation and skimming to remove oils, grease, fats and scum;
3. growth of beneficial bacteria under controlled conditions to remove soluble organic compounds;
4. disinfection to kill pathogens (bacteria, viruses and parasites).

Conservation Co-op's treatment system consisted of the following key components (see Figure 1):

- *screening* - Basket screens (1 mm mesh), located at the top of each of the two equalization sedimentation tanks, trapped hair, lint and other large particles. Sodium hypochlorite pucks were used to control odours and biofouling in the filter.
- *raw water equalization* - sedimentation tanks 1 and 2 - The two large tanks removed floating oils and scum, and settled solids, and provided initial disinfection. The tanks, which had a retention time of 6 to 12 hours, filled and were pumped out on an alternating basis. The waste from this process (about 50 litres per cycle) was automatically discharged to a sewer line through a sump after each fill-draw cycle was complete.

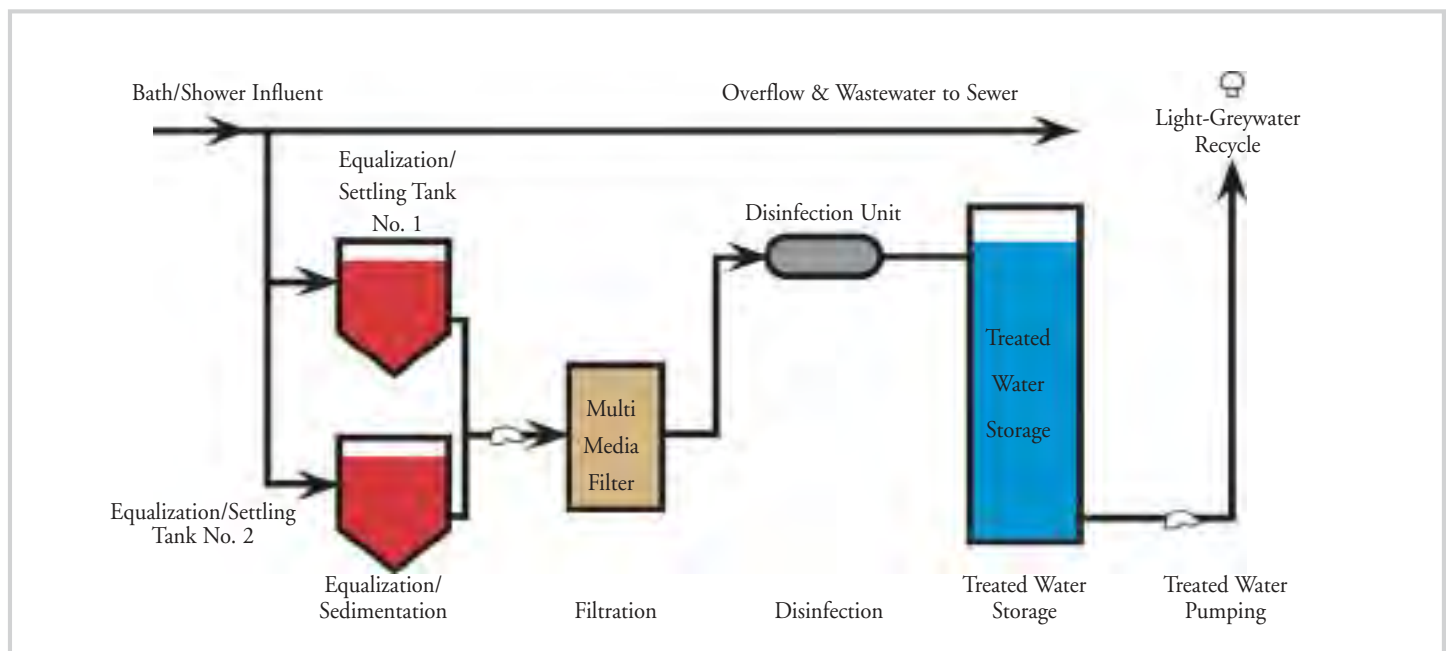


Figure 1 Diagram of Conservation Co-op's greywater treatment system

- *transfer pump* - A small pump transferred liquid from the two raw water tanks through a multimedia pressure filter. With a design flow rate of 0.33 litres per second, it took approximately 15 minutes to pump the contents of each tank through the multimedia filter.
- *multimedia pressure filter* - As the raw water moved through the filter, it passed through decreasing sizes of granular media (anthracite, fine sand, garnet and limestone), which filtered out particulate material. Solids trapped in the filter were removed during an automatic backwash cycle. The filters used, though, were more common in potable water treatment systems for filtering particulates, and they did not remove soluble organic (biochemical oxygen demand, or BOD) compounds.
- *ozonation* - After filtration, the water was injected with ozone to provide further disinfection, remove colour and break down organic chemicals in the water.
- *treated water tank* - The filtered and ozonated greywater was then stored in a 600 litre volume plastic tank. A distribution pump transferred water from this tank into the distribution pipe to the toilets. If the greywater treatment system was unable to keep up with the demand for reused water, additional make-up water was automatically supplied to the tank from a potable (city) water line.
- *distribution pump* - When a toilet was flushed, the resulting drop in water pressure within the distribution system was sensed, and a 0.75 hp distribution pump was activated to provide reused water to the toilet. Although the pump might have been able to supply adequate pressure and flow of water to a single toilet, it could not adequately meet the demands of multiple toilets flushing simultaneously, hence the need for residents to flush toilets repeatedly. This pump may have been the source of “banging” noises reported by the residents.

FINDINGS

Biochemical oxygen demand (BOD) is an indicator of the organic “strength” of wastewater. It represents the amount of oxygen bacteria consumes over a five-day period. Although the monitoring data for Conservation Co-op demonstrated that its greywater had a significant BOD—an average of 130 mg/L (equivalent to low-strength domestic wastewater)—the treatment processes did not appear to take this into consideration. As a result, bacteria grew within the treatment system tanks, the distribution pipe and toilets. In the absence of a supplied oxygen source, bacteria quickly depletes any available oxygen in solution, creating anaerobic conditions within a storage tank and a distribution system. This was the cause of foul odours and black particles (clusters of bacteria) noted by residents. Bacteria could also be expected to grow on the surfaces of toilet tanks and bowls, increasing the need for frequent bowl cleaning.

Although an intermittent sand filter (ISF) can effectively remove BOD from wastewater, the slow sand filter and rapid sand filters tested in this project were ineffective for this purpose. They are more appropriate for filtering particulate material in potable water treatment applications. The multimedia pressure filter installed as part of the final treatment system was even less likely to reduce BOD.

The incorporation of a properly designed pressure tank to supply reused water to the distribution system could improve the effectiveness of toilet flushing and reduce the potential for noise. A pressure tank is a common component of domestic (potable) well water systems. A rubber bladder within the pressure tank provides a larger reservoir of pressurized water (i.e., more uniform pressure and flow) than could be achieved using the distribution pump and pipe alone. Furthermore, the storage capacity of the pressure tank bladder requires less frequent pumping, and hence reduces operation noise.

RECOMMENDATIONS AND OUTCOME

NovaTec recommended the following remedial measures to improve system performance and address the problems observed with the treatment system:

1. Add a biological treatment component to the process, in place of the multimedia filter, to reduce BOD concentration from 130 mg/L to less than 10 mg/L. NovaTec recommended an Orenco AdvanTex AX10 treatment system, given the restricted area available for biological treatment. This system is unique in terms of its small size (8' x 6' room) and simplicity of operation, in comparison to more conventional methods of biological treatment.
2. Add a pressure tank to the system to provide water to the reuse water distribution system. The existing distribution pump would transfer water from the treated water tank to the pressure tank, which would be sized to provide adequate flow/pressure to accommodate up to six toilets flushed simultaneously. The pressure tank would also significantly reduce or effectively eliminate any "banging" noise.
3. Replace the ozonation system with either a secondary chlorination or ultraviolet disinfection system to ensure that faecal coliform levels in the treated water are less than 2.2 MPN/100 mL (i.e., non-detectable). This would eliminate the hazardous conditions associated with ozone being ventilated into an equipment room or a basement area. While a chlorination system is less expensive and simpler to operate and maintain than an ultraviolet disinfection system, it may be less acceptable, as the smell of chlorine may be objectionable to some people.
4. Relocate the treatment system to an alternative location within the basement area. The limited area and ceiling height within the existing treatment room cannot accommodate the recommended treatment modifications. The existing raw greywater settling-equalization tanks would remain in the existing equipment room, as these tanks are conveniently connected to a sump, and it would be difficult to extend the greywater drainage pipe to the proposed new area for treatment. Relocation would require extensive plumbing and electrical/ control modifications.

One of the disadvantages of most biological treatment systems is that they generally require frequent operator attention as they generate significant quantities of bacteria that must be periodically removed and disposed of. Consequently, they are typically installed outside to provide more convenient access for solids removal.

The recommended AdvanTex AX10 treatment system is a biological filtration system that has been shown to generate a minimal amount of biosolids (waste bacteria) in comparison to other more conventional secondary treatment technologies. The recirculation tank and filter require little operator attention other than routine weekly visual inspection. The only mechanical component is a recirculation pump, which is connected to a control and alarm system. Accumulated biosolids would need to be pumped into the sewer system, about once every six months or less frequently.

The ultraviolet disinfection system requires routine monitoring and, most likely, weekly cleaning of the quartz tubing, which is a simple procedure requiring only 5 to 10 minutes.

The raw water equalization and treated water tanks should be inspected weekly, and they might require periodic cleaning to clear any potential bacterial or scum build-up along the walls.

The proposed changes to the treatment system were costed at \$40,000, plus applicable taxes. This included the cost of supplying and installing the recommended biological treatment process, pressure tank and new water storage tank; relocating equipment to a new area of the basement; providing the necessary plumbing and power to the new area; and an allowance for engineering and overseeing equipment installation and commissioning.

Operating costs were expected to increase by about \$70 per year for the biological treatment process and about \$300 per year for the optional ultraviolet disinfection system. Overall, the changes were expected to decrease maintenance requirements from the original system, but requiring more maintenance than a building with standard plumbing.

In the end, Conservation Co-op decided against having a treatment system for the time being. In part, the Co-op was concerned about replacement parts and costs. As well, the system required a greater amount of time than anticipated for ongoing maintenance, about two hours every week, as opposed to the previously assumed two or three hours per month. The project also revealed that initial training of maintenance staff was insufficient, with considerably more time needing to be devoted to this system.

CONCLUSION

The project at Conservation Co-op demonstrated a need for a more foolproof, less expensive, and low maintenance residential greywater treatment system. It underscored the need for more extensive maintenance training and the importance of not underestimating the time required for ongoing maintenance. In terms of a financial return on investment, this project showed that it may be more appropriate, at least in a research setting, to pursue the use of these systems where many more residential units are involved.

In short, Conservation Co-op helped identify a number of barriers that need to be overcome regarding domestic greywater treatment systems. These barriers are a combination of technology (suitable to do the job with no noise, easy installation and no smells or other problems), cost (purchase and replacement) and maintenance requirements.

With new, less expensive and better technologies continuing to emerge for greywater treatment, other systems with potential for residential use will soon be available for testing.

Research Highlight

Final Assessment of Conservation Co-op's Greywater System

The following Technical Series Research Highlights available on CMHC's website offer additional information related to greywater systems and Conservation Co-op:

- 01-112 Advancing the "Light Grey Option":
Making Residential Greywater Reuse Happen
- 01-115 Commissioning Guide for the Toronto
Healthy Houses Water Systems
- 00-140 Compendium of Research on the
Conservation Co-op Building

CMHC Project Manager: Sandra Baynes

Research Consultant: Troy D. Vassos,
NovaTec Consultants Inc.

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642

Fax: 1-800-245-9274

©2002, Canada Mortgage and Housing Corporation
Printed in Canada
Produced by CMHC
Revised: 2006

08-12-06

Although this information product reflects housing experts' current knowledge, it is provided for general information purposes only. Any reliance or action taken based on the information, materials and techniques described are the responsibility of the user. Readers are advised to consult appropriate professional resources to determine what is safe and suitable in their particular case. Canada Mortgage and Housing Corporation assumes no responsibility for any consequence arising from use of the information, materials and techniques described.



CANADA MORTGAGE AND HOUSING CORPORATION

Business / Government / Housing Organizations

Quayside Village

West Vancouver, British Columbia



Situation:

The Quayside Village Co-Housing Ltd. building is a 20-unit apartment building in which renovated grey water will be reused for toilet flushing. The demonstration wastewater renovation and reuse system has been installed, and will be monitored, with the financial assistance of Canada Housing and Mortgage Corporation (CMHC). The building is located in an area where municipal water and wastewater services are available. Design water demand is about 20,000 L/day.

Motivation

This project is intended to:

- provide a showcase for residential wastewater reuse technology,
- demonstrate grey water reuse in a multi-unit residential building, and
- apply and adapt technology developed in CMHC's Toronto Healthy House project to a multi-unit residential building.

Description of Technology

The current demonstration will focus on reuse of light and dark grey water from all fixtures except toilets for reuse in toilets only.

Quayside Village is double-plumbed throughout to permit recycling to showers if advisable in the future.

The wastewater renovation system, based on that developed for the Healthy House (which recycles all wastewater for all non-potable uses), includes a settling tank, filtration tank, biofilter, pre-ozonation, multi-stage sand filtration, and ozonation.

Wastewater from toilets that is not renovated, and excess from the treatment system, discharge to the municipal sewer. A connection to the municipal water system, protected by backflow prevention devices, provides a back-up supply if the reuse system malfunctions or water use exceeds the renovated water supply.

Operation, maintenance, and on-line monitoring will be the responsibility of the developer. An independent engineering firm will perform inspections, monitoring, sampling, testing and reporting related to performance evaluation.

Costs

Capital cost of the equipment was approximately \$115,000. Estimated maintenance cost is \$100 per month.

Benefits

Benefits expected to be demonstrated by this project are:

- availability of an alternative approach to water supply and wastewater servicing for multi-unit residential buildings, which may have applications in situations where conventional services are unavailable, expensive, or raise environmental concerns, and specifically
- reduction of water demand, and associated water supply costs, of about 40%, and reduction in wastewater flows of about 40%, with associated reductions in the size and cost of an on-site wastewater treatment and disposal system.



Appendix B – Direct Potable Reuse Example

Water for Texas

Water Reuse

Water reuse is the practice of using water that has already been used. The terms “reclaimed water,” “reused water,” and “recycled water” are used interchangeably in the water industry. As defined in Texas Administrative Code Title 30 § 210.3, reclaimed water is “domestic or municipal wastewater which has been treated to a quality suitable for a beneficial use.” Reclaimed water is not the same as graywater, which is untreated household water from sinks, showers, and baths.

Types of Water Reuse

There are two major types of water reuse: direct reuse and indirect reuse. **Direct reuse** refers to the introduction of reclaimed water via pipelines, storage tanks, and other necessary infrastructure directly from a water reclamation plant to a distribution system. For example, treating wastewater and then piping it to an industrial center or a golf course for use would be considered direct reuse. **Indirect reuse** is the use of water, usually treated effluent, which is placed back into a water supply source such as a lake, river, or aquifer and then retrieved to be used again. Indirect reuse projects that involve a watercourse require a bed and banks permit from the state, which authorizes the permit holder to convey and subsequently divert water.

Both direct and indirect reuse can be applied to potable (suitable for drinking) and non-potable (suitable for uses other than drinking) purposes. As a result, water reuse is categorized into four classes:

Direct potable reuse refers to the use of reclaimed water that is piped directly from a wastewater treatment facility to a drinking water treatment and distribution system. The Texas Commission on Environmental Quality has not yet developed a rule for implementing direct potable reuse in the state.

Indirect potable reuse refers to the use of reclaimed water to augment drinking water supplies by discharging to a water body that is subsequently treated for potable consumption.

Direct non-potable reuse refers to the use of reclaimed water that is piped directly from a wastewater treatment facility to a site for non-potable beneficial uses such as landscape irrigation, power plant cooling, and manufacturing.

Indirect non-potable reuse refers to the use of reclaimed water for non-potable purposes by discharging to a water body that is a supply source for non-potable uses, such as golf course irrigation.

Texas Administrative Code Title 30 § 210.3 further categorizes reclaimed water into Type I and Type II uses. Type I use includes applications where the public may come in contact with the reclaimed water. Type II use includes applications where the public would not come in contact with the reclaimed water. 30 Texas Administrative Code Chapter 210 provides water quality standards for both types.

Regulations for Water Reuse

Federal Regulations

A water reuse project that involves discharge to waters of the United States must comply with federal and state requirements pursuant to the Clean Water Act. If applicable, water reuse projects must also comply with the requirements of the Safe Drinking Water Act, which ensures the quality of U.S. drinking water.

State Regulations

In Texas, the use of reclaimed water is regulated by Texas Administrative Code Title 30 § 210 and § 321, Subchapter P, and Texas Water Code § 26.0271. These regulations establish quality, design, and operational requirements for the beneficial use of reclaimed water.

Uses of Reclaimed Water

Reclaimed water is used in Texas for various purposes. The major applications of reclaimed water include (1) urban uses such as golf course irrigation, dust control, fire protection, toilet and urinal flushing, and landscape irrigation; (2) industrial uses including plant wash down, processing water, and cooling water supplies; (3) recreational uses such as developing and maintaining decorative ponds, lakes, and fountains; (4) agricultural uses such as irrigation; (5) groundwater recharge; and (6) surface water augmentation for potable reuse.

Water Reuse as a Water Management Strategy in the 2012 State Water Plan

Texas Water Code § 16.053(e)(5)(C) requires regional water planning groups to consider reuse of existing water supplies as a potentially feasible water management strategy. The 2012 State Water Plan estimates that existing supply from water reuse is projected to produce about 614,000 acre-feet of water per year by 2060. This supply would be increased to 1.5 million acre-feet per year if additional recommended water management strategies for reuse are implemented by 2060.

Major Water Reuse Projects in Texas

In the past few decades, several major water reuse projects have been implemented in Texas including the following: City of Abilene's Lake Fort Phantom Hill project, Tarrant Regional Water District's constructed wetland project, Cleburne's water reclamation project for power plant cooling water, and San Antonio Water System's recycled water project.

Currently, the Colorado River Municipal Water District and the City of Brownwood are developing direct potable water reuse projects. The Colorado River Municipal Water District will reclaim the wastewater effluent from the City of Big Spring, process it using advanced treatment technology, and produce approximately 1.8 million gallons per day of raw water that will be blended with other raw water from surface water reservoirs.

The City of Brownwood plans to process its wastewater effluent to produce approximately 1.5 million gallons of water per day that will be added to the water distribution system.

Assessing the potential for direct potable reuse

In 2011, TWDB published a three-part report documenting the history of water reuse in Texas, the current state of water reuse technologies, challenges confronting the practice of water reuse, and future research needed to advance water reuse in Texas.

In 2012, TWDB funded a study to assess the potential for direct potable reuse in Texas. The study will develop a resource document that can assist in planning future direct potable reuse projects in the state.

More information about the projects is available at <http://www.twdb.texas.gov/innovativewater/reuse/projects.asp>.

Funding for Water Reuse Programs

The TWDB has several funding programs in place that can be used for implementing water reuse projects, including the Clean Water State Revolving Fund, the Water Infrastructure Fund, the State Participation Program, Rural Water Assistance Fund, Texas Water Development Fund II (Financial Assistance Account) and the Water Research Grant program. Other potential funding sources for water reuse projects include the Bureau of Reclamation, the U.S. Environmental Protection Agency, the WaterReuse Foundation, the Water Research Foundation, and the Water Environment Research Foundation.

More Information

More information on TWDB's water reuse activities is available at

<http://www.twdb.texas.gov/innovativewater/reuse/> or by contacting Erika Mancha at erika.mancha@twdb.texas.gov or (512) 463-7932.



TECHNICAL MEMORANDUM A.3.3.2

Regional Municipality of Wood Buffalo

Wastewater Master Plan

Total Loadings Plan



June 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo Wastewater Master Plan. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE/PURPOSE

The main objective of Technical Memorandum A.3.3.2, Total Loadings Plan, is to develop an initial Total Loadings Plan (TLP) for the Regional Municipality of Wood Buffalo's (Municipality) urban area within Fort McMurray. As indicated in the existing WWTF Approval, the plan is required for Alberta Environment and Sustainable Resource Development's (AESRD) approval prior to July 1, 2015. This initial draft plan includes:

- Summary of receiving water baseline assessment data.
- Fort McMurray Wastewater Treatment Facility (WWTF) load and concentration impacts due to discharge to receiving waters.
- Preliminary estimates of snow melting and stormwater discharge data.

This initial draft of the TLP is limited to three key water quality parameters: Total Suspended Solids (TSS), Total Phosphorus (TP), and Ammonia Nitrogen (NH₃-N).

2 MAIN FINDINGS

The main findings of this work are summarized as follows:

Athabasca River Upstream of Fort McMurray:

- River Flows:
 - Average river flow for low flow month (February): 106 m³/s
 - Average annual river flow: 496 m³/s
- River Water Quality (key parameters):

Parameter	February Average/Median	Annual Average/Median
TSS	2.4/1	61/6
TP	0.028/0.023	0.062/0.029
NH ₃ -N	0.060/0.029	0.039/0.070

Total Load Impacts on River Water Quality at Low River Flows:

- The 25-year (2038) projections show the following estimated water quality impacts from the sanitary effluent discharges on the Athabasca River during low river flow conditions (typically February):

Regional Municipality of Wood Buffalo Wastewater Master Plan

Parameter	Water Quality Guideline	Upstream River	Downstream River	% Increase
TSS	≤ 10 mg/L increase over background value	2.38	2.44	2.4%
TP	0.050 mg/L	0.028	0.031	9.1%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0	0.060	0.093	55.8%

- Although the NH₃-N concentrations indicate a 56% increase above typical February upstream river concentrations, the downstream concentrations remain well below AESRD's chronic water quality guideline (0.093 mg/L or <5% of the 1.92 mg/L limit).

Total Load Impacts on River Water Quality at Annual Average River Flows:

- The 25-year (2038) projections show the following estimated water quality impacts from the sanitary effluent and stormwater discharges on the Athabasca River during average annual river flow conditions:

Parameter	Water Quality Guideline	Upstream River	Downstream River	% Increase
TSS	≤ 10 mg/L increase over background value	117.4	117.2	-0.1%
TP	0.05 mg/L	0.0973	0.0976	0.3%
NH ₃ -N	0.715 mg/L at 15°C and pH 8.0	0.0359	0.0375	4.3%

The estimated water quality impacts of the combined sanitary and stormwater discharges on an average annual basis are much less evident mainly because of greater dilution. It is noted that the downstream TP limit is exceeded because the upstream concentration already exceeded the water quality guideline.

3 NEXT STEPS

The following summarizes the proposed interim TLP:

- | | |
|---|---------------|
| • Finalize the draft TLP following the Municipality's feedback | December 2013 |
| • Submit stormwater and snow dump site monitoring plan for approval | December 2013 |
| • Submit draft TLP to AESRD for review | June 2014 |
| • Review meeting with AESRD | July 2014 |
| • Monitor stormwater and snow melt sites | 2014 – 2015 |
| • Update TLP with data from additional monitoring | May 2015 |
| • Submit updated plan to AESRD | June 2015 |

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	v
List of Figures	vi
1 Introduction	1
2 Background	2
2.1 Discharge Locations	2
2.2 Approval Requirement	2
2.3 Operations Plan	2
2.4 Previous Studies	3
2.5 River Water Quality Objectives	3
3 Athabasca River at Fort McMurray	5
3.1 Historical Flow Records	5
3.2 Key Water Quality Parameters – Concentrations	6
3.3 Municipality's River Monitoring	7
3.4 River Loads	8
4 Sanitary System	8
4.1 Wastewater Effluent Flows – Current and Projected	8
4.2 Key Wastewater Effluent Quality Parameters – Concentrations	8
4.3 Effluent Loads – Current and Projected	9
5 Stormwater System	10
5.1 Current and Proposed Systems	10
5.2 Flows – Current and Projected	10
5.3 Key Stormwater Effluent Quality Parameters	10
6 Snow Storage Sites	11
6.1 Flows – Current and Projected	11
6.2 Key Snow Melt Effluent Quality Parameters	11
7 Combined Discharges During Storm Events	12
7.1 Flows – Current and Projected	12
7.2 Loads – Current and Projected	12

Regional Municipality of Wood Buffalo Wastewater Master Plan

8	River Water Quality Impacts	14
8.1	Winter Low Flow Period Loads	14
8.2	Annual Average Loads	14
8.3	Estimated River Water Quality Impacts – Winter Low Flow Period	17
8.4	Estimated River Water Quality Impacts – Average Annual	17
9	Need for Treatment Improvements	19
10	Proposed Interim Total Loadings Plan	19
Closure		
Appendix A – River Load Calculation Protocol		
Appendix B – River Water Quality Monitoring Protocol and Preliminary Data		
Appendix C – Stormwater Outfalls in the Fort McMurray Urban Area		
Appendix D – Dickensfield Snow Disposal Site, Fort McMurray		

List of Tables

	PAGE NO.
Table 2-1 Summary of Surface Water Quality Guidelines (mg/L except pH units)	4
Table 3-1 Athabasca River Water Quality (mg/L) Upstream of Fort McMurray	7
Table 3-2 Athabasca River Loads (kg/d) Upstream of Fort McMurray	8
Table 4-1 Fort McMurray WWTF Effluent Quality 2010 to Mid-2013 (mg/L)	8
Table 4-2 Fort McMurray Wastewater Effluent Quality (mg/L) Assumptions for Loading Properties	9
Table 4-3 Estimated Loads from Fort McMurray WWTFs (kg/d)	9
Table 5-1 Annual Stormwater Loading Assumptions (kg/ha)	11
Table 7-1 Estimated Total Average Daily Flows from Fort McMurray's Treated Wastewater Effluent, Stormwater and Snow Storage Sites (MLD)	12
Table 7-2 Estimated Total Loads from Fort McMurray's Treated Wastewater Effluent, Stormwater and Snow Storage Systems (kg/d)	13
Table 8-1 Current and Projected River Loads (kg/d) at Fort McMurray During Typical Low River Flow Conditions (February)	14
Table 8-2 Current and Projected River Loads (kg/d) at Fort McMurray During Annual Average River Flow Conditions	15
Table 8-3 Estimated Average River Water Quality Impacts (mg/L) During Typical Low River Flow Conditions (February)	17
Table 8-4 Projected Annual Average River Concentrations (mg/L) Due to Fort McMurray Effluent Discharges	18

List of Figures

	PAGE NO.
Figure 3-1 Corrected Average Monthly Flow of the Athabasca River	6
Figure 8-1 Estimated Wastewater Effluent Load Impacts	16

1 Introduction

The main objective of Technical Memorandum A.3.3.2, Total Loadings Plan, is to develop an initial Total Loadings Plan (TLP) for the Regional Municipality of Wood Buffalo's (Municipality) urban area within Fort McMurray.

The plan is to be developed with input from various other tasks and projects. The Receiving Stream Water Quality Monitoring task of the South Regional Wastewater Treatment Facility (WWTF) predesign work developed the baseline water quality for the Athabasca and Clearwater Rivers. Wastewater treatment point source discharge loadings will be used together with snow melting and stormwater discharge quality data generated in other tasks as part of the Wastewater Master Plan project or the South Regional WWTF project.

The information generated in TM 1.3 (Influent Waste Streams) will form the basis to evaluate the impact of the wastewater treatment facility discharge on the river quality with regards to concentration and load increases. The TLP will include the River Load Calculation Protocol requirement of the Fort McMurray WWTF Operations Plan (Item 4.1.7 (e) of the Operations Plan).

This task includes:

- Summarize receiving water baseline assessment data as required for defined service area.
- Determine WWTF load and concentration impacts due to discharge to receiving waters.
- Prepare an initial Total Loadings Plan as required in the existing WWTF Approval.
- Summarize findings and recommendations in a Technical Memorandum.

Since not all required information was readily attainable, a number of assumptions are made in developing this initial plan, specifically:

- Load estimates will be limited to:
 - Total suspended solids (TSS)
 - Total phosphorus (TP)
 - Total Ammonia Nitrogen (abbreviated $\text{NH}_3\text{-N}$, comprised of ionized ammonia (NH_4^+) and un-ionized ammonia (NH_3) expressed as Nitrogen, N)
- Loads of interest:
 - Total annual loads based on actual or expected effluent quality
 - Loads during typical low river flow conditions (e.g. February)
 - Load increases based on concentrations after complete mixing.
- Projected loads based on current conditions and medium 4% annual linear increase (paralleling population growth) over 20 years.

2 Background

2.1 DISCHARGE LOCATIONS

Appendix C maps show the Fort McMurray area with the Athabasca River, main tributaries, the Fort McMurray WWTF outfall, the proposed future South Regional WWTF, and the stormwater outfalls.

2.2 APPROVAL REQUIREMENT

Alberta Environment and Sustainable Resource Development (AESRD) issued Approval No. 889-02-00 (effective February 25, 2009 to January 31, 2019) for:

“Construction, operation and reclamation of a Class IV wastewater treatment plant and a Class IV wastewater collection system, a storm drainage system and snow storage facilities for the City of Fort McMurray.”

Section 4.2 of the Approval, sub-section “**Total Loadings Plan**” includes:

- “4.2.6 The approval holder shall develop a Total Loadings Plan to the Director by July 1, 2015 and receive a letter of acceptance.
- 4.2.7 The approval holder shall implement the Total Loadings Plan as authorized in writing by the Director.”

Associated Engineering (AE) informally reviewed the proposed scope of the Total Loadings Plan (TLP) with AESRD on September 30, 2013.¹ The following summarizes the main discussion points:

- The plan will address WW effluent, stormwater effluent, and snow storage sites.
- Look at current, as well as 25-year projections.
- Parameters: TSS, TP, and NH₃-N.
- Evaluate loadings during low flow conditions as well as annual loadings.
- Use actual effluent water quality data, not regulatory limits.

2.3 OPERATIONS PLAN

Appendix A contains the Municipality’s “River Load Calculation Protocol”. The protocol indicates the Municipality’s goal is to establish a database during the approval period (2009-2019) for cBOD, TSS, TP, NH₃-N, NO₂+NO₃-N, and free and combined chlorine, if present.

¹ Telephone communication with Terence Ko.

2.4 PREVIOUS STUDIES

As part of the planning for the proposed South Regional Wastewater Treatment Facility (SRWWTF), AE prepared Technical Memorandum #3, Receiving Water Quality Monitoring Past/Present/Future in April 2013.

The report highlights, relevant to this TM, are summarized as follows:

- Athabasca River flow data were presented; the data were “corrected” by subtracting the Clearwater River flows from the downstream Athabasca River flows to reflect expected river flows at the proposed SRWWTF outfall site.
- Athabasca River water quality data for two sites a short distance upstream of Fort McMurray were amalgamated, summarized, and compared with Canadian Council of Ministers for the Environment (CCME) and AESRD’s chronic guidelines for the protection of aquatic life. Identified constituents of possible concern included:
 - Total phosphorus: Mean of 0.062 mg/L and upper quartile of 0.075 mg/L, both exceeded AESRD’s Chronic Guideline of 0.05 mg/L.
 - Aluminum: Median 0.24 mg/L exceeded CCME’s Guideline of 0.1 mg/L.
- Dilution ratio (204:1) was calculated, based on a projected wastewater flow of 45 ML/d and the average corrected flow (106 m³/s) in the lowest month (February), assuming all treated effluent is discharged at one location. It was also noted that the dilution ratio in September was much larger (2,300:1).

2.5 RIVER WATER QUALITY OBJECTIVES

On the next page, Table 2-1 summarizes published surface water quality guidelines.

Regional Municipality of Wood Buffalo Wastewater Master Plan

**Table 2-1
Summary of Surface Water Quality Guidelines (mg/L except pH units)**

Parameter	CCME ¹	AENV-Chronic ²
Ammonia (as NH ₃)	pH and Temperature dependent (for pH 8, guideline is 2.33 mg/L at 0°C & 0.715 mg/L at 15°C)	—
Ammonia (as N)	for pH 8, guideline is 1.92 mg/L at 0°C & 0.589 mg/L at 15°C	—
Dissolved Oxygen	cold water biota: early life stages = min. 9.5 mg/L; for cold water biota: other life stages = min. 6.5 mg/L	6.5 (7 Day Mean)
Nitrate	13	—
Nitrite	0.197	—
Nitrogen Total	—	1.0
Phosphorus Total	Range from Ultra-oligotrophic through to Hyper-eutrophic	0.05
pH	6.5 to 9.0	6.5-8.5 not altered more than 0.5
Total Suspended Solids	—	≤ 10 mg/L increase over background value
Turbidity	Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 & 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.	—
Water Temperature	≤ maximum weekly temperature	≤3°C increase above ambient water temperature
Aluminum	0.100	—
Arsenic	0.005	—
Boron	1.5	—
Copper	Varies with hardness - 0.0026 at 110 mg/L hardness	0.007
Lead	<i>Varies with hardness</i> - 0.0036 mg/L at 110 mg/L hardness	—
Mercury	0.000026	0.000005
Molybdenum	0.073	—
Nickel	<i>Varies with hardness</i> - 0.103 mg/L at 110 mg/L hardness	—
Silver	0.0001	—
Iron	0.300	—
Zinc	0.03	—

Notes:

1. CCME: Canadian Council of the Ministers of the Environment Guidelines for the Protection of Aquatic Life.
2. AENV- Alberta Environment Assurance Division, Science and Standards Branch. 1999. Guidelines for the Protection of Freshwater Aquatic Life.

3 Athabasca River at Fort McMurray

3.1 HISTORICAL FLOW RECORDS

The following information is taken verbatim from Technical Memorandum #3, Receiving Water Quality Monitoring Past/Present/Future, April 2013:

“WSC² has several active hydrometric (stream-flow monitoring) stations in the Fort McMurray area including stations on the Athabasca and Clearwater Rivers. The closest station on the Athabasca River is located below Fort McMurray (Station No. 07DA001). This station has records from seasonal monitoring in 1957 and continuous monitoring from 1958 to 2012. However, this station is below the confluence of the Horse and Clearwater Rivers while the point of discharge for the SWWTF³ is proposed to be to the Athabasca River upstream of the confluence of these rivers. To correct for input from the Clearwater River, flow data from the active WSC hydrometric station on the Clearwater River near the mouth (Station No. 07CD001; monitored from 1930 to 2011) was subtracted from the flow data from Station No. 07DA001 data. Hereafter the flow at the proposed discharge location is referred to as the “Corrected Flow”.

No correction for the inflow from the Horse River was completed as its drainage area is approximately 2,157 km² (RAMP 2012), which is 1.6% of the total drainage area of the Athabasca River basin. It likely contributes a relatively small component of the Athabasca River flow, and therefore the Horse River is not discussed further in this initial baseline data review. In addition, since the confluence is just downstream from the proposed discharge point, the Horse River flow would contribute to the dilution of the treated effluent.

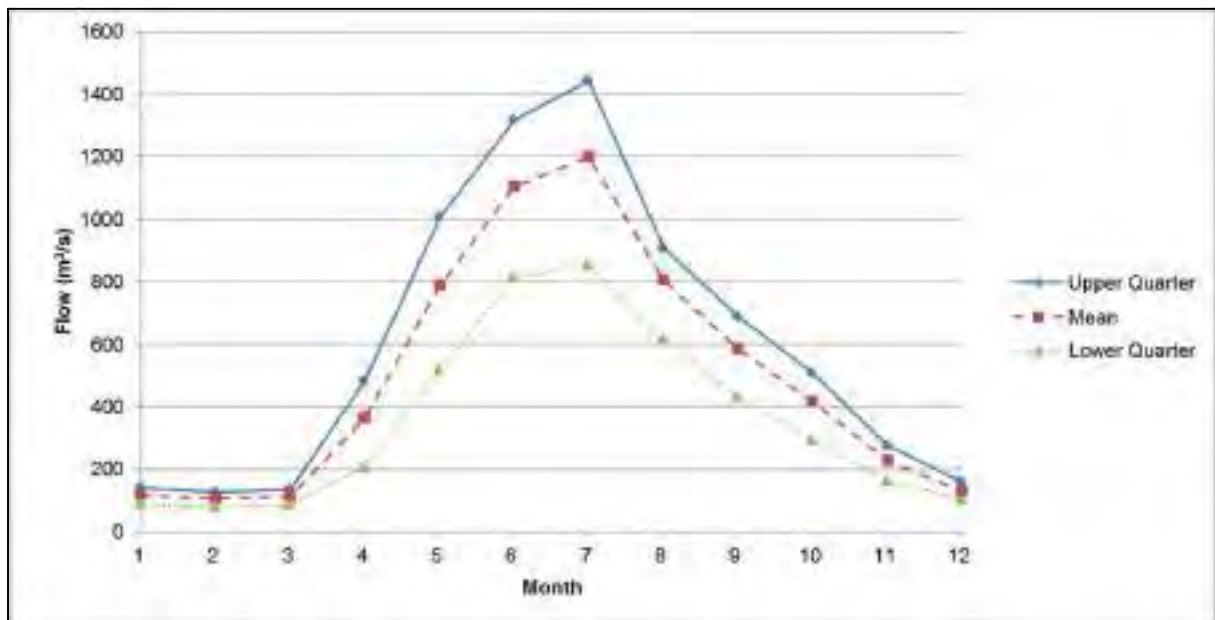
The effective drainage area for the Athabasca River at Fort McMurray (Station no. 07DA001) is 132,585 km² (RAMP 2012) and for the Clearwater River at Draper (Station No. 07CD001) is 30,800 km². The corrected flow rates for the Athabasca River are presented in an annual hydrograph showing the average, 25th percentile, and 75th percentile monthly flows (Figure 1).⁴ The hydrologic regime of the Athabasca River is dominated by snowmelt processes and the flow is highly seasonal. The proposed discharge site has low flows during the winter (average lowest flow month being February at 106 m³/s) and high flows during the summer (average highest flow month being July at 1,198 m³/s; WSC 2012).”

² Water Survey of Canada

³ South Wastewater Treatment Facility, also referred to as South Regional WWTF

⁴ Reproduced as Figure 3-1 on the next page.

Figure 3-1
Corrected Average Monthly Flow of the Athabasca River
(WSC Station No. 07DA001 Data minus WSC Station No. 07CD001 Data)



The above information focused on river flows at the site of the proposed SRWWTF. It should be noted, however, that the proposed SRWWTF is currently on hold. Nevertheless, AE proposes to use the same information as it will result in a conservative estimate of percentage load increases. Some of the stormwater outfalls discharge upstream of the Clearwater River as well, so the analysis will be simplified by assuming all discharges are upstream of the Clearwater River.

Further analysis of the information showed the following flow conditions upon which loading calculations will be based:

- Average river flow for low flow month (February): 106 m³/s
- Average annual river flow: 496 m³/s

3.2 KEY WATER QUALITY PARAMETERS – CONCENTRATIONS

We are limiting this initial TLP development to the three water quality parameters identified in Section 1:

- TSS
- TP
- NH₃-N

In future, other water quality parameters may be included in the plan.

The objective concentrations of these constituents, upon complete mixing in the Athabasca River, are as per Table 2-1 surface water quality objectives:

- TSS: ≤ 10 mg/L increase over background value
- TP: 0.05 mg/L
- $\text{NH}_3\text{-N}$: 1.92 mg/L at 0°C and 0.589 mg/L at 15°C

Table 3-1 summarizes the actual upstream river concentrations (mg/L) of these parameters.

Table 3-1
Athabasca River Water Quality (mg/L) Upstream of Fort McMurray

Parameter	February Average/Median	Annual Average/Median
TSS	2.4*/1	61/6
TP	0.028/0.023	0.062/0.029
$\text{NH}_3\text{-N}$	0.060/0.029	0.039/0.070

*With one "outlier" excluded (excluded abnormal TSS reading of 92.4 mg/L).

The indicated average concentrations reflect the simple averages (not flow proportioned) for all of the data.

3.3 MUNICIPALITY'S RIVER MONITORING

Appendix B provides the Municipality's "River Water Quality Monitoring Protocol". Recent data from this monitoring is also included. River water samples (right bank, centre, and left bank) are taken approximately 50 m upstream, and 500 m and 1,000 m downstream of the FMWWTF outfall, which discharges at the left bank (facing downstream).

The 2013 analyses showed no significant effect from the Fort McMurray WWTF outfall on the key Athabasca River water quality parameters (TSS, TP, and $\text{NH}_3\text{-N}$). However, nitrate-nitrogen ($\text{NO}_3\text{-N}$) appeared slightly elevated as summarized below:

- Left bank: 500 m downstream 0.214 mg/L
- Left bank: 1000 m downstream 0.081 mg/L
- All other downstream, as well as upstream locations <0.05 mg/L

On the same day, the effluent nitrate-N concentration was reported as 7.27 mg/L (grab sample) and 11.5 mg/L (ChemScan).

3.4 RIVER LOADS

Based on the indicated constituent concentrations, Table 3-2 summarizes the average river loads (kg/d) upstream of Fort McMurray.

**Table 3-2
Athabasca River Loads (kg/d) Upstream of Fort McMurray**

Parameter	February Average	Annual Average
TSS	22,000	5,030,000
TP	261	4,170
NH ₃ -N	552	1,540

The loads are based on monthly average flow-proportioned estimates. Concurrent actual river flows and concentrations would provide a more precise estimate, but were not deemed warranted at this time.

4 Sanitary System

4.1 WASTEWATER EFFLUENT FLOWS – CURRENT AND PROJECTED

Current (2013) wastewater effluent flows average approximately 26 ML/d; February flows are typically close to the annual average flows, and therefore, this will be the basis for estimating wastewater effluent loads during the low river flow conditions.

4.2 KEY WASTEWATER EFFLUENT QUALITY PARAMETERS – CONCENTRATIONS

Table 4-1 summarizes the 2010 to mid-2013 effluent quality data (mg/L) for the key parameters.

**Table 4-1
Fort McMurray WWTF Effluent Quality 2010 to Mid-2013 (mg/L)**

Parameter	February		Annual	
	Avg. Month	Max. Month	Avg. Month	Max. Month
TSS	6.8	12	5.8	17
TP	0.48	0.63	0.41	0.82
NH ₃ -N	0.48	1.23	0.63	5.85

With limited operational data, the indicated February performance data may not reflect future performance. In addition, the facility's flows and loads will increase in future, impacting its ability to produce the same effluent quality. For purposes of determining all loads from the wastewater treatment facility, both current and future, Table 4-2 shows the assumed effluent concentrations (mg/L). Note that the table shows lower concentrations for TSS and TP after mid-2015. This reflects anticipated improved treatment to meet more stringent limits at that time.

Table 4-2
Fort McMurray Wastewater Effluent Quality (mg/L)
Assumptions for Loading Properties

Parameter	Before July 1, 2015		After July 1, 2015	
	February Max Month	Annual Average	February Max Month	Annual Average
TSS	20	10	10	5
TP	1.0	0.5	0.5	0.25
NH ₃ -N	6.0	1.0	6.0	1.0

The above assumptions are considered conservative, and therefore, appropriate for effluent load estimation. The estimates should be re-evaluated from time to time.

4.3 EFFLUENT LOADS – CURRENT AND PROJECTED

Table 4-3 presents estimated loads from Fort McMurray's treated wastewater effluent, over the next 25 years.

Table 4-3
Estimated Loads from Fort McMurray WWTFs (kg/d)

Time/Parameter	2013	2023	2038
Month of February (corresponding to low river flow condition)			
TSS	520	364	520
TP	26.0	18.2	26.0
NH ₃ -N	156.0	218	313
Annual (corresponding to average river flow condition)			
TSS	260	182	260
TP	13.0	9.1	13.0
NH ₃ -N	26.0	36.4	52.0

5 Stormwater System

5.1 CURRENT AND PROPOSED SYSTEMS

Appendix C provides two figures, as well as a table of 41 identified outfalls within the urban boundaries of Fort McMurray. This includes two sanitary effluent outfalls at the FMWWTF. Flow and water quality data for the remaining 39 stormwater outfalls are not available. The Municipality is currently developing a plan to monitor some of the outfalls. Initial data collection is tentatively scheduled for 2014-2015.

The developed land area in Fort McMurray totals approximately 4,000 ha. With full development of all identified areas within Fort McMurray's boundary, the total developed area could climb to 13,200 ha, approximately.

5.2 FLOWS – CURRENT AND PROJECTED

Currently, stormwater volumes information is not available in Fort McMurray. AE is preparing a plan for gathering the missing information; hard data should be available in 2015.

In the absence of stormwater volume data, we have made an order-of-magnitude estimate, $4 \text{ m}^3/\text{ha}/\text{d}$ or $1,460 \text{ m}^3/\text{ha}$ annually⁵. This estimate will soon will be refined further, and then confirmed once data become available.

Applying the preliminary areal runoff estimate to the current total developed and developing areas provides annual stormwater runoff estimate in the order of $5,840,000 \text{ m}^3$ or $16,000 \text{ m}^3/\text{d}$ average.

As for sanitary wastewater flow projections, the stormwater flow increases are assumed to mirror the population growth rate. Based on a medium growth rate scenario (4%/year linear), the stormwater volumes will increase by an estimated $230,000 \text{ m}^3$ annually or about $640 \text{ m}^3/\text{d}$.

5.3 KEY STORMWATER EFFLUENT QUALITY PARAMETERS

The key parameters for stormwater quality are assumed to be the same as for the treated wastewater effluent, i.e., TSS, TP, and $\text{NH}_3\text{-N}$. Since none of this information is currently available, it will need to be included in a future monitoring program to be developed for the stormwater system.

Currently, almost 30% of Fort McMurray's stormwater collection system has stormwater retention ponds. For preliminary estimating purposes, loading data from the City of Edmonton's stormwater collection system as well as Alberta Environment's Stormwater Management Guidelines for Wet Ponds were assumed for the parameter loadings in Table 5-1.

⁵ This is a preliminary estimate based on our knowledge of average annual runoff volumes in a similar area.

Table 5-1
Annual Stormwater Loading Assumptions (kg/ha)

Parameter	Without Stormwater Ponds	With Stormwater Ponds
TSS	364	146
TP	1.42	0.78
NH ₃ -N	2.16	2.16

Stormwater ponds are assumed to provide 60% TSS removal and 45% TP removal. It is also assumed that all future development areas will contribute the lower loadings associated with stormwater ponds.

6 Snow Storage Sites

6.1 FLOWS – CURRENT AND PROJECTED

This information will tentatively be provided in 2015. In the meantime, the flows from snow melt at snow storage sites are assumed to be included as part of the stormwater.

6.2 KEY SNOW MELT EFFLUENT QUALITY PARAMETERS

The key parameters for snow melt quality reporting are assumed to be the same as for the treated wastewater effluent, i.e., TSS, TP, and NH₃-N. This information will tentatively be provided in 2015.

Appendix D provides a summary of limited monitoring data for Fort McMurray's Dickensfield Snow Disposal Site. Samples of snow were collected from the site, during the winter season of 2012-2013, melted, and then analyzed in a laboratory.

Actual snow melt runoff water quality may vary significantly. In the meantime, the stormwater loading estimates are assumed to account for the snow storage sites.

7 Combined Discharges During Storm Events

7.1 FLOWS – CURRENT AND PROJECTED

Stormwater and snow melt discharges normally occur during above-freezing months. Therefore, for the purposes of estimating river loads during low flow conditions in February, only the treated wastewater effluent flows must be considered.

Table 7-1 summarizes the estimated total discharge flow rates to the Athabasca River. It should be noted that some of the stormwater discharges are indirect, through tributary water courses.

7.2 LOADS – CURRENT AND PROJECTED

Table 7-2 presents average and projected loads from the Municipality's combined discharges on the Athabasca River at Fort McMurray.

Table 7-1
Estimated Total Average Daily Flows from Fort McMurray's
Treated Wastewater Effluent, Stormwater and Snow Storage Sites (MLD)

Time Period/Source	2013	2023	2038
February (low river flow condition)			
Wastewater effluent	26.0	36.4	52.0
Stormwater outfalls	0.0	0.0	0.0
Total	26.0	36.4	52.0
Annual (average river flow conditions)			
Wastewater effluent	26.0	36.4	52.0
Stormwater outfalls	16.0	22.4	32.0
Total	42.0	58.8	84.0

Table 7-2
Estimated Total Loads from Fort McMurray's
Treated Wastewater Effluent, Stormwater and Snow Storage Systems (kg/d)

Time/Parameter	2013	2023	2038
February (low river flow condition)			
TSS	520	364	520
TP	26	18.2	26
NH ₃ -N	156	218	312
Annual (average river flow conditions)			
TSS	1,453	1,609	2,037
TP	18	15	21
NH ₃ -N	35	49	69

NOTE: Annual river load contributions from Fort McMurray's stormwater and snow storage sites to be determined through future monitoring. For purpose of the report, estimates are used.

8 River Water Quality Impacts

8.1 WINTER LOW FLOW PERIOD LOADS

Table 8-1 summarizes current and projected loads (upstream, Fort McMurray discharges, and downstream) of key water quality parameters on the Athabasca River at Fort McMurray, for the winter low flow period (February).

Table 8-1
Current and Projected River Loads (kg/d) at Fort McMurray during
Typical Low River Flow Conditions (February)

Year/ Parameter	Upstream River	Fort McMurray	Downstream River	% Increase
2013				
TSS	22,000	520	22,520	2.4%
TP	261	26.0	287	10.0%
NH ₃ -N	552	156	708	28.3%
2023				
TSS	22,000	468	22,468	2.1%
TP	261	23.4	284	9.0%
NH ₃ -N	552	281	833	50.9%
2038				
TSS	22,000	520	22,520	2.4%
TP	261	26.0	287	10.0%
NH ₃ -N	552	312	864	56.5%

8.2 ANNUAL AVERAGE LOADS

Table 8-2 summarizes current and projected annual average loads (upstream, discharge, and combined downstream) the key water quality parameters on the Athabasca River at Fort McMurray.

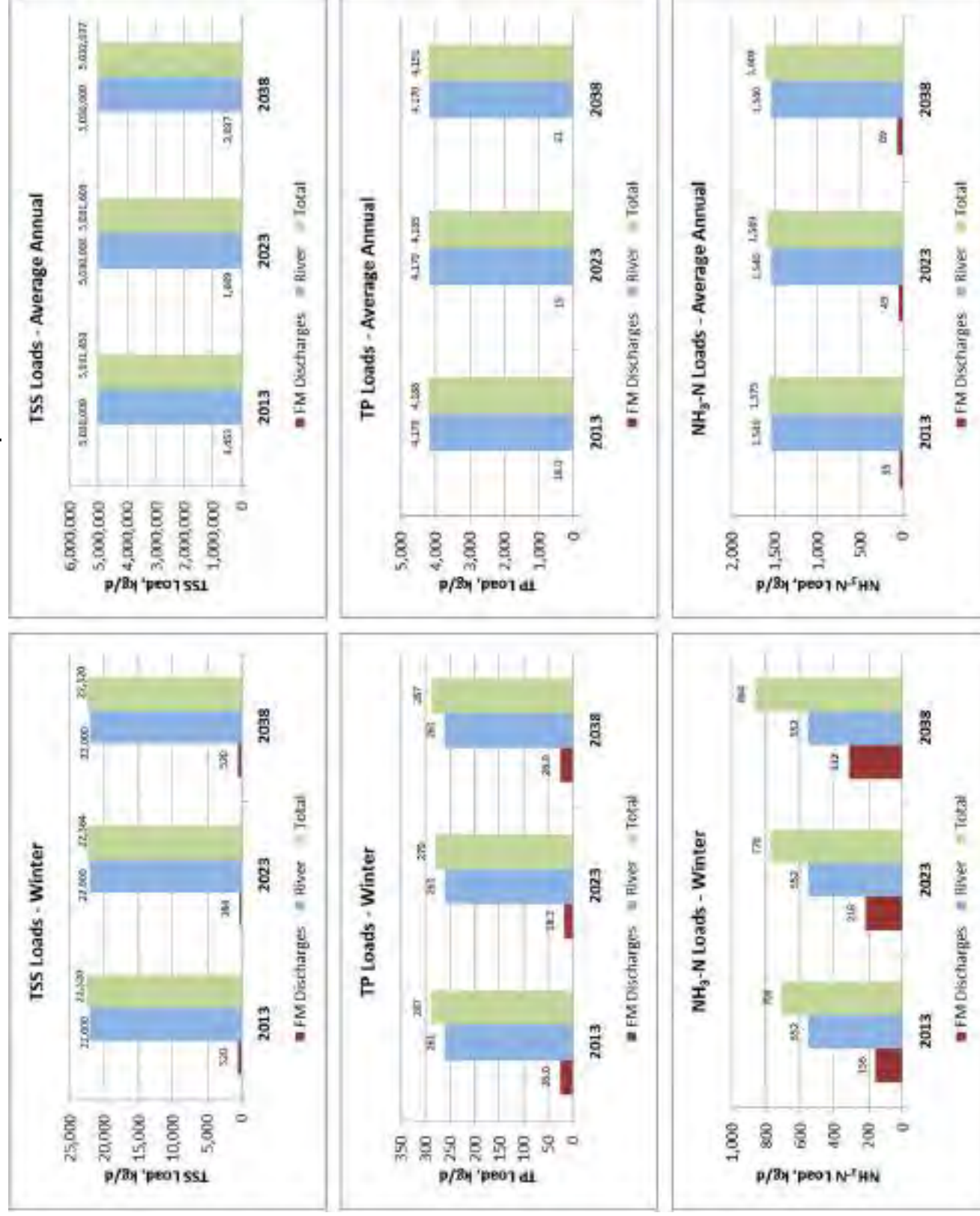
Table 8-2
Current and Projected River Loads (kg/d) at Fort McMurray during
Annual Average River Flow Conditions

Year/ Parameter	Upstream River	Fort McMurray	Downstream River	% Increase
2013				
TSS	5,030,000	1,453	5,031,453	0.0%
TP	4,170	18	4,188	0.4%
NH ₃ -N	1,540	35	1,575	2.3%
2023				
TSS	5,030,000	1,609	5,031,609	0.0%
TP	4,170	15	4,185	0.4%
NH ₃ -N	1,540	62	1,589	3.2%
2038				
TSS	5,030,000	2,037	5,032,037	0.0%
TP	4,170	21	4,191	0.5%
NH ₃ -N	1,540	69	1,609	4.5%

NOTE: Annual river load contributions from Fort McMurray's stormwater and snow storage sites to be determined through future monitoring. For the purpose of this report, estimates are used.

Figure 8-1 graphically illustrates the loading impacts for the three parameters, during low flow conditions (winter) and average annual flow conditions.

Figure 8-1
Estimated Wastewater Effluent Load Impacts



8.3 ESTIMATED RIVER WATER QUALITY IMPACTS – WINTER LOW FLOW PERIOD

Table 8-3 shows the estimated average river water quality impacts associated with the Fort McMurray effluent discharges, during the river low flow period (February).

Table 8-3
Estimated Average River Water Quality Impacts (mg/L) During
Typical Low River Flow Conditions (February)

Year/ Parameter	Water Quality Guideline	Upstream River	Downstream River	% Increase
2013				
TSS	≤ 10 mg/L increase over background value	2.38	2.44	2.7%
TP	0.05	0.028	0.031	9.5%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0	0.060	0.077	28.0%
2023				
TSS	≤ 10 mg/L increase over background value	2.38	2.43	2.2%
TP	0.050	0.028	0.031	8.2%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0	0.060	0.090	50.2%
2038				
TSS	≤ 10 mg/L increase over background value	2.38	2.44	2.4%
TP	0.050	0.028	0.031	9.1%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0	0.060	0.093	55.8%

The table shows that river water quality guidelines for the three parameters are maintained in all cases.

8.4 ESTIMATED RIVER WATER QUALITY IMPACTS – AVERAGE ANNUAL

Table 8-4 shows the estimated average annual river water quality impacts associated with the Fort McMurray treated wastewater effluent and stormwater discharges. The river water concentrations represent flow-proportioned concentrations.

Table 8-4
Projected Annual Average River Concentrations (mg/L)
due to Fort McMurray Effluent Discharges

Year/ Parameter	Water Quality Guideline	Upstream River	Downstream River	% Increase
2013				
TSS	≤ 10 mg/L increase over background value	117.4	117.3	-0.1%
TP	0.05	0.0973*	0.0976	0.3%
NH ₃ -N	0.715 mg/L at 15°C and pH 8.0	0.036	0.037	2.2%
2023				
TSS	≤ 10 mg/L increase over background value	117.4	117.3	-0.1%
TP	0.05	0.0973	0.0975	0.2%
NH ₃ -N	0.715 mg/L at 15°C and pH 8.0	0.0359	0.0370	3.0%
2038				
TSS	≤ 10 mg/L increase over background value	117.4	117.2	-0.1%
TP	0.05	0.0973	0.0976	0.3%
NH ₃ -N	0.715 mg/L at 15°C and pH 8.0	0.0359	0.0375	4.3%

NOTE: **Bolded** values exceed the most stringent of the surface water quality guidelines (CCME or AESRD).

The estimated annual increase in phosphorus concentrations are <1% and ammonia-N are <5%. TSS concentration changes are negligible. The table also shows that the estimated average annual total phosphorus concentrations exceed the water quality guidelines upstream of Fort McMurray; therefore the downstream concentrations also exceed the guidelines. The estimates will require updating once the results of stormwater and snow storage site monitoring become available.

9 Need for Treatment Improvements

The potential for additional wastewater, stormwater, and snow dump system improvements to help protect the Athabasca River will have to be reviewed with AESRD following submission of this preliminary TLP, and again from time to time, as more data become available.

10 Proposed Interim Total Loadings Plan

The following summarizes the proposed interim TLP:

- | | |
|---|---------------|
| • Finalize the draft TLP following the Municipality's feedback | December 2013 |
| • Submit stormwater and snow dump site monitoring plan for approval | December 2013 |
| • Submit draft TLP to AESRD for review | June 2014 |
| • Review meeting with AESRD | July 2014 |
| • Monitor stormwater and snow melt sites | 2014 – 2015 |
| • Update TLP with data from additional monitoring | May 2015 |
| • Submit updated plan to AESRD | June 2015 |

TECHNICAL MEMORANDUM A.3.3.2

Closure

This report was prepared for the Regional Municipality of Wood Buffalo to develop an initial Total Loadings Plan for the urban area within Fort McMurray, under the Regional Municipality of Wood Buffalo.

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.



Patrick W. Given, P.Eng.
Senior Wastewater Process Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF
Signature: <u>[Signature]</u>
Date: <u>March 10, 2014</u>
APEGA Permit to Practice P 3979

Appendix A – River Load Calculation Protocol

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Collection System Operations Plan	Approval No. 689-02-00	Page 1 of 4
4.1.7 (e) River Load Calculation Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

4.1.7 Collection Systems Operations Plan

The following section of the Operations Plan - 4.1.7 (e) - has been reviewed and approved for issuance. Management is committed to providing the resources necessary to ensure the actions required are carried out.



 Manager, Wastewater Treatment Branch

24 May 2011

 Date

Copies not showing the original signature are considered uncontrolled copies.

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Collection System Operations Plan	Approval No. 689-02-00	Page 2 of 4
4.1.7 (e) River Load Calculation Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

This page has been intentionally left blank

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Collection System Operations Plan	Approval No. 689-02-00	Page 3 of 4
4.1.7 (e) River Load Calculation Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

Issue

Point source loads discharged from the City of Fort McMurray facilities require confirmation.

Discussion

As a condition of Approval 689-02-00, the Regional Municipality of Wood Buffalo is required to submit a plan for calculating loads discharged to the Athabasca River. We interpret this to apply to potential constituents of concern from point source discharges including:

- Wastewater treatment facility;
- Snow storage sites;
- Storm water discharges; and
- Any Regional Municipality of Wood Buffalo's overflows that reach the river within the City of Fort McMurray.

In the longer term, the information will assist in the development of a total loadings plan.

Goals – Approval Period

The Regional Municipality of Wood Buffalo will establish a database of discharge loads from its City of Fort McMurray facilities to the Athabasca River.

Potential constituents of concern include:

- Carbonaceous BOD
- Total suspended solids
- Total phosphorus
- Ammonia-nitrogen
- Nitrate plus nitrite-nitrogen
- Free and combined chlorine if present

Calculations of river loads associated with the indicated constituents for each discharge type will be determined on an average annual basis. During the approval period the Wastewater Treatment Plan will develop a sampling program to begin monitoring the above constituents through the City of Fort McMurray collection system.

Approach – Focus Year

Initially data for the wastewater treatment facility will be based on effluent flow readings and composite sample test results. Plans are being developed for data collection from other facilities/locations this year and will be based on flow readings or discharge volume estimates.

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Collection System Operations Plan	Approval No. 689-02-00	Page 4 of 4
4.1.7 (e) River Load Calculation Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

Notification and Reporting

As data is collected in future years, results will be included in the Annual Report submitted to the Director each year by February 28th

Change History N/A

Appendix B – River Water Quality Monitoring Protocol and Preliminary Data

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**

Sampled: 10-Oct-13		Results											
In Situ		50 m Upstream			500 m Downstream			1000 m Downstream					
		Right Bank	Centre	Left Bank	Right Bank	Centre	Left Bank	Right Bank	Centre	Left Bank			
	Time	9:30	9:35	9:40	9:10	9:50	9:55	8:50	8:45	8:40			
	Conductivity (µS/cm)	202	198	212	162	235	203	165	195	222			
	Specific Conductivity (µS/cm)	306	299	321	250	352	306	253	295	333			
	DO	11.01	11.10	11.01	11.12	10.70	11.02	11.25	11.22	11.00			
	pH (pH units)	6.72	6.74	6.83	5.47	6.92	7.04	8.12	8.15	7.31			
	Temperature (°C)	7.23	7.40	7.09	6.69	7.63	7.32	6.75	7.33	7.32			
	Easting	0475228	0475180	0475102	0475693	0475066	0475107	0475247	0474995	0474851			
	Northing	6291743	6291770	6291735	6292490	6292342	6292378	6293874	6293947	0474995			
Laboratory		50 m Upstream			500 m Downstream			1000 m Downstream					
		Right Bank	Centre	Left Bank	Right Bank	Centre	Left Bank	Right Bank	Centre	Left Bank			
	BOD	<2	<2	<2	<2	<2	<2	<2	<2	<2			
	CBOD	<2	<2	<2	<2	<2	<2	<2	<2	<2			
	TSS	11	8	10	28	10	11	32	14	12			
	Ammonia (NH ₃ -N)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008			
	Total Phosphorous (PO ₄ -P)	0.016	0.023	0.019	0.038	0.025	0.028	0.038	0.024	0.024			
	Nitrate (NO ₃ -N)	<0.05	<0.05	<0.05	<0.05	<0.05	0.214	<0.05	<0.05	0.081			
	Nitrite (NO ₂ -N)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			

*All laboratory analyses are reported in mg/L, unless otherwise indicated.

Notes:

The left and right bank samples are facing downstream. All lab analyses are performed by an ISO 17025 accredited lab. Samples were collected by Golder.

Sampling point : Samples were collected on the Athabasca River approximately 50 m upstream from the plant, as well as 500 m and 1000 m downstream of the plant.

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Operations Plan	Approval No. 589-02-00	Page 1 of 4
4.1.7 (b) River Water Quality Monitoring Protocol		Effective Date: June 1, 2011 Revised Date: July 21, 2011	

4.1.7 Collection Systems Operations Plan

The following section of the Operations Plan - 4.1.7 (b) - has been reviewed and approved for issuance. Management is committed to providing the resources necessary to ensure the actions required are carried out.


 Operations Supervisor, Wastewater Treatment Branch

22 Dec 2011
 Date

Copies not showing the original signature are considered uncontrolled copies.

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Operations Plan	Approval No. 689-02-00	Page 2 of 4
4.1.7 (b) River Water Quality Monitoring Protocol		Effective Date: June 1, 2011 Revised Date: July 21, 2011	

This page has been intentionally left blank

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Operations Plan	Approval No. 689-02-00	Page 3 of 4
4.1.7 (b) River Water Quality Monitoring Protocol		Effective Date: June 1, 2011 Revised Date: July 21, 2011	

Issue

The sampling and testing of the Athabasca River water downstream of the Fort McMurray Wastewater Treatment Facility will give an indication of the effect the discharge of treated wastewater has on the river water quality.

Discussion

The in-stream sampling of the Athabasca River downstream of the Fort McMurray Wastewater Treatment Facility outfall will be performed annually in the fall or by request of Alberta Environment and the sampling will not form part of the routine sampling points. The reason for this is:

- The size of the river and the distant location of bridges upstream of the river outfall require sampling to be performed by boat and sampling by boat requires a minimum of three (3) people to perform the sampling. RMWB does not have the staff availability to perform the task and will have to contract out the sampling activity.
- The sampling and measurement of the final wastewater before discharge to the river is considered to be the critical sampling point as that is where approval to permit requirements are measured. In-stream sampling is considered to be indicative to how the wastewater discharged to river changes the river parameters and thus how effective the permit discharged limitations are to ensure the river's health. In-stream sampling and testing will not confirm if permit discharges requirements are met.

Goals – Approval Period

The goals of the Monitoring Protocol during the approval period are to continue to build and maintain a historical database of river quality data.

One (1) upstream sample will be taken at least 50 m upstream from the Wastewater Treatment Plant's outfall. Two (2) downstream samples will be taken at least 500 m downstream and 1000 m of the Wastewater Treatment Plant's outfall. All samples locations will consist of three (3) equally spaced locations along a river cross-section (left bank, mid-stream and right bank).

In situ observations will include:

- Temperature
- pH
- Dissolved Oxygen (DO)

Laboratory testing will include:

- Biochemical Oxygen Demand (BOD)
- Carbonaceous Biochemical Oxygen Demand (CBOD)
- Ammonia (NH₃-N)
- Nitrate + nitrite
- Total Phosphorus
- Total Suspended Solids

 Regional Municipality of Wood Buffalo	RMWB WWTP Operations Plan	Approval No. 689-02-00	Page 4 of 4
4.1.7 (b) River Water Quality Monitoring Protocol		Effective Date: June 1, 2011 Revised Date: July 21, 2011	

Due to the requirements of the sampling on the river, this protocol will be outsourced to a local company which has the resources to complete in-stream sampling and measurements, Laboratory testing will be completed at an ISO/IEC17025 accredited laboratory.

Approach – Focus Year

The approach for this focus year is to continue to monitor the river quality

Notification and Reporting

Results of testing will be included in the Annual report submitted by February 28th of each year.

Change History

Date	Changes Made	Completed by
July 21, 2011	Feedback from meeting with AB-ENV – July 13, 2011	N. Lewis

Appendix C – Stormwater Outfalls in the Fort McMurray Urban Area

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**

Appendix C – Stormwater Outfalls in the Fort McMurray Urban Area

Fort McMurray Stormwater Outfalls

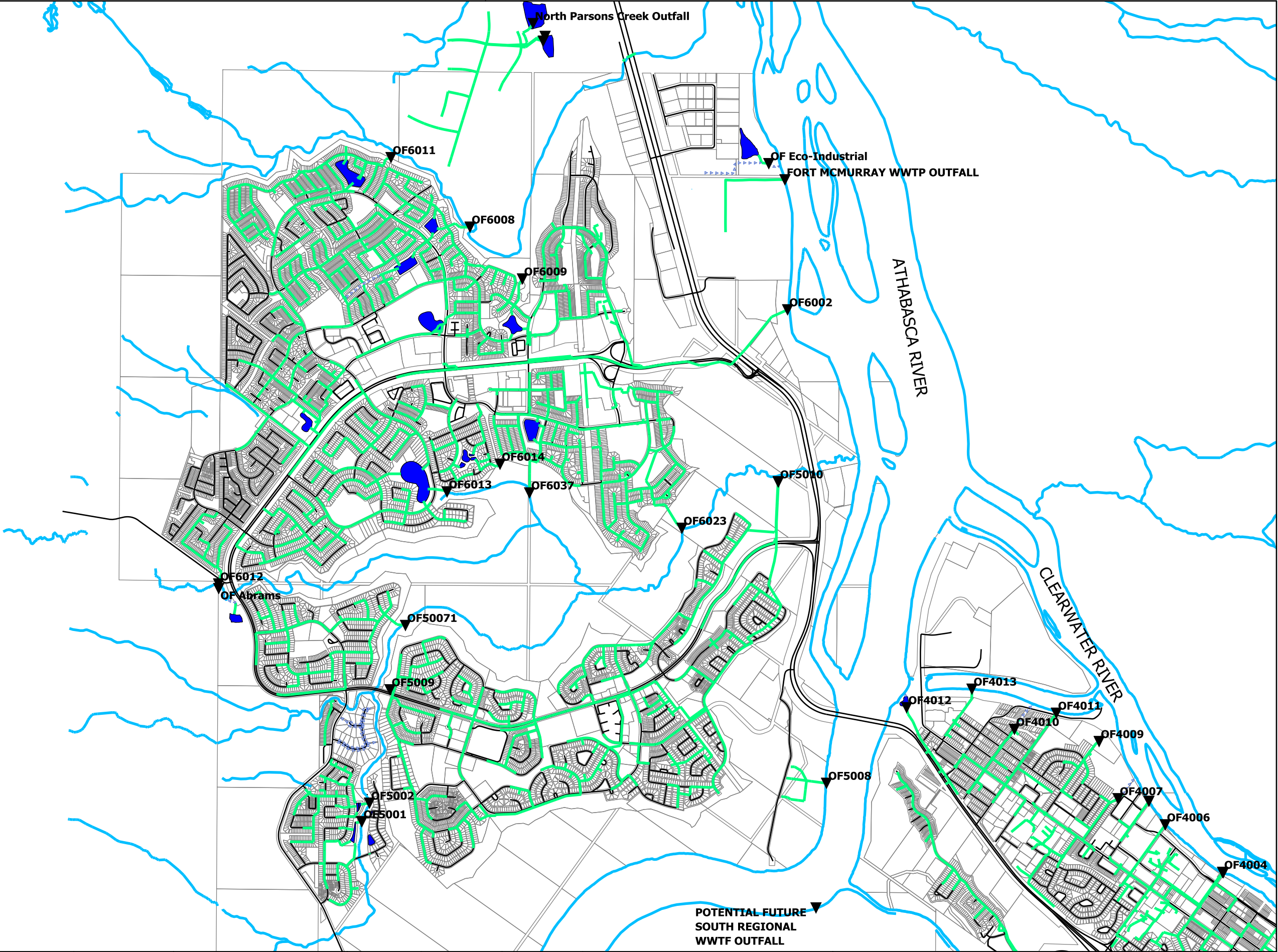
Neighborhood	Outfall ID	Pipe Size (mm)	Discharge Location
Abasand	OF1001	675	Hangingstone River
Abasand	OF1002	1350	Hangingstone River
Abasand	OF1003	1050	Memorial Drive (S)
Beacon Hill	OF2001	450	Hangingstone River
Lower Townsite	OF4	450	Hangingstone River
Lower Townsite	OF4001	1050	Hangingstone River
Lower Townsite	OF4002	900	Clearwater River
Lower Townsite	OF4003	525	Hangingstone River
Lower Townsite	OF4004	900	Clearwater River
Lower Townsite	OF4005	680	Clearwater River
Lower Townsite	OF4006	750	Clearwater River
Lower Townsite	OF4007	450	Clearwater River
Lower Townsite	OF4008	910	Clearwater River
Lower Townsite	OF4009	525	Clearwater River
Lower Townsite	OF4010	1200	SNYE
Lower Townsite	OF4011	1200	SNYE
Lower Townsite	OF4012	900	Athabasca River
Lower Townsite	OF4013	900	SNYE
Lower Townsite	OF4015	1050	Clearwater River
Mackenzie	OF2002	750	Hangingstone River
Thickwood	OF5001	250	Unnamed Creek
Thickwood	OF5002	300	Unnamed Creek
Thickwood	OF50071	750	Unnamed Creek
Thickwood	OF5008	1050	Athabasca River
Thickwood	OF5009	900	Unnamed Creek
Thickwood	OF6023	1200	Unnamed Creek
Timberlea	OF5010	900	Unnamed Creek
Timberlea	OF5011	900	Unnamed Creek
Timberlea	OF6002	1600	Athabasca River
Timberlea	OF6008	600	Unnamed Creek
Timberlea	OF6009	375	Unnamed Creek
Timberlea	OF6011	750	Unnamed Creek
Timberlea	OF6012	900	Unnamed Creek
Timberlea	OF6013	900	Unnamed Creek
Timberlea	OF6014	525	Other

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**



Neighborhood	Outfall ID	Pipe Size (mm)	Discharge Location
Timberlea	OF6037	900	Unnamed Creek
Abrams	Abrams Outfall	450	Unnamed Creek
Parsons	West Parsons Outfall		Parsons Creek
Industrial	Eco-Industrial Outfall	1350	Athabasca River
Industrial	WWTP Outfall	1500	Athabasca River
Industrial	WWTP Outfall	750	Athabasca River

Time: 10:12:28 AM | Date: 11/28/2013
Scale: 1:30000
Map File: P:\20123694\03_Stormwater_MP\Engineering\01.00_Background_Data_Collection\GIS\Overall_Outfalls_Map_05082013.map



LEGEND

Outfall

Existing Storm Sewer

DITCH

Major Waterbodies

Road network

No.	REVISION	DATE

	(Name)	(Date)
	(Name)	(Date)
	(Name)	(Date)



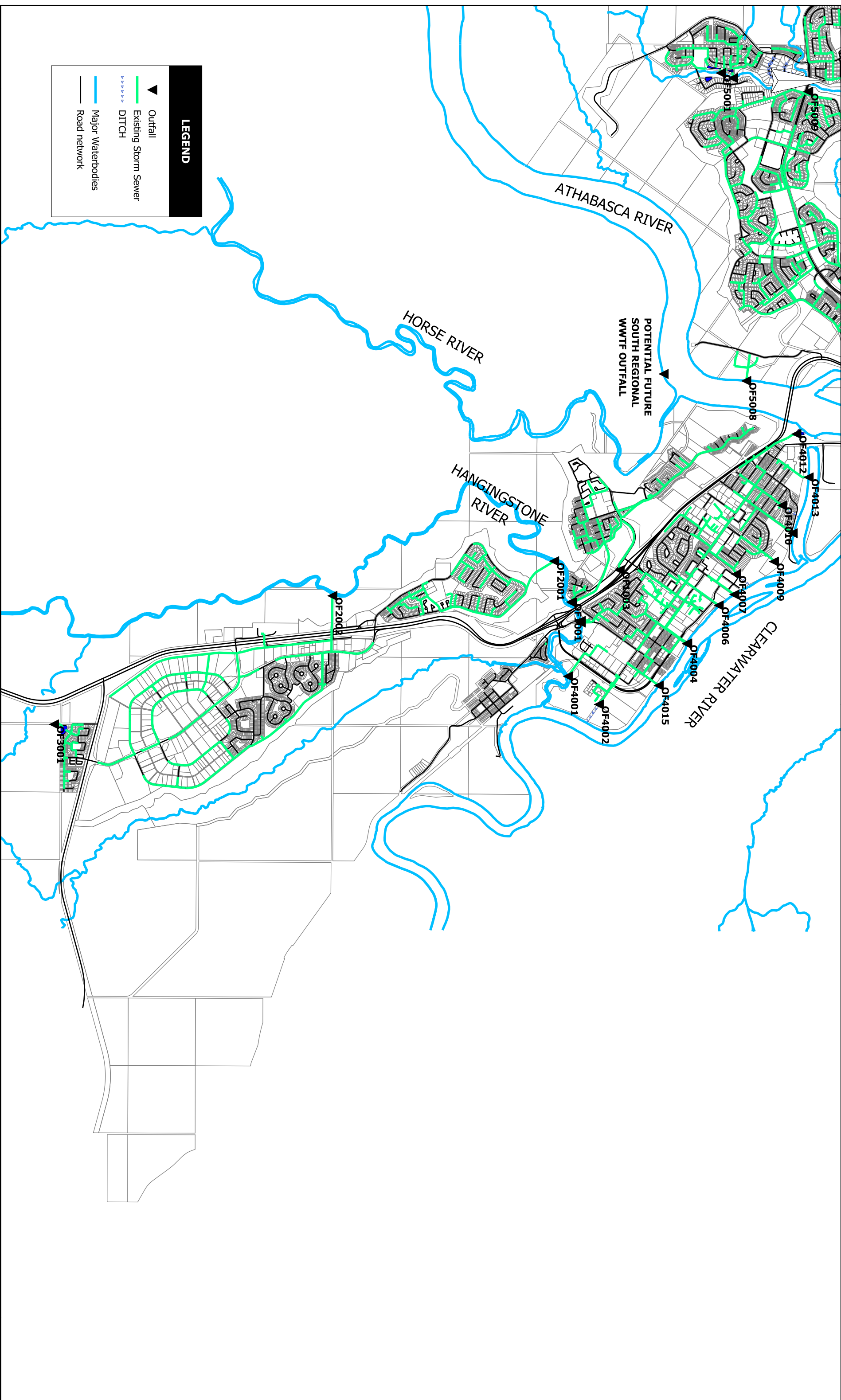
**WASTEWATER MASTERPLAN
STORMWATER COLLECTION SYSTEM
THICKWOOD & TIMBERLEA**

OUTFALL MAP

PROJECT No.:2012-3694.030

DATE: 11/28/2013

SCALE: 1:30,000



Appendix D – Dickensfield Snow Disposal Site, Fort McMurray

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**

Summary of Recent Snow Melt Analyses

Parameter	Units	Date 2012 - 2013						
		23-Nov	30-Nov	10-Dec	08-Jan	12-Dec	22-Jan	13-Feb
BOD	mg/L	<2.0	16.0	34.0	30.2	39.5	14.1	117
cBOD	mg/L						13.7	76.8
Chloride	mg/L	110	927	1990	4770	2880	899	4470
TDS	mg/L	226	1620	3210	7720	4750-5110	1510	7360
Hardness as CaCO ₃	mg/L	49.7	129	169	179	138-153	72.7	250
Nitrate as N	mg/L	0.182	0.117	<0.50	<1.0	<0.50	<0.50	<1.0
Nitrite as N	mg/L	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0
Sulphate	mg/L	2.9	6.69	9.6	18	14.8	<5.0	19
pH	pH	7.63	7.75	7.67	7.54	7.63	7.76	7.58
EC	µS/cm	480	3190	6510	13700	8920	3060	13400
Benzene	mg/L					<0.00050		
Toluene	mg/L					<0.00050		
Ethylbenzene	mg/L					<0.00050		
o-Xylene	mg/L					<0.00050		
m+p-Xylene	mg/L					<0.00050		
F1 (C6-C10)	mg/L					<0.10		
F1-BTEX	mg/L					<0.10		
Xylenes	mg/L					<0.00071		
F2 (>C10-C16)	mg/L					<0.25		
F3 (C16-C34)	mg/L					1.52		
F4 (C34-C50)	mg/L					1.00		
Fecal Coliforms	CFU/100 mL					260		
Oil & Grease	mg/L					<1.0		

* Data summarized from ALS laboratory reports. Additional data were also reported for Ca, Mg, K, Na, HCO₃, CO₃, OH, and Alkalinity. Snow samples were obtained from the Dickensfield Snow Disposal Site, melted, and then analyzed by ALS Laboratory.

TECHNICAL MEMORANDUM A.3.4

Regional Municipality of Wood Buffalo

Wastewater Master Plan

Solids Management Review



June 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo Wastewater Master Plan. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE/PURPOSE

The main objectives of Technical Memorandum A.3.4 Solids Management Review are to confirm the source of wastewater solids in Fort McMurray, both current and future, to identify options, and to develop a solids management plan.

2 MAIN FINDINGS

The recommended near-term (up to 5 years) plan for solids management is summarized as follows:

1. Sludge production estimates should be reviewed further to agree on the basis for the solids management plan. This should include a review of totalized flows to the centrifuges for confirmation of solids loadings.
2. The near term solids management plan should focus on continued composting; direct disposal of dewatered sludge at the landfill should be utilized only during emergency operations such as compost facility out of operation (the current condition).
3. The beneficial uses of composted biosolids should be further investigated to provide the Municipality with alternatives for their ultimate end use.
4. The characteristics of the solids (metals, total solids, volatile solids, etc.) should be confirmed for dewatered sludge, composted biosolids, hydro-vac-type wastes, and septage solids to help confirm viable management options and appropriate beneficial uses.
5. Longer term options for biosolids management should also be evaluated further during the near term to facilitate transition to improved biosolids management in the longer term, should alternate management options prove favourable.

The recommended longer term (>5 to 25 years) plan for solids management is summarized as follows:

1. At this time, longer term options which may have merit appear to include:
 - a. Gasification of dewatered sludge with municipal solids waste.
 - b. Anaerobic digestion with energy recovery (gas, heat, power) and side stream nutrient recovery.
 - c. Combinations of gasification and anaerobic digestion options with sludge drying.
2. Should a gasifier for combined sludge and municipal solid wastes be included in the Municipality's future plans, then the proximity of the gasifier to the sludge drying facility should be evaluated to maximize the energy recovery potential.
3. Should anaerobic digestion be included in the Municipality's future plans, then methods to maximize energy recovery should be evaluated. These should include uses of the digester gas and pre-treatment technologies for waste activated sludge to increase digester gas production.
4. The long term plan will require periodic updating depending on the Municipality's growth, operating experience, and technology advances.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	ii
List of Tables	iv
List of Figures	v
1 Introduction	1
2 Background	1
2.1 Previous Studies	1
2.2 Municipality's Green Initiatives	2
2.3 Biosolids Quality	2
3 Solids Steams – Current Practices and Solids Loads	3
3.1 Grit	3
3.2 Screenings	4
3.3 Primary Solids	4
3.4 Secondary Solids	7
3.5 Septage	8
3.6 Blended Primary/Secondary Sludge	8
3.7 Composted Biosolids	10
3.8 Ultimate Biosolids Beneficial Use or Disposal	10
3.9 Summary of Current Solids Waste Sources and Quantities	11
4 Solids Streams – Projected Loads	12
5 Review of South Regional WWTF Solids Management Technologies and Strategies	13
5.1 SRWWTF Solids Management Conclusions	13
5.2 SRWWTF Solids Management Recommendations	14
6 Solids Management Technologies	15
6.1 Pre-treatment Technologies	16
6.2 Treatment Technologies	17
6.3 Resource Recovery Technologies	21

7	Biosolids Management Options	24
7.1	Solids Stream	24
7.2	Hydro-vac Type Wastes	28
7.3	Septage Solids	29
8	Solids Management Capital Costs	29
9	Solids Management Plan	29
9.1	Near Term (up to 5 years)	29
9.2	Long Term (5 to 20 years)	29

Closure

Appendix A – Summary of Monthly Solids Data at Fort McMurray WWTF

List of Tables

	PAGE NO.
Table 3-1 Comparison of Current Dewatered Sludge Unit Production Estimates	11
Table 6-1 Allowable Uses of Class A & B Biosolids	17
Table 6-2 Resource Recovery Approaches and Technologies	22
Table 7-1 Comparison of Biosolids Processing Options	26

List of Figures

	PAGE NO.
Figure 3-1 Solids Streams	5
Figure 4-1 Solids Production Projections (average dry solids, kg/d)	13
Figure 6-1 Charting the Future of Biosolids Management	15
Figure 6-2 Anaerobic Digester Schematic	19
Figure 6-3 Rotary Drum Dryer	21

1 Introduction

This technical memorandum comprises one of several technical memoranda prepared as part of the Regional Municipality of Wood Buffalo (Municipality) Fort McMurray Wastewater Master Plan (WWMP).

At the time the initial scope of this assignment was developed, the Municipality was planning for a second wastewater treatment facility (WWTF) located in the south at the new landfill. While this is still the long range intention, the Municipality subsequently decided that anticipated growth rates will not warrant proceeding with the South WWTF in the near future. Therefore the solids management review now focusses on the Fort McMurray WWTF (FMWWTF) as if all of the growth will impact that facility. The plan will require updating once the Municipality re-initiates plans for the South WWTF.

The Solids Management Review examines the sources of solid waste (grit, screenings, waste sludge, biosolids, mud pit solids, compost, etc.) from the existing Fort McMurray WWTF and the future South Regional WWTF. The task develops a solids management plan for the solids generated by the wastewater treatment facilities in the urban Municipality. The solids management plan looks at options from point of generation to disposal.

The solids management review includes:

- Review solids treatment technologies used and future strategies developed in the South Regional WWTF predesign work.
- Define sources of solids from the existing WWTF (e.g., screenings, grit, and biosolids).
- Review quantities and quality from available data collected by the Municipality.
- Conduct a site visit to gather information at the Municipality.
- Develop a solids management plan to deal with solids produced by existing WWTF.
- Incorporate solids management plan for South Regional WWTF into the existing WWTF plan to create an urban Municipality Solids Management Plan.
- Summarize all findings and recommendations in a Technical Memorandum.

2 Background

2.1 PREVIOUS STUDIES

The initial planning for the Fort McMurray WWTF, including solids management, is documented in Earth Tech's 2004 "Predesign Report – Fort McMurray Water Reclamation Facility".

Due to rapid growth, the project scope was subsequently re-evaluated during the construction phase and documented in Associated Engineering's 2007 Peer Review Report, "Fort McMurray WWTP – Phases 2 and 3".

In 2012, Associated Engineering (AE) completed a Conceptual Design for a new wastewater treatment facility that would serve Fort McMurray's south growth areas: "South Regional Wastewater Management Concept". Five alternative wastewater sites were identified and it was concluded that one central south site would best serve the area. The initial solids management plan recommended haulage of the south solids to the existing north facility, the Fort McMurray WWTF, for processing.

In 2012, AE commenced the predesign for the south facility. In 2013, close to 90% of 22 planned Technical Memoranda were completed for the facility at a new location – Fort McMurray's new landfill site. However the planning of the project was placed on hold as the Municipality's planners lowered their growth projections for Fort McMurray's south areas. The most relevant technical memorandum from that work dealing with solids was completed to near final stage: "Technical Memorandum #13, South Regional Wastewater Treatment Facility, Solids Stream Processes". The initial solids management plan recommended haulage of dewatered sludge to the Fort McMurray WWTF for incorporation in the composting process.

2.2 MUNICIPALITY'S GREEN INITIATIVES

AECOM's March 2013 report, Fort McMurray Green Utilities, reviewed options for district energy systems (DES) to minimize energy use, costs, and greenhouse gas emissions. The analyses showed the DES economics were not favourable; however specifics of utilizing municipal solid waste (MSW) and dried sludge (DS) from WWTFs as "free" energy sources did not appear to be considered in any detail. It is AE's understanding that the Municipality is considering MSW and DS as energy sources at a low temperature gasification facility (or facilities) with the generation of combined heat and power (CHP).

The Municipality's green initiatives were recently presented by Kevin Scoble, Director of the Environmental Services Department.¹ The Municipality's vision is to develop world class waste to energy facilities and an eco-industrial park to take the place of the landfill. Low temperature gasification/biodiesel facilities would convert waste to energy, producing electricity, heat, and biodiesel. As well, with the low temperature gasification process, recovery of materials from the residuals would be greatly facilitated.

Electricity and heat would be supplied to greenhouses and CO₂ from the gasification process would be recovered and supplied to nearby greenhouses to increase plant productivity. One of the significant net environmental benefits would be a significant reduction in greenhouse gas emissions, achieved through leading waste management practices and reduced transportation requirements.

2.3 BIOSOLIDS QUALITY

The Municipality's biosolids composting system is designed to achieve a Class A biosolids standard. This includes meeting fecal coliform and Salmonella limits at the time of use or disposal (<1000 MPN/g or <3 MPN/4 g, respectively).

¹ <http://tedxtalks.ted.com/video/TEDxFortMcMurray-Kevin-Scoble-W;search%3Atag%3A%22tedxfortmcmurray%22>

Class A biosolids with very low metals concentrations have “unrestricted use” and are described as having exceptional quality. Class A biosolids with generally higher metals concentrations up to ceiling limits have “restricted use” and are subject to annual pollutant loading rates. The Municipality’s biosolids quality after composting is expected to be in the latter category, subject to the Municipality’s confirmation.

Class B biosolids have less restrictive bacterial limits, but more restrictive end uses.

3 Solids Steams – Current Practices and Solids Loads

Basic information on various systems described in this Section has been extracted from the Municipality’s Process Control Narratives, last updated by AECOM, c2010. Figure 3-1 shows the general locations of the solids streams, which are also identified by the numbers as shown below:

Solids Stream	To Location
1. Grit	Landfill
2. Screenings	Landfill
3. Primary sludge	Fermenter
4. Primary scum	Landfill
5. Fermented sludge	Centrifuge
6. Waste activated sludge (WAS)	DAF
7. DAF-thickened WAS (TWAS)	Centrifuge
8. Septage lagoon solids	Geobags/Landfill
9. Blended primary/secondary sludge	Centrifuge
10. Dewatered sludge	Composting (landfill backup)
11. Composted biosolids	Landfill
12. Hydro-vac type wastes	On site

Sections 3.1 to 3.7 provide additional details.

3.1 GRIT

Grit removal takes out heavy inorganic and some organic particulates. Grit (Stream 1) is removed to minimize abrasive wear on downstream equipment and to prevent accumulation and deposition of heavy, non-biodegradable material in downstream tanks. Grit removed by the grit vortex chamber is pumped to the headworks area where it is classified and dewatered prior to discharge into the collection bin prior to transport to the landfill. According to the Municipality, the volume of grit averages about 1 m³ per day; however it may increase to 3 or 4 m³ per day during a heavy rain.

Classifying and washing the grit removes most fine organic solids and returns them in the drainage to the influent channel. Compaction further reduces the free water and volume of the grit thus reducing amount of the material going to landfill. Washing and compaction also eliminate offensive odours so grit can be accumulated in the bins without becoming excessively malodorous.

3.2 SCREENINGS

Screening removes large material such as rags, wood, and plastic objects. If not removed, large solids can cause operational and maintenance problems, including the plugging of and damage to downstream mechanical equipment. The screenings (Stream 2) are macerated, washed and compacted (new system to be installed) prior to discharge into a collection bin for transport to the landfill. Washing the screenings removes most fine organic solids and returns them in the drainage to the influent channel. Compaction further reduces the free water and volume of the screenings thus reducing the amount of the material going to landfill. Washing and compaction also help eliminate offensive odours so screenings can be accumulated in the bins without becoming excessively malodorous. According to the Municipality, the screenings volume averages about 3 m³ per week.

Each fine screen is equipped with a rake and rotating brush for removing debris larger than 6 mm (screen opening size), depositing the debris in the screenings washer compactor which discharges washed and dewatered material into the disposal bin.

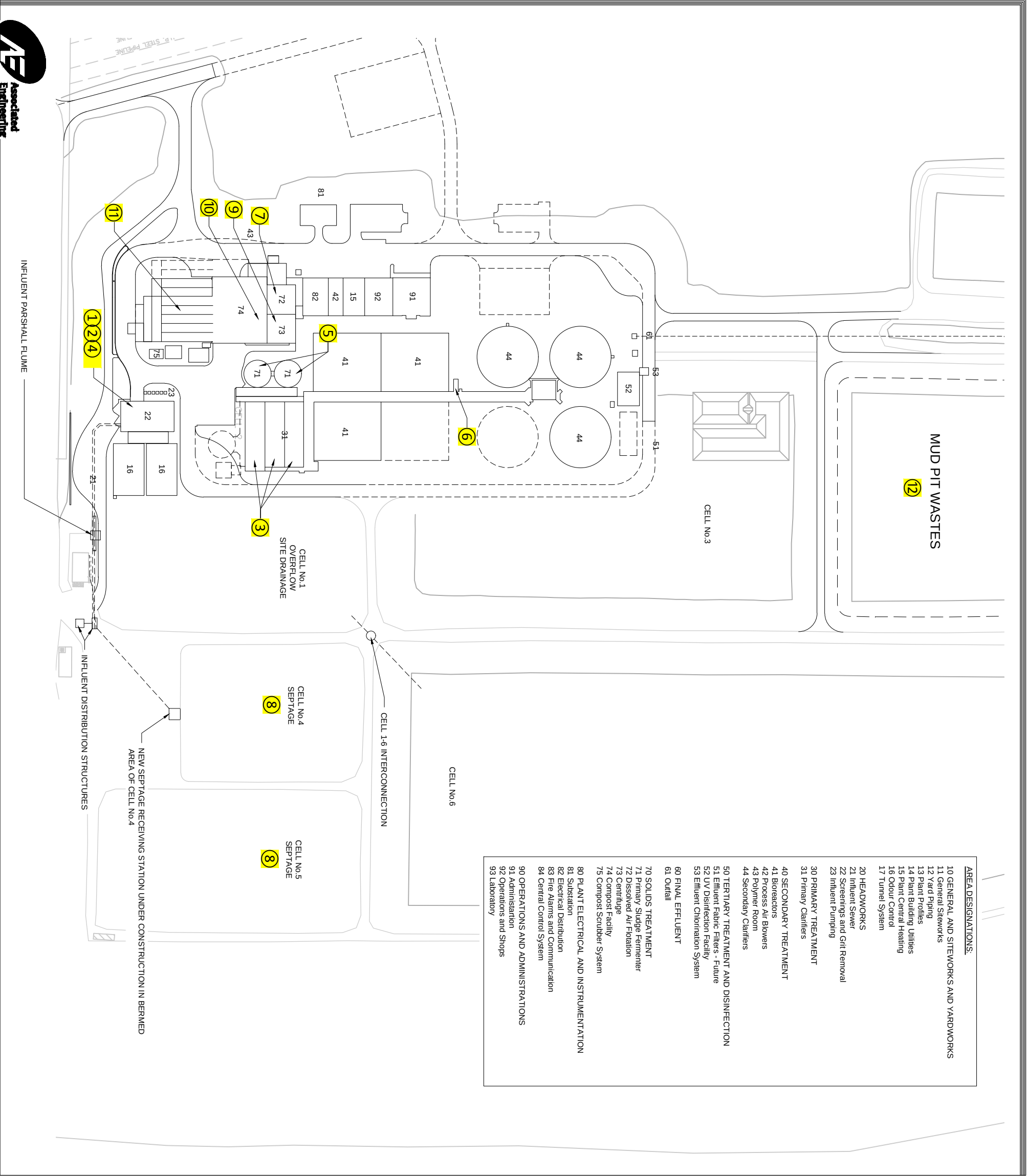
A third screen is also provided (50 mm openings). If this screen is operated, then the screenings must be removed manually and deposited in the disposal bin.

3.3 PRIMARY SOLIDS

3.3.1 Primary Sludge

Screened and degritted raw wastewater is pumped to the primary clarifier influent chamber and then allowed to flow by gravity into three primary clarifiers (T-31-100, T-31-200, and T-31-300). The three primary clarifiers are sized to handle a peak flow of 156 ML/d.

Each clarifier has one sludge collection hopper. Primary sludge (Stream 3) is withdrawn from these hoppers by the primary sludge pumps (P-31-120, 220 and 320) and is pumped to the fermenters. The primary sludge (PS) pumps are centrifugal recessed impeller pumps equipped with VFDs sized for a capacity of 13-27 L/s and a total dynamic head (TDH) of 6.0 m. The pumps are configured such that any pump can withdraw sludge from any clarifier's sludge collection hopper, in the event that one of the pumps is taken off line. However, under normal operation conditions P-31-120 withdraws sludge from primary clarifier 1; P-31-320 withdraws sludge from primary clarifiers 2 and 3. P-31-220 is the common standby. Flow control valves on the suction lines of the three sludge pumps (FCV-31-103, 203 and 303) allow for the sequential removal of sludge from the primary clarifiers that are in service.





REGIONAL MUNICIPALITY
OF WOOD BUFFALO

WASTEWATER MASTER PLAN

FORT MCMURRAY

WASTEWATER TREATMENT FACILITY

SOLIDS STREAMS

NOTES:

Background Drawing Based on EarthTech Drawing (G00 001 REV B)

Solids Streams:

- 1 Grit
- 2 Screenings
- 3 Primary Sludge
- 4 Primary Scum
- 5 Fermented Sludge
- 6 Waste Activated Sludge
- 7 DAF - Thickened WAS
- 8 Septage Lagoon Solids
- 9 Blended Primary / Secondary Sludge
- 10 Dewatered Sludge
- 11 Composted Biosolids
- 12 Hydro-vac type Wastes

SCALE: 1:2500

MARCH, 2014

FIGURE 3-1

3.3.2 Primary Scum

Scum (Stream 4) from the primary clarifiers is collected in primary scum standpipes and is pumped to the primary rotary screen (SCRN-22-810) located in the Headworks Building for further dewatering. The scum screen hot water flush runs for 1 minute then waits for 3 minutes and repeats the 1 min hot water flush. This continues until the primary scum pumps have stopped.

3.3.3 Fermenter Sludge

There are three basic functions of the fermenter sludge (FSL) pumps:

- Waste fermenter sludge to the centrifuge;
- Empty one fermenter into another; and
- Recycle fermenter sludge back into the inlet of the fermenter tank.

There are two FSL pumps (P-71-210 and P-71-310). The FSL pumps are progressing cavity pumps sized for a capacity of 8 L/s and are equipped with VFDs. The Municipality's records (2012) showed that approximately 6,500 kg/d dry solids with an average solids concentration of 6.8% total solids concentration were pumped from the fermenters.

During the Wasting Mode, FSL (Stream 5) is withdrawn from the central sludge collection hopper of the fermenters by the FSL pumps, and transferred to the centrifuge(s) for dewatering. The pumps discharge to the centrifuge intermittently to coincide with the operation of the centrifuge. Wasting alternates between fermenters, typically over the course of the day.

The fermenter sludge wastage pumping is linked to the thickened waste activated sludge (TWAS) pumping and to the operation of the centrifuge.

3.4 SECONDARY SOLIDS

3.4.1 Waste Activated Sludge

A portion of the active biomass is wasted continuously to remove the excess solids generated by biological activity in the bioreactor, thereby maintaining a relatively constant solids retention time (SRT). Wasting a portion of the active biomass is normally achieved by surface wasting of mixed liquor (WAS); the design also enables wasting of return activated sludge (RAS).

The wasted biomass (Stream 6) is pumped to the dissolved air flotation (DAF) for thickening.

3.4.2 DAF-Thickened Sludge

WAS is withdrawn from the bioreactors and discharged into one or both DAF Tanks on a continuous basis. Alternatively, RAS can be wasted and sent to the DAF tank using the WAS pumps – although this is not the normal operating mode.

Each DAF tank has a skimmer that collects the float and pushes it over a beach into a float box that drains into a thickened WAS (TWAS) storage tank.

The DAF tanks are not equipped with a scraper drive to remove heavier solids that may accumulate at the bottom of the hopper. As a result, they must be manually pumped out or drained out of the hopper on a regular basis.

TWAS (Stream 7) is pumped from the storage tank and fed to each centrifuge. The Municipality's records (2013) showed that approximately 3,000 kg/d dry solids with an average solids concentration of 3.7% total solids concentration were pumped.

3.5 SEPTAGE

3.5.1 Lagooned Septage

Currently, hauled septage is discharge directly to aerated lagoon Cell 5. Supernatant from the lagoon is pumped to the plant influent where it combines with piped wastewater influent. Sludge from the lagoon has required periodic removal.

Lagooned sludge (Stream 8) is pumped to geo-bags for further dewatering over an extended time period. The dewatered sludge is then transported to landfill.

3.5.2 New Septage Receiving Station – Direct Solids Feed

A new septage receiving station is currently under construction. Trucks will discharge through a gravity main directly to the station. A macerator will grind the solids which will then be pumped directly to the influent distribution chamber. It should be noted that this direct return of septage solids to the WWTF will increase the solids handling requirements of the WWTF.

The new septage receiving station has provisions for bypassing septage flows to a modified, aerated lagoon cell 4, and subsequently returned to the influent distribution chamber. Depending on the extent of this practice, the need for lagoon desludging will be reduced or eliminated.

3.6 BLENDED PRIMARY/SECONDARY SLUDGE

3.6.1 Dewatered Sludge

The blended, fermented primary and thickened secondary sludge (Stream 9) are dewatered (Stream 10) and discharged via gravity from either or both of two centrifuges into a horizontal sludge conveyor. The Municipality's data shows that the blended stream averaged 9,500 kg/d dry solids at 5.3% TS concentration. The dewatered solids averaged about 9,400 kg/d at 25.4% TS concentration, or approximately 37,000 kg/d wet weight. It should be noted that this number does not appear to agree with landfill haulage records; therefore, it requires further checking.

Allowance for discharge from a third centrifuge has been made. An inclined conveyor transfers the sludge from the horizontal conveyor onto the mixing area floor in the compost building. New screw conveyors are currently being tendered to provide better reliability and increased capacity.

Around October – November, 2012, the compost system became inoperable as a result of a foul air blower (FOA) explosion. This necessitated an alternate plan for managing the dewatered sludge. To cope with this emergency situation, the Municipality is hauling dewatered sludge directly to the landfill without composting.

3.6.2 Composting of Dewatered Sludge

The dewatered sludge from the mixing area floor currently is loaded onto trucks for landfill disposal. That practice will continue until the compost foul air blowers (FOA) are replaced.

Once the foul air blowers (FOA) have been replaced, the operator will use a loader to load the desired portions of dewatered sludge and wood chips into the Raw Compost Mixer (MIX-74-060). The mixer is equipped with two vertical augers driven with a remote-mounted, air-cooled, hydrostatic (oil) drive system driven with a 300 hp electric motor. The drive system includes a dedicated hydrostatic pump and independent speed control for each auger.

The raw compost mixture is generally comprised (by volume) of:

- One (1) part sludge;
- Two (2) parts wood chip amendment; and
- One (1) part recycled and finished compost.

A load cell measurement system can assist with ensuring the proper proportioning of dewatered sludge, wood chips and recycled compost feed stocks batched into the mixer using the loader. The mixer has three different cycles for operator adjustable times:

- “Blend Cycle” as wood chip and recycle compost feed stocks;
- “Mix Cycle”, once the sludge is dumped into the mixer; and
- “Discharge Cycle”, when the mixer is being emptied.

Once the required quantity of each ingredient has been added, the complete raw compost mixture is agitated for a short adjustable time period. The prepared, raw compost mixture is then transferred into a stockpile area by an inclined Raw Compost Conveyor.

The loader picks up the material and loads the mixture into an open compost bunker.

3.7 COMPOSTED BIOSOLIDS

When the compost system functions, aerobically composted biosolids (Stream 11) are transported to the landfill where they are allowed time to mature in windrows. A mass balance suggests that the composted biosolids (2013 data) averaged about 39,000 kg/d dry solids at 80% TS concentration, or approximately 48,000 kg/d wet weight. Unlike the dewatered sludge weights, it should be noted that this number does appear to agree reasonably with landfill haulage records. Due to its relatively low bulk density (estimated at 310 kg/m³), the composted biosolids require more trips to the landfill, averaging >4 loads per day versus <2 loads per day for the dewatered raw sludge (bulk density estimated at 800 kg/m³).

To date, beneficial re-use of the biosolids has been limited. Some of the biosolids have been mixed with soil for use as final cover material at the old landfill site.²

3.8 ULTIMATE BIOSOLIDS BENEFICIAL USE OR DISPOSAL

3.8.1 Hydro-vac Type Wastes (Stream 12)

Tech Memo A.1.3 describes the hydro-vac type waste management practices used at FMWWTF. The basic information is repeated here for ease of reference.

Some of the hauled waste is inert material such as hydro-vac waste not suitable for direct discharge at the wastewater treatment facility. Data on the origin of hydro-vac type wastes was not available.

Sources of hydro-vac wastes may include industrial cleaning, waste removal, day-lighting, trenching, post hole digging, and spill clean-up. Therefore, hydro-vac wastes can potentially have significant contaminant concentrations depending on the waste source.

Hydro-vac and other liquid wastes with high inert solids contents are hauled to the Municipality's mud pit (approx. 30,000 m² area) located at the FMWWTF. Assuming the pit is filled to a 4.0 m depth, it potentially could store up to 120,000 m³ of waste before waste removal for drying, and/or ultimate disposal is required. The Municipality's 2012 records showed that an estimated 90,700 m³ of hydro-vac type wastes were deposited at the mud pit (about 250 m³/d average), representing about 75% of the mud pit volume.

The Municipality indicated about \$300,000 was spent for desludging the mud pit in 2012. The Municipality brings in a contractor with an excavator which has about a 9 m reach from the bank of the mud pit. Solids in the middle of the mud pit cannot be reached by the excavator. Typically the mud pit fills completely each year so solids removal is required annually. The excavator loads dump trucks which deposit the concentrated slurry in the drying area adjacent/east of the mud pit. Excess water is also periodically pumped from the mud pit to lagoon Cell 6, then Cell 1, and returned for treatment in the plant.

² W. Goodridge, 2013. Personal communication with Municipality's Supervisor, Waste Process, Environmental Services, Solid Waste.

The Municipality estimates that the drying area has space for only about two more years of solids; therefore, a longer term solution is required.

3.9 SUMMARY OF CURRENT SOLIDS WASTE SOURCES AND QUANTITIES

The main solids waste source of interest is the raw dewatered sludge and associated compost. Raw sludge mainly comprises thickened fermented primary sludge from the fermenters and thickened secondary sludge from the dissolved air flotation thickeners. Appendix A provides summary information on the estimated waste quantities from these sources. It is noted that the calculation of DAF and FSL sludges for dewatering is based on the respective flow rates, pumping duration, and TS concentrations. Totalized flows along with TS concentrations may provide more accurate estimates.

The data were reviewed from various perspectives to seek confirmation of reasonable accuracy. However, this confirmation was unfortunately not achieved. Table 3-1 presents summary findings.

The huge variation in the wastewater solids production estimates cannot be explained at this time. The information will require review with the Municipality to agree on the basis for future planning. This should include a review of totalized flow data to check if the flow duration numbers are accurate. In addition, the estimates will require upward adjustment to account for the higher solids generation when septage is handled directly by the WWTF.

Table 3-1
Comparison of Current Dewatered Sludge Unit Production Estimates

Methodology	Dry Solids Production kg/ML Wastewater Treated	Comments
Mass balance with centrifuge data	380 (rounded)	9,378 kg/d dry solids with WWTF flow averaging 24.6 ML/d (9,378/24.6). Estimate appears reasonable.
Municipality estimates	565	49,300 kg/d wet sludge hauled to landfill at 25.4% TS concentration with WWTF flow averaging 24.6 ML/d (49,300*0.254/24.6). Estimate appears high.
Landfill haulage records	509	Average 53,461 kg/d wet sludge hauled to landfill at 25.4% TS concentration with WWTF flow averaging 24.6 ML/d (53,461*0.254/24.6). Records appear high.
Original plant design*	266	Phase 1 winter/summer mass balance 9,650 kg/d dry solids with average WWTF flow of 36.3 ML/d (9,650/36.3)

* Earth Tech 2004 Predesign Report

It appears that the mass balance provides the most reasonable estimate of solids production (380 kg/ML); however, this will require future verification. This preliminary conclusion is based on our knowledge of average solids production at other Alberta WWTFs (e.g., Grande Prairie – 332 kg/ML, Alberta Capital Region Wastewater Commission – 305 kg/ML).

Table 3-2 summarizes the recent overall solids production estimates.

**Table 3-2
Summary of Recent Overall Solids Disposal Estimates**

Source*	Average Quantity	Comments
1. Grit	~1 m ³ /d	Landfill disposal. May increase to 3 m ³ or 4 m ³ per day during a heavy rain
2. Screenings	~3 m ³ /wk	Landfill disposal
4. Primary Scum	Not known	Landfill disposal
8. Septage Lagoon Solids	Not known	Landfill disposal. Septage lagoon solids accumulation will be eliminated with direct septage discharge. However, solids loads at FMWWTF are estimated to increase by 43% with direct septage discharge.
10. Dewatered Sludge	~9,400 kg/d dry solids at 25.4% TS conc. ~37,000 kg/d wet solids	Backup landfill disposal. Comprised of 6,000 kg/d FSL and 3,500 kg/d TWAS dry solids. This represents ~380 kg dry solids production per ML wastewater treated.
11. Composted Biosolids	~39,000 kg/d dry solids at 80% TS conc. ~48,000 kg/d wet weight.	Landfill beneficial re-use. Bulk density is estimated to be <40% of that for dewatered sludge, requiring more than double the trips to the landfill.
12 Hydro-vac Type Wastes	~90,700 m ³ annually ~250 m ³ /d	On site accumulation. Ultimate disposal or re-use locations required.

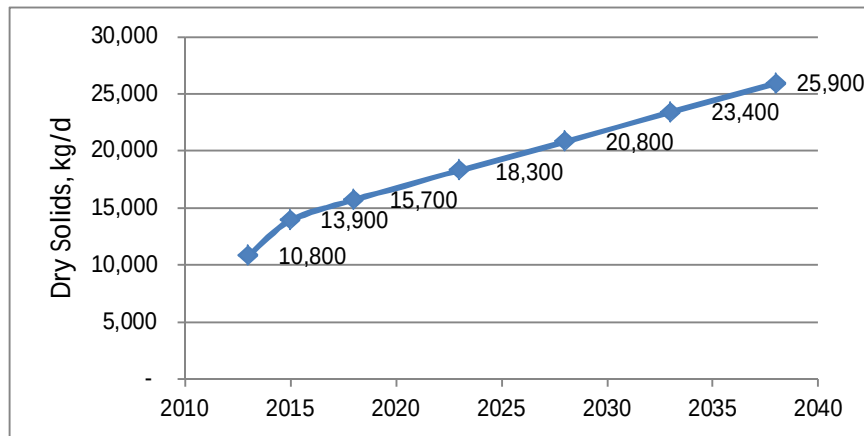
* The sources/numbers for solids streams correspond with those shown in Figure 3-1. Only those sources requiring disposal are shown in the table. Sources 3, 5, 6, 7, and 9 are managed within the WWTF; their respective quantities contribute to the listed sources that require disposal.

4 Solids Streams – Projected Loads

In the near future the FMWWTF will be able to handle septage directly and, therefore, increased solids loads from septage must be considered from 2014 and onwards. Also, by 2015, the proposed Anzac WWTF (and possibly Conklin WWTF) should handle an estimated 40% of the septage loads, leaving the FMWWTF with the remaining 60%. Considering these factors, medium growth rate (4% linear), and current

dry solids production rates averaging 380 kg/ML (based on mass balance), Figure 4-1 illustrates the projected dry raw solids production estimates for Fort McMurray. As previously indicated, the assumed unit solids production value needs to be confirmed.

Figure 4-1
Solids Production Projections (average dry solids, kg/d)



5 Review of South Regional WWTF Solids Management Technologies and Strategies

5.1 SRWWTF SOLIDS MANAGEMENT CONCLUSIONS

The main conclusions arising from the review of solids stream processes for the proposed SRWWTF are summarized as follows:

- The initial SRWWTF facility should incorporate many of the same solids handling facilities as the FMWWTF including: fine screening, vortex grit removal, alum feed system, and centrifuges.
- The initial SRWWTF should haul dewatered sludge to the existing FMWWTF until such time as the solids quantities or the opportunity for processing solids at a nearby gasifier becomes available.
- The initial SRWWTF should have design provisions to accommodate the future addition of DAF for WAS thickening, fermenters for VFA supply to a BNR process, as well as for primary sludge thickening, and possible utilization of the dewatered sludge in conjunction with municipal solids waste at a nearby gasification facility.
- Anaerobic digestion is rejected as a sludge stabilization option ³ due to:
 - Incompatibility with future BNR process;
 - High cost and complexity; and

³ The rejection of anaerobic digestion for SRWWTF was preliminary. For purposes of this Tech Memo, anaerobic digestion will be reconsidered.

- Loss of sludge energy value that can otherwise be captured with Municipality's proposed gasification facility.
- Possible future direct gasification of dewatered sludge at 25% solids composition appears to be energy-neutral.
- Further concentration of dewatered sludge to 30% to 40% total solids by drying could help achieve autogenic thermal oxidation in a future gasifier. However, unless the energy is "free" (waste heat that otherwise would be lost), the additional energy required for drying is not justified (energy required for drying would exceed the additional recoverable energy after drying).

5.2 SRWWTF SOLIDS MANAGEMENT RECOMMENDATIONS

5.2.1 Initial Solids Stream Processes

The recommended initial solids stream processes should include:

- Fine screening, screenings washing/compaction, landfill disposal of screenings.
- Vortex grit removal, washing/dewatering, landfill disposal of grit.
- Source thickening of waste activated sludge with primary sludge in primary clarifiers.
- Alum for chemical phosphorus removal.
- Dewatering of the combined primary/secondary sludge tentatively with centrifuges. Other dewatering processes (e.g., screw press) may also have merit and should be considered further.
- Haulage of dewatered sludge to the FMWWTF for inclusion in the composting process.

5.2.2 Provisions for Future Solids Stream Processes

The recommended initial solids stream processes should be planned to facilitate future modification as follows:

- Fine screening, screenings washing/compaction, landfill disposal of screenings: Feed screenings to gasifier when it is available.
- Vortex grit removal, washing/dewatering, landfill disposal: no changes.
- Source thickening of waste activated sludge with primary sludge in primary clarifiers: Terminate source thickening of WAS, utilize DAF to thicken WAS, utilize fermenters to thicken primary sludge, and produce VFAs required for BNR treatment.
- Alum for chemical phosphorus removal: Utilize alum only for trimming effluent phosphorus concentrations, as may be required, after converting the secondary/chemical treatment process to a BNR process. Both secondary and tertiary feeding (before filtration) should be included.
- Dewatering of the combined primary/secondary sludge tentatively with centrifuges: Predesign should also evaluate the possible merits of other dewatering technologies such as screw presses.
- Haulage of dewatered sludge to the FMWWTF for incorporation in the composting process: Feed dewatered sludge to gasifier when it is available. Consider a dryer using waste heat from the gasifier for further removal of moisture from the sludge prior to gasification.

- The layout of the sludge management facilities at the proposed SRWWTF should remain flexible to accommodate a range of sludge stabilization processes in the event that the Municipality changes direction and chooses not to proceed with a gasifier or other type of energy recovery facility.
- Consider backup sludge stabilization processes (e.g., alkaline stabilization) to provide reliable operation if the primary sludge stabilization process is temporarily out of service.

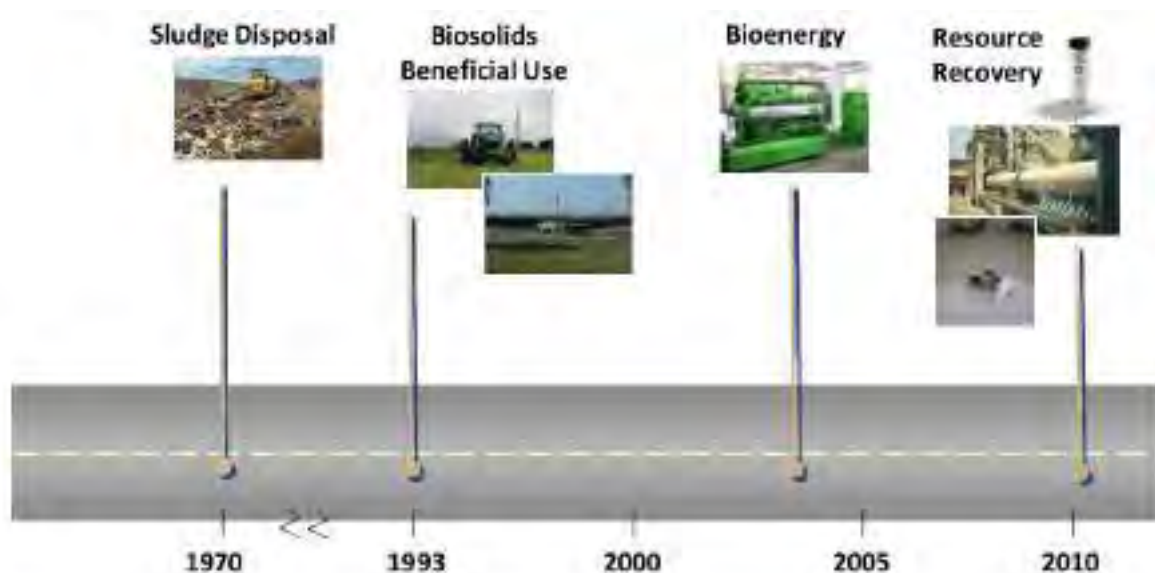
5.2.3 Applicable Solids Management Processes

With current growth projections for the Fort McMurray area, the timing of the proposed SRWWTF will be delayed well beyond 5 years. Therefore, the applicable recommendations from the SRWWTF study relate more to the longer term (refer to Section 5.2.2). The plan suggests that sludge stabilization by a means other than composting may be considered in future. This may include gasifiers for handling dewatered or dried sludge in combination with municipal solid waste (MSW).

6 Solids Management Technologies

The focus of solids management for WWTFs has transitioned from disposal to beneficial reuse and beyond. WEF (2011) report, "Charting the Future of Biosolids Management", illustrated this in Figure 6-1.

Figure 6-1
Charting the Future of Biosolids Management



Dewatered screenings, grit, and scum are transported to the landfill. We envisage that landfilling of these wastes will continue in the future, although the Municipality may choose alternate management techniques should the opportunity arise. The quantities associated with these types of wastes are relatively minor

compared to dewatered sludge, hydro-vac type wastes, and septage solids; and therefore, detailed analysis of options is limited to the latter three types of wastes.

The following are the main solids management options for consideration at both the existing FMWWTF and the future SRWWTF.

Technologies for managing biosolids may be categorized as:

- Pretreatment
- Treatment
- Resource recovery

6.1 PRE-TREATMENT TECHNOLOGIES

Thickening of biosolids prior to dewatering and subsequent treatment processes may be considered as pre-treatment. The Municipality already thickens primary sludge with fermenters and secondary sludge with DAF thickeners. This improves the performance of the centrifuges that are used for dewatering the sludge. Further review of these thickening technologies is not warranted at this time.

In the context of this report, biosolids pre-treatment processes are those aimed at reducing the generation of waste activated sludge (WAS) or improving its degradability prior to aerobic or anaerobic digestion.

6.1.1 Reduced Solids Generation

Cannibal® is an example of a solids reduction process. It removes inert materials from mixed liquor and hydrolyses excess biological solids to a degradable carbon source. Solids are removed from return activated sludge (RAS) with a 0.25 mm fine screen and hydrocyclones; typically this results in a 30% solids concentration suitable for haulage to a landfill. A sidestream “interchange” bioreactor handles a portion of the screened, cycloned RAS flow that would otherwise be wasted. The reaction is ORP⁴-controlled, alternating between aerobic and anoxic-anaerobic states, helping to condition the microorganisms. The process typically reduces WAS mass in the order of 40% to 60%. This may be considerably less at plants with primary clarifiers. WEF reports that the process is applicable to activated sludge plants without primary clarifiers and with a design flow of 1.9 to 95 ML/d.⁵ Since the FMWWTF has primary clarifiers, it appears that the potential benefits of the Cannibal process may not be significant enough to warrant further consideration at the facility.

6.1.2 Degradability Improvement

Generally the cell walls are weakened and the cell contents are lysed, providing a more readily biodegradable food source for organisms. Some of the methods include:

⁴ Oxidation Reduction Potential

⁵ WEF, WERF & USEPA, 2012. Solids Process Design and Management.

- Thermal hydrolysis (e.g., Cambi thermal hydrolysis process)
- Chemical treatment
- Pulsed electric fields
- High intensity ultrasound

The benefits of WAS pre-treatment include improved digestion with additional gas production and recovery (with anaerobic digestion) for heating, fuel supply and/or electricity generation. Should the Municipality decide at a future date to digest sludge, then WAS pre-treatment should be considered at that time.

6.2 TREATMENT TECHNOLOGIES

The main objective of treating raw sludge is to stabilize it. Stabilization renders the sludge much less putrescible (primarily reduced odour), reduces vector attraction (e.g., insects, rodents), improves appearance for end-user acceptance, reduces health hazards (e.g., achieves low pathogen levels), and ultimately enables its beneficial use. Once sludge has been stabilized to the intended level, it transitions to “biosolids”, a term which generally implies it is available for beneficial use. Therefore, biosolids are solids that have been stabilized in the treatment process, whereas sludge has not been stabilized. The two classes of biosolids that are generally recognized:

- Class A: Fecal coliform density <1000 MPN/g total solids or Salmonella sp. Density <3 MPN/4 g total solids, plus other requirements.
- Class B: Fecal coliform geometric mean <2x10⁶ MPN/g total solids or <2x10⁶ CFU/g total solids, plus other requirements.

In addition, solids that are land-applied, must meet metals pollutant loading limits, both ceiling concentrations and cumulative loadings.

In the United States, Class A biosolids have a wide variety of approved uses relative to Class B (refer to Table 6-1).

Table 6-1
Allowable Uses of Class A & B Biosolids⁶

Uses	Class A	Class B
Home lawns and gardens	✓	
Public contact sites	✓	
Urban landscaping	✓	
Agriculture	✓	✓
Forestry	✓	✓

⁶ WEF, 2010. Manual of Practice No. 8, Design of Municipal Wastewater Treatment Plants.

Regional Municipality of Wood Buffalo Wastewater Master Plan

Uses	Class A	Class B
Soil and site rehabilitation	✓	✓
Landfill disposal	✓	✓
Surface land disposal	✓	✓

Also, Class A biosolids application sites have unrestricted access and crop harvesting; whereas, Class B application sites have significant public access and crop harvesting restrictions (e.g., public access restrictions up to 1 year, no harvesting of food crops for up to 38 months after application).

With its composting process, the FMWWTF is designed to produce Class A biosolids; however, the end use of the biosolids to date has only been landfill application and disposal.

AESRD's limitations on biosolids land application are significantly different than USEPA's. There is no definition of Class A or B biosolids quality, i.e. no limits on coliforms or Salmonella. Alberta's 2001 "Guidelines for the Application of Municipal Sludges to Agricultural Lands" prescribe allowable application rates based on nutrient to metals ratios, site classification, and allowable maximum application rates for digested sludge, lagoon sludge, and undigested sludge.

With respect to compost facilities, the Alberta Government has published a Code of Practice for Compost Facilities. The document applies to composting of any organic feedstock including not only wastewater sludge but also municipal solid wastes. The Code of Practice stipulates coliform and Salmonella limits identical to those for USEPA's Class A biosolids and CCME's 2005 Guidelines for Compost Quality. It should also be noted that one of CCME's objectives for the compost guidelines is to discourage the application of untreated organic wastes to land.

Before biosolids can be beneficially utilized, they generally require some form of stabilization. Common stabilization technologies are aerobic digestion, anaerobic digestion, composting, alkaline stabilization, and heat drying.

6.2.1 Aerobic Digestion

Aerobic digestion is most common at small wastewater treatment facilities where ease of O&M is more important than the additional net energy requirements for aeration. Aerobic digestion is not considered further in this TM.

6.2.2 Anaerobic Digestion

Anaerobic digestion is common at mid to large size wastewater treatment facilities and may be a net positive energy provider. However, anaerobic digestion at BNR facilities has significant sidestream nutrient recycle implications and has often not been used at BNR facilities for that reason. Although anaerobic digestion was previously rejected as an option for the proposed SRWWTF, we suggest that it should be re-

considered in view of the possible significant net energy savings that may be achieved and its possible increased suitability at the larger FMWWTF.

“Anaerobic” essentially means no dissolved oxygen in a highly reducing environment (e.g., nitrates and sulphates reduced to nitrogen gas and sulphur forms, respectively). The process involves hydrolysis (solubilization of complex organics), acid formation (conversion of the solubilized organics to organic acids), and methane formation (conversion of the organic acids primarily to methane and carbon dioxide).

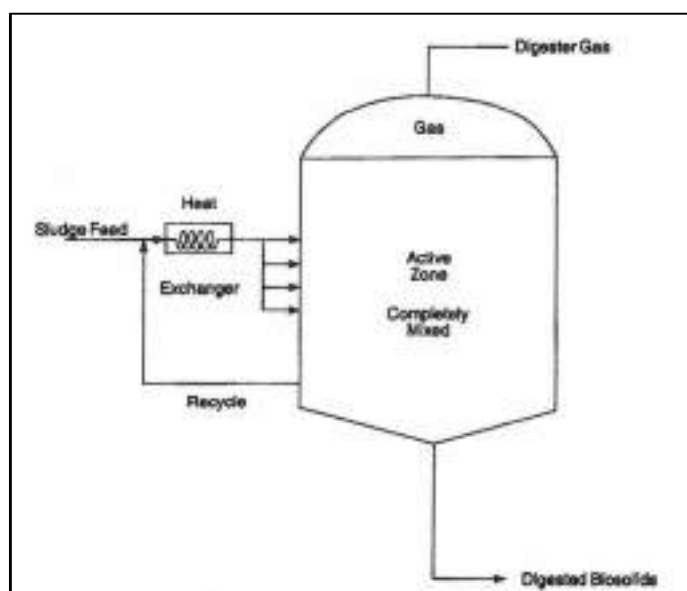
Two main anaerobic digestion processes comprise:

- Mesophilic (typically around 35°C).
- Thermophilic (typically around 55°C).

With mesophilic anaerobic digestion, Class B stabilization is achievable. Further processing is required if a Class A product is required. With thermophilic anaerobic digestion, Class A stabilization is achievable; and therefore, further processing may not be required. Treatment facilities with anaerobic digestion more commonly have mesophilic rather than thermophilic digesters.

Figure 6-2 shows a typical high rate anaerobic digester. Raw sludge and recycled sludge from the digester are fed through a heat exchanger to achieve the design temperature. Digester mixing may be achieved through recirculating the digester gas through spargers, through recirculation pumping, or through mechanical mixing. The digester gas may be beneficially used for heating, power, or fuel. Digested biosolids may also be beneficially utilized, typically after dewatering, and processed further.

Figure 6-2
Anaerobic Digester Schematic⁷



⁷ Reference: WEF MOP No. 8, Fifth Edition, 2010

6.2.3 Aerobic Composting

Composting of dewatered sludge has generally been adopted as the preferred solids stabilization process at BNR facilities, mainly due to its lower nutrient recycling concerns. It is the current solids stabilization process at the FMWWTF, although currently not operational. The aerobic composting process requires no further description since the Municipality is familiar with the process.

6.2.4 Alkaline Stabilization

Alkaline stabilization of dewatered sludge is a solids stabilization process generally applicable at small to large-size WWTFs. Historically, lime has been the chemical of choice but recently various other chemicals have been employed in advanced alkaline stabilization. The alkaline chemical is mixed with the raw sludge to achieve a starting pH >12 for 2 hours followed by pH >11.5 for 22 hours to meet the pathogen and other organism reduction objectives.

Alkaline stabilization can achieve a Class B product. Some advanced alkaline stabilization processes can also achieve Class A. To meet Class A requirements, elevated temperatures >70°C must also be achieved for at least 30 minutes. The associated chemical doses may be 2 to 4 times greater for Class A relative to Class B.

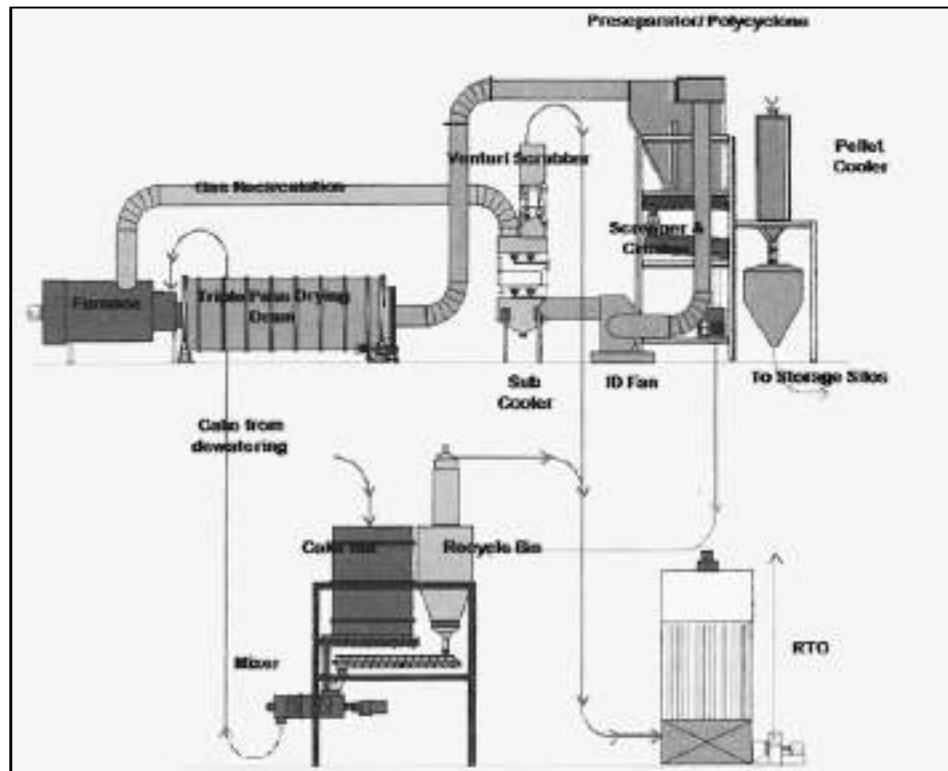
6.2.5 Heat Drying

Operating at temperatures >70°C for >30 minutes, heat drying can achieve Class A biosolids quality. The dewatered sludge must be dried to at least 90% solids concentration to meet Class A requirements when processing unstabilized primary sludge, or to at least 75% solids concentration when processing stabilized primary sludge. Drying to other percentage solids levels can also be considered depending on the subsequent use of the product.

The resulting pellets (granules) may be used as a fertilizer, soil conditioner, or a fuel supplement.

Figure 6-3 provides an illustration of a rotary drum dryer. Various other types of dryers are also available.

Figure 6-3
Rotary Drum Dryer⁸



6.3 RESOURCE RECOVERY TECHNOLOGIES

Wastewater biosolids are recognized as a source of multiple recoverable assets: nutrients, organics, energy, and water. A recent publication⁹ provides an excellent reference on resource recovery from biosolids. Table 6-2 highlights approaches and technologies for resource recovery – energy, nutrients and other.

⁸ Reference: WEF MOP No. 8, Fifth Edition, 2010.

⁹ National Biosolids Partnership, Water Environment Research Foundation and Water Environment Federation, 2013. Enabling the Future, Advancing Resource Recovery from Biosolids.

Table 6-2
Resource Recovery Approaches and Technologies

Category/Sub-category	Description
Energy Recovery	
Available Energy	- The energy contained in wastewater and biosolids exceeds the energy needed for treatment by a factor of 10. - Three types of energy: thermal, hydraulic, and chemical. Thermal energy may be recovered by heat exchangers. Hydraulic energy may be recovered by low head turbines. "The embedded chemical energy in wastewater is on average 2 to 10 times the energy needed for treatment."
Anaerobic digestion	- Variety of technologies to recovery energy with anaerobic digestion as well as multiple uses for the gas. - Gas production can be increased with co-digestion (e.g. blending FOG* with sludge). - Pre-treatment technologies can increase gas production (thermal hydrolysis, sonication, mechanical disintegration, and electrical pulse). Pretreatment technologies have the potential to increase biogas production by 30 to 60%.
Biogas use	- Digester heating, building heating, machinery drivers, power generation, pipeline injection, and vehicle fuel (various gas cleaning requirements). - Various combined heat and power (CHP) options are available. Established technologies include internal combustion engines, gas turbines, micro-turbines, and Stirling engines. Fuel cells are an emerging technology.
Thermal conversion	<u>Incinerators</u>: Multiple-hearth incinerators are being phased out in favour of more efficient fluidized bed incinerators with energy and heat recovery. Autogenous combustion at 26 to 35% Total Solids (TS). <u>Off-site co-combustion</u>: cement kilns as a secondary fuel source. <u>Gasification</u>: thermal conversion of biomass with limited oxygen supply into syngas. The sludge is normally dried to at least 80% TS before gasification. Syngas at a Florida biosolids gasification facility supplies about 80% of the energy required for drying the 16 to 23% TS sludge. <u>Pyrolysis</u>: The thermal conversion of carbonaceous biomass in the absence of oxygen to produce chars and bio-oil. <u>Super-critical water (SCW) oxidation</u>: SCW is a state in which water behaves as both a gas and a liquid and occurs at high temperatures and pressures. Chemical reactions occur extremely rapidly. This technology is in the development stage (one facility in Ireland and another in Florida).

Category/Sub-category	Description
Nutrient Recovery	
Electro dialysis	- Electro dialysis represents an <u>embryonic</u> extraction technology that allows for the recovery of all ions from nutrient streams at nutrient concentrations below 2000 mg/L. - An electrical current is used to separate anions and cations across an ion exchange membrane. - Successful application of this technology in full-scale facilities may be hampered by the high energy consumption, chemicals required for the regeneration of the membranes, membrane fouling, and heavy metal contamination.
Liquid-gas stripping	- Innovative technology. - Removes only nitrogen (N), not phosphorus (P). - pH needs to be raised above 9.3, temperature above 80°C. Air bubbled through the mixture forces the soluble N into the gas phase where the ammonia is then recovered by bubbling the nutrient-rich gas into sulfuric or nitric acid. This produces ammonium sulfate or ammonium nitrate, respectively (liquid fertilizer). - Ammonia removal efficiencies up to 98%. - The relatively high cost makes this option challenging for implementation in waste streams with N content less than 2000 mg/L.
Struvite crystallization	- Established technology. - Generally preceded by anaerobic digestion. - Ostara is the most common commercially recognized struvite (magnesium ammonium phosphate) crystallization process providing dry fertilizer pellets.
Other	
Enhanced fertilizer production	- Manufacture of a chemical fertilizer with biosolids as a component. - Two fertilizer companies have facilities under development in the U.S. - Both companies have adapted traditional chemical fertilizer technologies to use biosolids and introduce an organic fraction to the fertilizers.
Biodegradable plastics	A US company is developing a biological process that will use the carbon and other nutrients in biosolids to generate biodegradable plastic with a lifespan of months, not the centuries required to break down petroleum-based plastics.

*FOG = Fats, Oils, Greases

6.3.1 Energy Recovery

A noteworthy statement is that: “the energy contained in wastewater and biosolids exceeds the energy needed for treatment by a factor of 10”.

Anaerobic digestion, biogas use, and thermal conversion technologies enable energy recovery from biosolids. Anaerobic digestion is reviewed further in Section 7. Of the thermal conversion technologies, gasification is currently being evaluated by the Municipality for municipal solid waste (MSW) feedstock; dewatered/dried biosolids may supplement this feed.

Energy recovery processes typically imply the need for pre-treatment with anaerobic digesters (for biogas production and use) or thermal conversion (e.g., incineration or gasification). Although anaerobically digested sludge has reduced total energy relative to raw sludge, the digested sludge has been found to have superior dewatering characteristics so that the feed to a thermal conversion process has a higher unit calorific value.

6.3.2 Nutrient Recovery

Nutrient recovery technologies include electro dialysis, liquid-gas stripping, and struvite (magnesium ammonium phosphate) crystallization. Of these, struvite crystallization is a newly established technology gaining increased application. The technology is based on controlled chemical precipitation in a fluidized bed reactor that recovers struvite in the form of crystalline pellets. According to a vendor’s website (ostara.com/technology), nutrient-rich feed streams are mixed with magnesium chloride and, if necessary, sodium hydroxide and then fed into the reactor where minute particles or struvite “seeds” begin to form. These seeds grow in diameter until they reach a size of 1.0 mm to 3.5 mm. In a municipal wastewater treatment plant, up to 90% of the phosphorus and 40% of the ammonia load is removed from sludge dewatering liquid using this process and the resulting product is marketed as a commercial fertilizer called Crystal Green®.

6.3.3 Other Processes

Enhanced fertilizer production (two operating US facilities) and biodegradable plastics production (in development stage) are other technologies. Currently neither process is applicable to the Municipality. Fertilizer production requires a large scale production and existing production facility with nearby markets. Biodegradable plastics production has yet to be demonstrated at a full scale facility.

7 Biosolids Management Options

7.1 SOLIDS STREAM

What are the technologies that the Municipality should adopt for the short term (0-5 years) and consider for the long term (>5 years)?

Table 7-1 reviews the advantages and disadvantages of nine candidate biosolids management options for consideration:

1. Continued aerated static pile composting in tunnels (status quo).
2. Direct disposal at landfill (emergency operation).
3. Alkaline stabilization.
4. Stabilization through heat drying.
5. Gasification of dewatered sludge.
6. Gasification of dewatered sludge along with municipal solid waste (MSW).
7. Anaerobic digestion with combined heat and power (CHP) generation and no nutrient recycle mitigation.
8. Anaerobic digestion with CHP and side stream nutrient recovery through struvite crystallization
9. Combinations of the above.

The ninth “option” could comprise combinations of viable options, for example:

- Heat drying followed by gasification (Options 4 and 6).
- Anaerobic digestion with struvite crystallization (to reduce adverse nutrient recycle impacts on WWTF performance), heat drying (after dewatering), and gasification (Options 4, 6 and 8).

Except for direct landfill disposal of dewatered sludge (Option 2) during emergencies, beneficial re-use of biosolids is an implicit assumption in the following listing of candidate sludge/biosolids management options.

Beneficial biosolids re-use could involve use for:

- Landfill daily cover;
- Landfill final cover;
- Nutrient addition (greenhouse, tree growth/harvesting);
- Disturbed area reclamation (e.g., reclamation of mined oil sands areas); and
- Energy recovery (heat and power).

Further analysis of beneficial biosolids re-use options is beyond the scope of this report.

In addition to reviewing the advantages and disadvantages of the options, Table 7-1 provides preliminary recommendations on options to reject, to limit application, or to consider further.

Table 7-1
Comparison of Biosolids Processing Options

Option	Advantages	Disadvantages	Recommendation
1. Status quo – aerated static pile composting	• Can achieve Class A biosolids. • Handles variations in feed concentrations and loading rates. • Simple mechanical equipment.	• Labour intensive. • Large space requirements. • Operators exposed to composting piles. • Potentially dusty environment.	• Resume composting following replacement of the damaged foul air blowers. • Consider future decommissioning if other management options are implemented in the longer term.
2. Direct disposal of dewatered sludge at landfill	• Can serve as interim/emergency operation. • Reduced labour.	• Cannot achieve Class A or B biosolids. • Sludge/biosolids are not beneficially used. • Greater GHG production with uncontrolled anaerobic decomposition. • Difficulty in handling raw sludge at landfill. • Increased odour and vector attraction (e.g. insects and rodents).	• Reject as a primary option. Consider for emergency operation only.
3. Alkaline stabilization	• Can achieve Class A biosolids. • Relatively low capital cost. • Simple to start-up, operate, shut-down. • Suitable end product for acidic soils.	• High chemical use and annual cost. • Increased ammonia emissions may require additional odour control. • Some proprietary processes (annual patent fee). • Safety concerns with alkaline dust and ammonia gas. • Higher mass of solids to transport (short haul distances preferred).	• Reject. Re-consider in future only if other options are not satisfactorily implemented.
4. Stabilization through heat drying	• Can achieve Class A biosolids. • Reduced volume of product with lower transport costs. • Dried biosolids can be used as a fertilizer, soil conditioner or biofuel. • Less operator-intensive than composting. • Relatively small footprint compared to composting.	• More complex than compost process. • Proprietary systems. • High equipment costs. • More suited to continuous operation (smaller equipment, longer life, improved thermal efficiency). • Increased fire hazard. • Require design and operation measures to address explosion hazards. • Potential dust hazards with dried product.	• Reject as a stand-alone option due to high energy requirements. • Consider with Options 6 and 8.
5. Gasification of dewatered sludge	• Potential for recoverable fuel, heat and power. • Relatively small footprint compared to composting. • Complete destruction of pathogens. • Potential for reduced odour control requirements if odorous air can be utilized for gasifier air supply.	• No net energy benefit without pre-drying of dewatered sludge. • Minimal operating experience with sludge. • Mechanically complex system. • Air emission concerns? (e.g. nitrous oxide)	• Reject at this time due to limited full scale operating experience.

Option	Advantages	Disadvantages	Recommendation
6. Gasification of dewatered sludge with municipal solid wastes (MSW)	- Potential for recoverable fuel, heat and power. - Heat may be readily used for drying of dewatered sludge prior to gasification. - Complete destruction of pathogens. - Potential for reduced odour control requirements if odorous air can be utilized for gasifier air supply. - Gasifier operation can be smoothed with MSW as the main feed source.	- More mechanically complex than compost system. - No net energy benefit without pre-drying of dewatered sludge or improved dewatering of digested sludge. - Larger footprint required due to MSW. - Proprietary systems. - High equipment costs. - More suited to continuous operation (smaller equipment, longer life, improved thermal efficiency – both dryer and gasifier). - Emerging technology – potential for unsatisfactory operation and performance. - Significantly increased truck traffic at WWTF if gasifier is constructed to also handle MSW at the WWTF site. - Air emission concerns? (e.g. nitrous oxide). - BNR process capacity would be reduced – require expansion to produce same effluent quality. - Increased operating complexity with anaerobic digestion.	- Consider further subject to successful gasifier piloting trials. - Consider pre-drying of the dewatered sludge only if the heat energy for drying is free (would otherwise be wasted).
7. Anaerobic digestion with CHP ¹⁰ generation and no nutrient recycle mitigation	- Lower sludge treatment capital costs than for Option 8. - Significant energy recovery. - Improved sludge dewatering characteristics.		Reject due to diminishing returns – energy recovery benefits offset largely by additional treatment requirements.
8. Anaerobic digestion with CHP and side stream nutrient recovery through struvite crystallization	- Lower capital and O&M costs for BNR relative to Option 7. - Significant energy recovery. - Potentially usable end product (fertilizer pellets). - Improved sludge dewatering characteristics.	- Increased operating complexity with anaerobic digestion and nutrient recovery. - Some additional nutrient recycle slightly impacting BNR process.	Consider
9. Combinations of the above	Refer to above.	Refer to above.	- Consider combinations of options: 4 and 6 4, 6 and 8 - Others?

¹⁰ Combined heat and power.

Options **recommended for rejection**, along with the primary reasons for rejection at this time, include:

- Option 3 - Alkaline stabilization: High operating and haulage costs.
- Option 4 - Stabilization of dewatered sludge through heat drying: Reject as a stand-alone option due to high energy requirements. However, consider heat drying in conjunction with Options 6 and 8 since energy for drying can be recovered.
- Option 5 - Gasification of dewatered sludge: Limited full scale operating experience with sludge alone.
- Option 7 - Anaerobic digestion with CHP generation and no nutrient recycle mitigation: Energy recovery benefits offset largely by additional treatment requirements.

One option **recommended for limited application** at this time includes:

- Option 2 - Direct disposal of dewatered sludge at landfill: Biosolids are not beneficially utilized. Therefore, consider only for emergency operations.

Options **recommended for consideration** at this time include:

- Option 1 - Continued aerated static pile composting: Existing composting system is being restored to full operation. However, the future decommissioning of the composting system would be considered if Options 4, 6, 8, or 9 are implemented in future.
- Option 6 - Gasification of dewatered sludge with municipal solid wastes: Subject to successful gasification trials.
- Option 8 - Anaerobic digestion with CHP and side stream nutrient recovery
- Option 9 - Combinations of options with heat drying:
 - Options 4 and 6
 - Options 4, 6 and 8.

7.2 HYDRO-VAC TYPE WASTES

As indicated in Tech Memo A.1.3, Influent Waste Streams, further study should be undertaken with the objective of developing a sustainable plan for managing mud pit wastes. This should include:

- Confirmation of Total Solids concentrations of the wastes being discharged, stored in the mud pit, and following drying;
- Confirmation of the decant loads and the possible need to attenuate the return flows to the FMWWTF;
- Review of sustainable options (e.g., landfilling and tour of other Alberta facilities); and
- Preparation of a conceptual design report.

7.3 SEPTAGE SOLIDS

As indicated in Tech Memo A.1.3 (Influent Waste Streams):

- Confirm septage characteristics and restrict loads if necessary to enable proper WWTF operation.
- Evaluate direct septage load impacts versus indirect impacts with the septage lagoon providing a buffer.

8 Solids Management Capital Costs

The estimation of solids management capital costs most logically should be deferred until the feasibility of the gasification of sludge with MSW has been confirmed. This will be subject to future piloting trials.

9 Solids Management Plan

9.1 NEAR TERM (UP TO 5 YEARS)

1. Sludge production estimates should be reviewed further to agree on the basis for the solids management plan. This should include a review of totalized FSL and TWAS flows with the respective TS concentrations processed by the centrifuges.
2. The near term plan for solids management should focus on Option 1 (continued composting) with Option 2 (direct disposal of dewatered sludge at the landfill) utilized only during emergency operations such as compost facility out of operation.
3. The beneficial uses of composted biosolids should be further investigated to provide the Municipality with alternatives for their ultimate end use.
4. The characteristics of solids (Metals, TS, VS, etc.) should be confirmed for dewatered sludge, compost, hydro-vac type wastes, and septage solids to help confirm viable management options and appropriate beneficial uses.
5. Longer term options for biosolids management should also be evaluated further during the near term to facilitate transition to improved biosolids management in the longer term, should alternate management options prove favourable.

9.2 LONG TERM (5 TO 20 YEARS)

1. At this time, longer term options which may have merit appear to include:
 - a. Gasification of dewatered sludge (Option 6).
 - b. Anaerobic digestion with CHP and side stream nutrient recovery (Option 8).
 - c. Combinations of gasification and anaerobic digestion options with sludge drying (Option 9).
2. Should a gasifier be included in the Municipality's future, then the proximity of the gasifier to the sludge drying facility should be evaluated to maximize energy recovery potential.

Regional Municipality of Wood Buffalo Wastewater Master Plan



3. Should anaerobic digestion be included in the Municipality's future plans, then methods to maximize energy recovery should be evaluated. In addition to CHP, these should include WAS pre-treatment technologies.
4. The long term plan will require periodic updating, depending on the Municipality's growth, operating experience, and technology advances.

TECHNICAL MEMORANDUM A.3.4

Closure

This report was prepared for the Regional Municipality of Wood Buffalo Wastewater Master Plan to confirm the source of wastewater solids in Fort McMurray, both current and future, to identify options, and to develop a solids management plan.

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.

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.



Patrick W. Given, P.Eng.
Senior Wastewater Engineer

ASSOCIATED ENGINEERING	
QUALITY MANAGEMENT SIGN-OFF	
Signature:	<i>Edith [Signature]</i>
Date:	<i>June 13, 2014</i>
APEGA Permit to Practice P 3979	



Associated
Engineering

GLOBAL PERSONNEL
LOCAL FOCUS

Appendix A – Summary of Monthly Solids Data at Fort McMurray WWTF

Summary of Monthly Solids Data at Fort McMurray WWTF

Year	Mo.	FSL										TWAS						Feed		Cake		Treated Effluent [ML]
		Centrifuge 1 m³	Centrifuge 2 m³	Total FSL m³	Total Days	Total Hours	Avg FSL Q L/s	Avg FSL DC %	FLS Dry Solids kg	TWAS 1 m³	TWAS 2 m³	Total TWAS m³	TWAS Q L/s	TWAS DC %	TWAS Dry Solids kg	Total Feed Solids kg	Feed Solids %	DC %*	Vol m³			
2011	Jan	693	1,349	2,043					653	1,722	2,375									657		
	Feb	729	1,261	1,991					497	994	1,490									633		
	Mar	1,506	427	1,934					1,772	158	1,930									699		
	Apr	789	1,406	2,195					742	1,759	2,501									737		
	May	2,512	353	2,865					3,446	313	3,758									759		
	Jun	1,541	1,884	3,425					1,417	2,578	3,995									602		
	Jul	395	1,375	1,770					976	1,853	2,829									620		
	Aug	1,020	841	1,862					1,397	1,467	2,864									712		
	Sep	434	773	1,207					742	1,601	2,343									655		
	Oct	212	1,250	1,462					408	2,880	3,289									620		
	Nov	1,929	471	2,400					1,926	300	2,226									638		
	Dec	1,668	1,501	3,169					1,634	1,282	2,916									730		
2012	Jan	2,383	244	2,627	18	190	5.4	6.8%	178,800	2,211	342	2,554	5.1	3.3%	84,700	263,500	5.1%	24.9%	1,060	763		
	Feb	516	1,322	1,838	17	149	4.1	7.3%	134,400	770	1,956	2,726	6.1	3.4%	93,700	228,100	5.0%	22.0%	1,040	703		
	Mar	645	1,614	2,259	15	140	4.7	7.1%	161,000	780	1,716	2,497	5.3	3.8%	94,400	255,400	5.4%	20.2%	1,260	743		
	Apr	2,993	192	3,184	14	168	4.3	8.8%	280,000	2,418	182	2,601	4.9	4.3%	110,600	390,600	6.4%	28.0%	1,400	720		
	May	2,613	199	2,812	16	183	6.8	8.0%	223,900	2,175	251	2,426	5.0	3.8%	92,500	316,400	6.2%	27.2%	1,170	712		
	Jun	5,147	10	5,157	18	200	6.5	5.4%	280,900	3,032	2	3,034	4.8	3.6%	109,900	390,800	4.7%	26.9%	1,460	739		
	Jul	1,915	801	2,715	14	166	4.2	7.2%	196,400	2,372	401	2,773	4.2	3.9%	109,400	305,800	5.6%	25.7%	1,190	836		
	Aug	742	3,122	3,865	16	206	6.9	4.9%	189,800	490	1,439	1,929	3.5	3.9%	75,000	264,800	4.6%	24.7%	1,070	671		
	Sep	1,333	1,298	2,631	13	126	5.6	5.3%	138,700	1,130	700	1,830	4.6	3.7%	68,600	207,300	4.6%	25.5%	810	771		
	Oct	842	1,959	2,801	10	99	6.5	5.9%	165,900	773	1,273	2,046	5.0	3.8%	78,200	244,100	5.0%	24.6%	990	800		
	Nov				8	96	4.1	8.9%					3.9	4.0%				27.5%				
	Dec	2,211	544	2,756	6	119	4.5	8.2%	226,500	1,830	634	2,464	4.5	3.5%	85,000	311,500	5.8%	29.5%	1,060	797		
2013	Jan	1,412	1,198	2,610					1,977	1,044	3,021									804		
	Feb	1,895	732	2,626					1,964	992	2,957									714		
	Mar	1,120	820	1,939					1,628	938	2,566									817		
	Apr	789	1,591	2,380					742	1,763	2,505									767		
2012 Avg (excl. Nov)		1,940	1,028	2,968	14.3	159	5.4	6.8%	197,845	1,635	809	2,443	4.8	3.7%	91,100	288,900	5.3%	25.4%	1,137	750		
						11.1	average hours per operating day															
Daily avg		63.6	33.7	97.3	0.47	5.2			6,487	54	27	80			2,987	9,472			37	24.6		

* Detailed data on centrate quality is also available elsewhere. Generally target centrate TSS of 800 mg/L or 0.08% TSS is met.
FSL = fermenter sludge, TWAS = thickened waste activated sludge, DC = dry concentration (of totalsolids)

TECHNICAL MEMORANDUM A.3.5

Regional Municipality of Wood Buffalo

Wastewater Master Plan

Foul Air Management



September 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo Wastewater Master Plan. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Executive Summary

1 OBJECTIVE/PURPOSE

The foul air management review examines the sources of gas waste (odorous gases and greenhouse gases) from the existing wastewater treatment facility (WWTF) and the future South Regional WWTF. The overall purpose of this task is to develop a foul air (FOA) management plan for the gas generated by the wastewater treatment facilities in the urban RMWB.

The foul air management review includes:

- Review FOA management practices developed in the South Regional WWTF predesign work.
- Define sources of FOA from the existing WWTF (e.g., odour and other foul air sources).
- Estimate quantities and quality of gases.
- Develop a FOA management plan to deal with FOA produced by the existing WWTF.
- Summarize all findings and recommendations in a Technical Memorandum.

2 FINDINGS

FOA emissions from the Fort McMurray WWTF include:

- Some traces of odorous gases (stray and treated emissions) which may include:
 - Ammonia (NH_3)
 - Volatile organic compounds (VOCs)
 - Hydrogen sulphide (H_2S)
 - Organosulphur compounds
- Some greenhouse gases (GHGs), principally:
 - Carbon dioxide (CO_2)
 - Methane (CH_4)
 - Nitrous oxide (N_2O)

Emissions of GHGs are both direct (related to the wastewater and biosolids management operations) and indirect (related to support activities outside of the WWTF boundary, e.g., power generation, transportation of biosolids).

Identified odorous gas management technologies include:

1. Wet scrubbers
2. Foul air (FOA) diffusion in an activated sludge aeration basin
3. FOA supply to gasifiers
4. Ionizers
5. Carbon adsorbers

Regional Municipality of Wood Buffalo Wastewater Master Plan

6. Biofilters
7. Biotrickling filters
8. Solids scavengers
9. Chemical oxidation in the liquid phase.

The Fort McMurray WWTF currently utilizes Technologies 1 and 6 (one wet scrubber and two biofilters). These technologies have proven reasonably effective in minimizing fence line odours as evidenced by minimal odour complaints.

With respect to GHG emissions, quantification of the emissions and evaluation of their significance cannot be readily assessed within the scope of this report. However, it should be noted that the Municipality does have future GHG reduction opportunities, for example:

- Near term restoration of the compost process (significant reduction of CH₄ generation from the anaerobic degradation of undigested sludge disposed at the landfill).
- Offsetting some of the facility's heat and power requirements with renewable energy (e.g., gasification of wastewater solids and introduction of anaerobic digestion for gas production to generate heat and power).

The near term plan (up to 5 years) for the Fort McMurray Wastewater Treatment Facility's (FMWWTF's) FOA management is summarized as follows:

- The FMWWTF's current odour management systems should be kept operational.
- If the longer term solids management plan involves continued composting, then a second wet scrubber should be installed for backup.

The long term plan (5 to 25 years) for gas management is summarized as follows:

- If a gasifier is planned in future at the new landfill site, in close proximity to the proposed South Regional Wastewater Treatment Facility (SRWWTF), the opportunity to use FOA to meet part of the gasifier's air supply requirements should be considered. This approach would serve two purposes: supplement the gasifier's oxygen supply requirements and provide thermal destruction of the odours in the FOA.
- Haulage of dewatered sludge from the FMWWTF to a future gasifier at the landfill site would simplify odour control at the FMWWTF site. The large volume of FOA from the compost facility would be eliminated with the decommissioning of the compost process. The remaining FOA treatment could be effectively accommodated with the existing wet scrubber and/or biofilters.
- The possible future construction of a gasifier at the existing FMWWTF site could afford the Municipality with the same benefits as for the SRWWTF site.
- In the possible absence of a future gasifier at the SRWWTF site, consider diffusion of the FOA sources into the activated sludge aeration basins at that site.
- The recommended FOA management approach may require re-evaluation if a solids management approach, other than continued composting or gasification, is adopted in future.

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	iii
List of Tables	v
List of Figures	vi
1 Introduction	1
1.1 Scope of Work	1
1.2 Background	1
2 Existing Fort McMurray WWTF Foul Air Management	3
2.1 Odour Sources	3
2.2 Quality and Quantity	3
2.3 Odour Control Equipment	3
3 Review of Previously Proposed South Regional WWTF FOA Management	4
3.1 Sources	4
3.2 Equipment	5
4 FOA Management Options	5
4.1 Wet Scrubber	6
4.2 Activated Sludge Diffusion Using FOA Blowers	6
4.3 Gasifier	6
4.4 Ionizers	8
4.5 Carbon Adsorbers	8
4.6 Biofilter	8
4.7 Biotrickling Filters	9
4.8 Solid Scavengers	10
4.9 Oxidizing Chemicals	10
5 FOA Management Options Evaluation	11
6 Greenhouse Gases	14
6.1 Background	14
6.2 Fort McMurray WWTF GHG Sources	15
6.3 GHG Significance	16

Regional Municipality of Wood Buffalo Wastewater Master Plan



7	Conclusions and Recommendations	17
7.1	Short Term (up to 5 years)	17
7.2	Long Term (5-25 years)	17
	Closure	
	References	
	Appendix A – Odour Management Protocol	
	Appendix B – Drawings Showing Existing FMWWTF and Proposed SRWWTF Odour Sources	

List of Tables

	PAGE NO.
Table 1-1	Odourous Compounds from Wastewater Treatment Plants
Table 2-1	Centrifugal FOA Blower
Table 5-1	Comparison of FOA Management Options
Table 6-1	Greenhouse Gases and their Global Warming Potential
Table 6-2	Relative GHG Emissions
	2
	4
	12
	15
	16

List of Figures

	PAGE NO.
Figure 4-1 Wet Scrubber	6
Figure 4-2 Gasifier	7
Figure 4-3 Ionizer	8
Figure 4-4 Biofilter	9
Figure 4-5 Biotrickling Filter	10
Figure 6-1 Sources of Greenhouse Gas Emissions	15

1 Introduction

This technical memorandum comprises one of several technical memoranda prepared as part of the Regional Municipality of Wood Buffalo (Municipality) Fort McMurray Wastewater Master Plan (WWMP).

At the time the initial scope of this assignment was developed, the Municipality was planning for a second wastewater treatment facility, located in the south at the new landfill (South Regional WWTF). While this is still the long range intention, the Municipality subsequently decided that the anticipated growth rates would not warrant proceeding with the second plant, in the near future. Therefore, the foul air (FOA) management review has focused on the Fort McMurray WWTF (FMWWTF) under the assumption that all growth will impact the facility. The plan will require updating, once the Municipality re-initiates plans for the South Regional WWTF.

1.1 SCOPE OF WORK

The FOA management review examines the sources of FOA (odorous and greenhouse gases) from the existing wastewater treatment facility (WWTF) and the future South Regional WWTF. The overall purpose of this task is to develop a FOA management plan for the gas generated by the wastewater treatment facilities in the urban Municipality.

The FOA management review includes:

- Review FOA management practices developed in the South Regional WWTF predesign work.
- Define sources of FOA from the existing WWTF (e.g., odour and other foul air sources).
- Estimate quantities and quality of gases.
- Develop a FOA management plan to deal with gas waste produced by the existing WWTF.
- Summarize all findings and recommendations in a Technical Memorandum.
- Facilitate Tech Memo A.3.5 review meeting with the Municipality.

1.2 BACKGROUND

Ammonia (NH_3), hydrogen sulphide (H_2S), organosulphur compounds, and volatile organic compounds (VOCs) are the main sources of odour in a treatment plant. Table 1-1 lists the major compounds that cause odour at a wastewater treatment plant and their various limits.¹

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the main sources of greenhouse gas emissions related to WWTF operations. This is reviewed further in Section 6.

**Table 1-1
Odourous Compounds from Wastewater Treatment Plants (Concentrations in ppm)**

Compound	Olfactory Sensation	Absolute Threshold Concentration *	Alberta OH&S 8-hr Occupational Exposure Limit	Alberta Ambient Air Quality Objectives
Hydrogen Sulphide (H ₂ S)	Rotten Eggs	0.00047	10	0.010 (1-hr avg)
Ammonia (NH ₃)	Pungent	46.8	25	2
Methyl Mercaptan (CH ₄ S)	Rotten Cabbage	0.0021	—	—
Carbon Disulfide (CS ₂)	Sweet/Pungent	0.21	1	0.010
Biphenyl Sulfide (C ₁₂ H ₁₂ S)	Burned Rubber	0.0047	—	—
Dimethyl Sulfide (C ₂ H ₆ S)	Rotten Vegetables	0.001	10	—

* Absolute Threshold Concentration is defined as the minimum concentration that can be detected by 100% of the persons involved in olfactory analysis.

Odour control is an important design and operational factor for WWTFs. Alberta's Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Draining System (2012) state:²

"Setback distances from mechanical wastewater treatment plants are required to prevent the occurrences of objectionable odours in subdivision when plants are operated normally and within designed capacities. A building site for school, hospital, food establishment, or residential use has a setback of 300 m."

In most cases, odour can be detected by the human nose at very low concentrations, as reflected in the absolute threshold concentrations which are normally well below the Occupational Health and Safety (OH&S) Code (2009) limits.

Appendix A, which contains "RMWB WWTP Odour Management Protocol", states:

"The goal is to operate the facility such that on-site odour outside of buildings are generally considered acceptable by the staff and off-site odours are insignificant (ideally no complaints but not more than six annually)."

2 Existing Fort McMurray WWTF Foul Air Management

2.1 ODOUR SOURCES

Appendix B includes relevant Piping and Instrumentation Diagrams (P&ID), showing odour sources for the existing Fort McMurray WWTF, which are as follows:

- Sludge Equalization Hopper
- Process Drainage Wet Well
- DAF Supernatant Wet Well
- Centrate Tank
- TWAS Tank
- Dewatering Centrifuge
- Fermenters
- Headworks
- Primary Clarifier Inlet Channel
- Compost Tunnel
- Compost Building

2.2 QUALITY AND QUANTITY

FOA exhausted from the compost tunnels is laden with ammonia at an expected average concentration of 200 ppm,³ which must be treated to below 50 ppm to ensure that the biofiltration process is not adversely affected by high ammonia concentrations. This FOA stream is expected to have low concentrations of H₂S, amines, volatile organic compounds and reduced sulphur compounds.

The other FOA streams are combined and connected to the off gas from the scrubber. With the use of single stage centrifugal blowers, FOA streams are then delivered to the biofilter.

2.3 ODOUR CONTROL EQUIPMENT

The odour control system includes two stages of treatment including a wet scrubber for ammonia removal and biofilters for VOC removal. Only FOA from the compost tunnels is sent to the scrubber; all other FOA streams, including compost FOA from the wet scrubber, are sent to the biofilters.

2.3.1 Wet Scrubber

A packed bed wet scrubber is used to treat the ammonia laden exhaust gas from the compost tunnels. Sulphuric acid is used to precipitate out the ammonia. The cleaner FOA stream from the wet scrubber is blended (mixed) with other FOA from around the plant before entering the biofilters. Fresh water is constantly added to the scrubber system and the excess ammonia laden water overflows the scrubber sump and discharges into the scrubber room sump.

2.3.2 Biofilters

There are two biofilter cells for FOA treatment. There are four Centrifugal foul air blowers that provide ventilation for odour control to certain areas in the wastewater treatment plant (refer to Appendix B P&ID). The foul air blowers run continuously and their ratings are shown in Table 2-1. All of the FOA streams are directed using the blowers to the biofilters for treatment. Flow rate and pressure drop across the biofilters is measured, and the speed of the FOA blowers is modulated to achieve the desired flow.

**Table 2-1
Centrifugal FOA Blower**

Equipment	FOA Source	Design Flow (m³/hr)
Blower #1 (B-16-101)	Sludge Equalization Hopper Dewatering Fermenters Solids Building	6,150
Blowers #2/#3 (B-16-201/301)	Wet Scrubber FOA Outlet	70,000 each
Blower #4 (B-16-401)	Headworks	6,150

3 Review of Previously Proposed South Regional WWTF FOA Management

3.1 SOURCES

The South Regional WWTF studies focussed on the management of odourous gases, not GHGs. Appendix B illustrates the potential odour sources for the proposed South Regional WWTF. The following are the possible sources of foul air (FOA) in the facility:

- Mixed equalization tank
- Vortex grit tank
- Primary clarifier
- Future fermenter
- Future DAF
- Solids blend/buffer tank
- Centrifuge
- Future dryer

3.2 EQUIPMENT

3.2.1 Gasifier

Gasification is a thermal-chemical process functioning in a limited oxygen environment to produce syngas (CO, H₂, CO₂, and possibly CH₄) and other usable by-products. Currently, the Municipality is researching the feasibility of a municipal solid waste (MSW) gasifier through the study of a pilot gasifier. The Municipality is focusing on gasification technology to not only reduce waste sent to the landfill but also to recover energy for heating and power generation.

A gasifier may potentially be located in close proximity to the proposed South Regional WWTF. This could provide an opportunity to feed wastewater solids with the MSW to the gasifier to achieve additional benefits, specifically utilization of heat recovered from the gasifier for pre-drying of the wastewater solids, increased energy recovery from the additional feedstock, and an outlet for odourous air from the WWTF if it is blended with other air to meet the gasifier's partial oxidation requirements.

3.2.2 Chemical Scrubber

Compared to the existing Fort McMurray WWTF, the proposed South Regional WWTF doesn't have any composting so there is no ammonia laden FOA that needs to be treated. Nevertheless, chemical scrubbers to reduce various odourous gases collected around the WWTF could be considered for stand-alone odour treatment or in combination with other technologies (e.g., backup odour control for a gasifier when not in operation, or as pre-treatment ahead of a biofilter).

4 FOA Management Options

Identified FOA management options include:

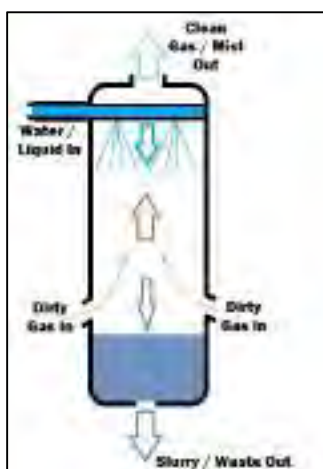
1. Wet scrubbers
2. FOA diffusion in an activated sludge aeration basin
3. Gasifiers
4. Ionizers
5. Carbon adsorbers
6. Biofilters
7. Biotrickling filters
8. Solid scavengers
9. Chemical oxidation in the liquid phase.

All, but the latter option, are vapour phase odour treatment technologies.

4.1 WET SCRUBBER

Figure 4-1 provides a simplified sketch of a wet scrubber. Wet scrubbers provide flexible, reliable technology to remove many water soluble compounds. The scrubbers may be effective in removing H_2S , VOC odours, and NH_3 . Typically packed towers containing plastic media provide contact between the upward flowing FOA and a downward spray of scrubbing solution with pH-adjusting and/or oxidizing chemicals to dissolve and/or oxidize the odorous compounds. Sodium hypochlorite is a commonly used oxidizing chemical, and sodium hydroxide or sulfuric acid is commonly used pH adjustment chemicals. Because wet scrubbers rely mainly on chemical processes, they are not dependent on physical or biological processes. Spent chemicals are typically discharged back to the WWTF for treatment.

**Figure 4-1⁴
Wet Scrubber**



4.2 ACTIVATED SLUDGE DIFFUSION USING FOA BLOWERS

An activated sludge air diffusion system can provide effective odour control. This approach has been applied at two Texas WWTFs,⁵ including the headworks, primary distribution structures, covered primary clarifiers/weirs, and primary sludge holding tanks. The FOA is collected and diffused through fine bubble air diffusers into activated sludge aeration basins. Closer examples of diffusing odorous air into activated sludge aeration basins are provided at the Alberta Capital Region Wastewater Treatment Plant, Red Deer Wastewater Treatment Plant, and the Grande Prairie Wastewater Treatment Plant. This method exhibits a relatively low O&M cost compared to most other odour control technologies.

4.3 GASIFIER

TM A.3.4, Solids Management Review, recommends gasification of dried biosolids with municipal solid waste (MSW) as an option for consideration in the longer term (>5 years). Practical experience with gasification of biosolids with or without MSW is limited and therefore not well proven. Piloting would be required to confirm the validity of this solids management option. If gasification is implemented in future, then there may be an opportunity to deliver odorous air collected from WWTFs to supplement the air

supply requirements for partial oxidation of the waste stream. Figure 4-2 shows the air supply for a gasifier as well as the other main inputs to, and outputs from, a gasifier.

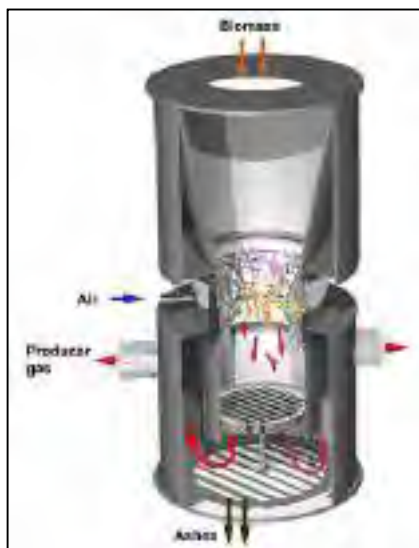
Although the air requirements for gasification are significantly less than the amount for complete oxidation (20% to 30% of stoichiometric air amount), the air requirement is still significant. Therefore, it appears that if 100% of the FOA is collected from a WWTF, it could supplement the gasification air requirement while simultaneously accomplishing odour control.

For this option to be feasible, the gasifier would need to be located in close proximity to the FOA source. Siting a gasifier at the new landfill site could provide the opportunity for feeding not only dried solids from a future SRWWTF, but also FOA from the SRWWTF to the gasifier. The gasifier may also potentially handle solids from the existing FMWWTF, but not the FOA, due to its relatively remote location.

If the solids from the FMWWTF are hauled for gasification at the new landfill site, the FOA treatment requirements at the FMWWTF would be greatly reduced, since composting—the major source of FOA—would no longer be practiced.

Siting of an additional gasifier at the existing FMWWTF may also be an option, although the handling of MSW at this location would also need to consider traffic flow/impacts. If a gasifier is constructed at or near the FMWWTF (perhaps within the current composting area), it could provide an opportunity to not only feed dried solids from the FMWWTF, but also feed FOA from the FMWWTF to the gasifier. As indicated above, the FOA treatment requirements at FMWWTF would be greatly reduced since composting—the major source of FOA—would no longer be practiced.

Figure 4-2⁶
Gasifier

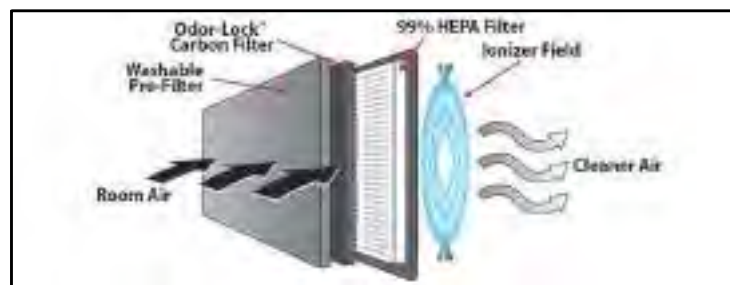


4.4 IONIZERS

Ionizers pass clean air along specialized tubes producing clusters of negative and positive oxygen ions. These ions are discharged into the foul air environment where VOCs are oxidized and other odorous compounds such as hydrogen sulphide are neutralized. Figure 4-3 illustrates how an ionizer treats FOA to cleaner air.

One of the key advantages of this method of odour treatment is that treatment occurs in the space where the odours are produced, and not on the discharge air, as with most other types of treatment. Other advantages are low power and low pressure drop.

**Figure 4-3⁷
Ionizer**



4.5 CARBON ADSORBERS

A Carbon Adsorber system operates on the basis of drawing in FOA to be processed through granular activated carbon that is often impregnated with chemicals (e.g., potassium permanganate, sodium hydroxide) to improve the adsorption of the components causing foul odours. Treated air is discharged to the outdoors, preferably near the building high point. Hydrogen sulphide and other sulphur based compounds are removed effectively by carbon adsorption systems, but ammonia and other nitrogen-based compounds are not effectively treated.

For typical systems, the carbon adsorbent becomes clogged within approximately two to four years of operation and requires replacement or regeneration. However, this time period largely depends on the concentration of hydrogen sulphide and other sulphides being removed and the volume of adsorbents within the system. Adsorbent replacement is expensive, cumbersome, and unpleasant. The adsorbent media itself is costly, bulky, and heavy.

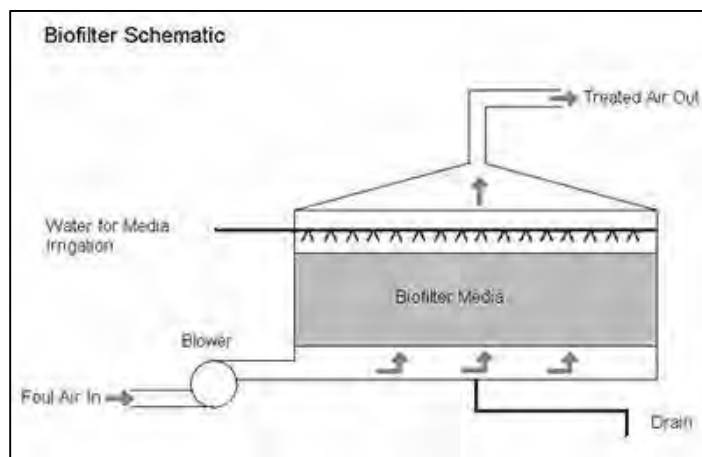
4.6 BIOFILTER

Biofiltration involves the passing of air through a biologically active media to clean FOA through biological oxidation processes. The filter media may have virtually any composition, from organic to synthetic, as long as it supports biological activity. How well a filter media works determines the biofilter's effectiveness in removing odour, volatile organic compounds, and toxic elements from a polluted air stream. The biological

processes in a biofilter system take place in the wetted surfaces of the filter media, where naturally occurring bacteria survive and grow. By passing the foul air through the media, the bacteria digest the contaminants in the air, thus purifying the air. The microorganisms in the biofilm require water that is sometimes maintained by spray system. Figure 4-4 shows a general schematic of a typical biofilter. Where the FOA is 100% water-saturated, which is the operating environment at FMWWTF, the media does not require a spray system.

Maintenance and operating costs are moderate and remain low throughout the lifetime of the biofilter. After the initial installation, the system requires power for the blower and water to keep the inorganic media wet as well as periodic media replacement (depending on the media type and loading rates). Maintenance and operating costs are moderate after the initial installation of the system.

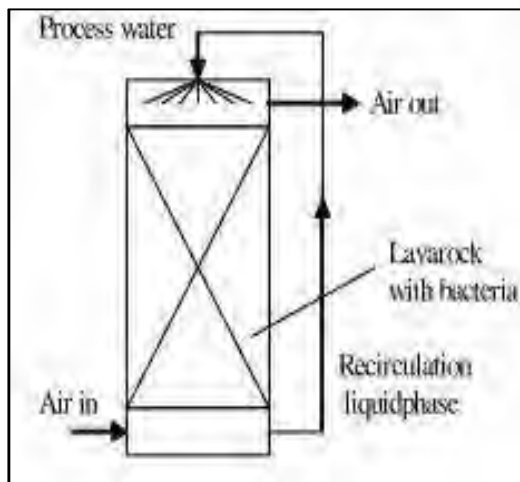
Figure 4-4⁸
Biofilter



4.7 BIOTRICKLING FILTERS

Biotrickling filters are designed for removal of high levels of hydrogen sulphide and other water soluble odorous gases. These filters incorporate inorganic filtration media and water recirculation to improve odorous contaminant removal in the liquid phase. Compared to biofilters, biotrickling filters have a lower pressure drop and a smaller footprint. Figure 4-5 shows a typical biotrickling filter.

Figure 4-5⁹
Biotrickling Filter



4.8 SOLID SCAVENGERS

Solid scavengers can be used to remove sulfur compounds from gas streams by reacting with them and making stable compounds, thus removing odourous chemicals in the gas. They are simple to use and have low capital cost. On the other hand, the solid itself cannot be regenerated and is therefore consumed. As a result, the solid scavengers need to be replaced periodically. This limits the application to cases with only low levels of sulphur compounds in the gas. Therefore, their use has been restricted more to gas industries than to wastewater treatment plants.¹⁰

4.9 OXIDIZING CHEMICALS

Iron salts can oxidize and/or precipitate dissolved sulfide in wastewater streams, thereby preventing their release into the atmosphere. Ferrous sulfate, ferrous chloride, and ferric chloride are common salts use for this process.

Other oxidizing chemicals for liquid phase odour sequestering include hydrogen peroxide, potassium permanganate, and ozone. This technology is applicable only for liquid streams and is not applicable to the FOA streams identified.

5 FOA Management Options Evaluation

Table 5-1 reviews the advantages and disadvantages of the identified FOA management options and provides preliminary recommendations for their further consideration or rejection.

At this time, options **recommended for rejection**, along with the primary reasons for rejection, include:

- Option 2 – Diffusion of FOA into activated sludge: Not currently practical at FMWWTF because of the large volume of FOA flows from the compost system and the significant distance between the compost process and the aeration tanks (may be considered for future SRWWTF as indicated below).
- Option 4 – Ionizers: Reject at this time since not capable of managing large volume FOA flows from compost system.
- Option 5 – Carbon adsorbers: Reject at this time due to high carbon replacement costs.
- Option 7 – Biotrickling filters: Reject at this time due to costly, proprietary media costs.
- Option 8 – Solids scavengers: Reject at this time due to costly solids replacement costs.
- Option 9 – Oxidizing chemicals: Not needed at this time, however consider in future if source-generated odours intensify significantly.

At this time, options **recommended for consideration** include:

- Option 1 – Wet scrubber: Continue use of wet scrubber at FMWWTF. If the compost process is to be retained in the long term use (>5 years), install a second wet scrubber to provide redundant capacity. Depending on future SRWWTF processes, also consider wet scrubbers for application at that site.
- Option 2 – Diffusion of FOA into activated sludge: Consider for future SRWWTF (but not FMWWTF as indicated above).
- Option 3 – FOA supply to gasifiers: Consider if gasifier is to be constructed in close proximity to either WWTF.
- Option 6 – Biofilters: Continue biofilter use at FMWWTF. Also consider for future SRWWTF if gasifier option proves not to be feasible.

Table 5-1
Comparison of FOA Management Options

Option	Advantages	Disadvantages	Recommendations for Consideration
1. Wet Scrubbers	- Flexible and reliable technology. - Can remove hydrogen sulphide, ammonia, and organic compounds in the foul air. - Can treat large volumes of FOA. - Moderate capital.	Hard to minimize the use of chemicals and cost while maintaining reliable treatment.	Consider a second scrubber (backup) at the Fort McMurray WWTF. Also consider similar technology at the future SRWWTF.
2. Diffusion of FOA into Activated Sludge	- Low capital cost. - Effective and low maintenance required. - Easy to operate. - No chemicals	- FOA blower may be prone to corrosion. - Not feasible to utilize all of the FOA for the FMWWTF.	- Existing FMWWTF: Not practical since the compost FOA air volumes are too large - Future SRWWTF: Consider.
3. FOA Supply to Gasifier	- Gasifiers are proven technology - Additional benefit of odour control. - FOA volume for treatment greatly reduced with elimination of compost process.	- Need continuous operation of gasifier or standby odour control. - Limited experience with gasification of sludge alone. - Odour source needs to be close to gasifier.	Consider in future if a gasifier is installed at the landfill site (future SRWWTF site).
4. Ionizers	- Effective odour management in localized areas. - Improved indoor air quality with odours being managed at source. - Low operating costs	- Odour control facilities need to be dispersed (at locations of odour generation). - Not practical for treating large volumes of air from compost operations.	Reject at this time.
5. Carbon Adsorbers	Effectively removes odorous sulphur compounds including hydrogen sulphide	- Not effective in removing ammonia. - Periodically requires costly carbon replacement - Not practical for treating large volumes of air from compost operations.	Reject from further consideration at this time.

Option	Advantages	Disadvantages	Recommendations for Consideration
6. Biofilters	• Low operating and maintenance costs. • Simple and effective against VOCs. • Can treat large volumes of FOA.	• Requires monitoring of bed and media replacement. • Cost of proprietary media can be expensive.	• FMWWTF: Continue biofilter use. • Future SRWWTF: Consider, together with activated sludge diffusion.
7. Biotrickling Filters	• Effective in removing high levels of hydrogen sulphide and other water-soluble odorous gases. • Smaller footprint than for biofilters. • Low pressure drop through porous media	• Requires water recirculation. • Proprietary filter media may be costly.	• Reject at this time.
8. Solids Scavengers	• Effective odour control.	• Solid is consumed and requires expensive, continuous replacement. • Not commonly used at WWTFs.	• Reject at this time.
9. Oxidizing Chemicals	• Effective liquid phase treatment. • Treatment at source reduces release of odours that would otherwise be liberated.	• Chemical addition can be expensive. • A supplementary odour management option that still requires other options for overall effective odour control.	• Consider in future if source-generated odours intensify significantly.

6 Greenhouse Gases

6.1 BACKGROUND

The historical focus of off-gas streams in WWTFs has been on odorous air; however, attention is now being given to off-gas streams containing greenhouse gases (GHGs). It is important for the Municipality to monitor industry developments in this area.

Figure 6-1 illustrates sources of greenhouse gas (GHG) emissions at a typical WWTF.¹¹ The emissions include CO₂, N₂O, and CH₄.

Carbon dioxide is considered “biogenic” (produced by living organisms) with respect to WWTF emissions and, therefore, it is not included as a global warming potential (GWP) contributor. On the other hand, both N₂O and CH₄ are “anthropogenic” (created by human activity) and are included in GWP contributors.

Recently, nitrous oxide emissions have received increased attention due to their relatively high GWP and known production at WWTFs. Nitrous oxide emissions impact GWP approximately 300 times (based on mass equivalent) more than carbon dioxide. Nitrous oxide emissions at WWTFs emanate mostly from the aerated zones of bioreactors.

Three possible phenomena that increase nitrous oxide emissions in aerated zones¹² are:

- Increased air stripping of nitrous oxide;
- Nitrous oxide production due to oxygen-inhibited heterotrophic denitrification; and
- Nitrous oxide production by autotrophic nitrification during changes in aeration.

Canada does not currently have any regulations for WWTFs to follow for nitrous oxide emissions.

Figure 6-1
Sources of Greenhouse Gas Emissions

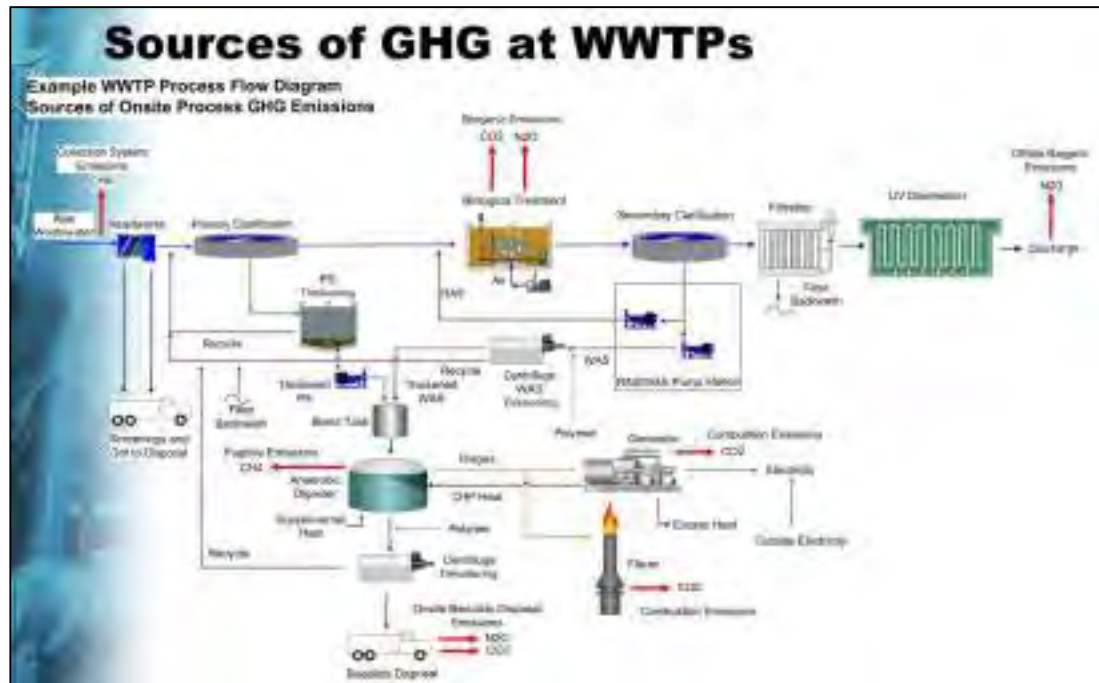


Table 6-1 lists the major GHGs and their Global Warming Potential (GWP) for a period of 100-year.¹³

Table 6-1
Greenhouse Gases and their Global Warming Potential

GHG	GWP for 100-Year
Carbon Dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous Oxide(N ₂ O)	298
Chlorofluorocarbon	10,900

6.2 FORT MCMURRAY WWTF GHG SOURCES

Some direct GHG emissions from the Fort McMurray WWTF originate from the aerobic biological treatment processes, that is the biological nutrient removal (BNR) and aerobic composting processes. As organisms in the wastes consume their carbon-based food supply, they utilize about 5 to 10% of the oxygen from the air (containing approximately 21% O₂ by volume) for respiration and release carbon dioxide, the most widely recognized GHG. In so doing, the oxygen in the air may be reduced to 18% to 19% by volume while the carbon dioxide replaces the lost oxygen. Nitrous oxide (N₂O) is also released in much smaller

quantities; however, the equivalent GHG impact of N_2O is in the order of 300 times that of CO_2 . In addition, there may be some minor releases of methane (CH_4) where anaerobic conditions contribute to the conversion of organic acids to CH_4 .

The existing septage receiving lagoons are another source of GHGs since anaerobically decaying sludge deposits in the lagoons release some methane which may escape into the atmosphere. The direct treatment of septage in the WWTF should help to greatly reduce this GHG source.

The current landfilling of the WWTF's raw sludge may be a relatively significant contributor to GHG releases. With the burial of the sludge, anaerobic conditions are maintained as the sludge slowly degrades. This source of GHG emissions will be eliminated when the aerobic composting process is re-activated at the WWTF.

6.3 GHG SIGNIFICANCE

USEPA¹⁴ published estimates of annual GHG emissions in terms of equivalent CO_2 loads from various sources in the United States between 1990 and 2011. The estimates included wastewater systems. While US estimates may not necessarily reflect relative impacts of various activities in Canada in general, or more specifically in Fort McMurray, we expect that they should provide a general idea of their relative GWP significance.

Table 6-2 provides a summary of some of the relative contributions. This shows that of the total emissions, wastewater systems account for an estimated 0.3% of the emissions. Landfills account for 1.5% of the total emissions, or about 5 times the wastewater emissions. Fossil fuel combustion is the primary source of GHG emissions at 78.7% of the total.

**Table 6-2
Relative GHG Emissions (2011 Estimates for USA)**

Source	% of Total Emissions	Comments
Fossil fuel combustion	78.7%	Main GWP contributor (CO_2 release)
Wastewater systems	0.3%	Excludes biogenic CO_2 . Relative impacts: $CO_2 : CH_4 : N_2O = 0 : 76 : 24$
Landfills	1.5%	Approx. 5 times more contribution than from wastewater. Landfill emissions based solely on CH_4 release.
Remainder	19.5%	
Total	100%	

7 Conclusions and Recommendations

7.1 SHORT TERM (UP TO 5 YEARS)

- The FMWWTF's current odour management systems should be kept operational.
- If the longer term solids management plan involves continued composting, then a second wet scrubber should be installed for backup.

7.2 LONG TERM (5-25 YEARS)

- If a gasifier is planned in future at the new landfill site, in close proximity to the proposed SRWWTF, the opportunity to use FOA to meet part of the gasifier's air supply requirements should be considered. This approach would serve two purposes: supplement the gasifier's oxygen supply requirements and provide thermal destruction of the odours in the FOA.
- Haulage of dewatered sludge from the FMWWTF to a future gasifier at the landfill site would simplify odour control at the FMWWTF site. The large volume of FOA from the compost facility would be eliminated with the decommissioning of the compost process. The remaining FOA treatment could be effectively accommodated with the existing wet scrubber and/or biofilters.
- The possible future construction of a gasifier at the existing FMWWTF site could afford the Municipality with the same benefits as for the SRWWTF site.
- In the possible absence of a future gasifier at the SRWWTF site, consider diffusion of the FOA sources into the activated sludge aeration basins at that site.
- The recommended FOA management approach may require re-evaluation if a solids management approach, other than continued composting or gasification, is adopted in future.

TECHNICAL MEMORANDUM A.3.5

Closure

This report was prepared for the Regional Municipality of Wood Buffalo Wastewater Master Plan to examine the sources of FOA waste from the existing wastewater treatment facility and the future South Regional wastewater treatment facility, thus developing a FOA management plan.

The services provided by Associated Engineering Alberta Ltd. 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.



Patrick W. Given, M.Sc., P.Eng.
Senior Wastewater Engineer

A handwritten signature in blue ink, appearing to read "Abu Waraich".

Abu Waraich, E.I.T.
Project Engineer

ASSOCIATED ENGINEERING QUALITY MANAGEMENT SIGN-OFF
Signature: <u>Edith Abselin</u>
Date: <u>Sept 10, 2014</u>
APEGA Permit to Practice P 3979



Associated
Engineering

GLOBAL PERSPECTIVE
LOCAL FOCUS

TECHNICAL MEMORANDUM A.3.5

References

- 1 Sewage and Wastewater Odour Control - Spartan Environmental Technologies, Alberta Occupational Health and Safety Code 2009, Alberta Ambient Air Quality Guidelines and Objectives.
- 2 Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Draining System: <http://environment.alberta.ca/01249.html>
- 3 Earth Tech Pre-Design Report Section 9.0.
- 4 IHS Global Specification: http://www.globalspec.com/learnmore/manufacturing_process_equipment/air_quality/scrubbers
- 5 Activated Sludge Diffusion Provides Cost Effective Biological Odour Control At Two Texas Wastewater Treatment Facilities: <http://www.environmental-expert.com/Files/5306/articles/12153/350.pdf>
- 6 EMISPEC: <http://emispec.ca/en/gaseous-fuel-production.php>
- 7 <http://www.inspiredliving.com/surround-air-ionizers/ti02-s3000-air-purifier.htm>
- 8 Odour Control at Ashbridges Bay: <http://www1.toronto.ca/wps/portal/contentonly?vnextoid=b7e807ceb6f8e310VgnVCM10000071d60f89RCRD&vnextchannel=0db7f75e4f18f310VgnVCM10000071d60f89RCRD>
- 9 Odour Control on Waste Water Treatment Plants and Pumping Stations using DMT Biotrickling Filtration: <http://www.dirkse-milieutechniek.com/dmt/do/download/ /true/202744>
- 10 Water and Waste Digest: <http://www.wwdmag.com/decentralized-wastewater/wastewater-odor-control-evaluation-technologies>
- 11 WERF, Carbon Heat Energy Assessment, and Plant Evaluation Tool Plant Evaluation Tool
- 12 Greenhouse Nitrogen Emissions from Wastewater Treatment Operation: Phase I Water Environment Research Foundation (WERF)
- 13 Carbon Dioxide Information Analysis Centre: http://cdiac.ornl.gov/pns/current_ghg.html
- 14 USEPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks

Appendix A – Odour Management Protocol

 REGIONAL MUNICIPALITY OF WOOD BUFFALO	RMWB WWTP Operations Plan	Approval No. 689-02-00	Page 1 of 2
4.1.4. (m) Odour Management Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

Issue

Operate the Fort McMurray Wastewater Treatment Plant with insignificant off-site odours.

Discussion

The treatment facility has a number of potential odour sources. Most of these are associated with the solids handling processes. Septage handling is another potential source. A number of measures and systems are in place to help control these odours, including:

- Aeration of septage in holding ponds prior to discharge to the facility;
- Covers over or enclosures around potential odour sources;
- Foul air collection system; and
- Foul air treatment with a wet scrubber and biofilters.

These measures and systems need to be operated efficiently in order to minimize odours.

Goals

The goal is to operate the facility such that on-site odours outside of buildings are generally considered acceptable by the staff and off-site odours are insignificant (ideally no complaints but not more than six annually).

Approach

The facility operators will maintain a database of on-site odour observations as well as odour complaints from the public.

If on-site odours are apparent, observations will be recorded including:

- Date, time, person who observed the odour;
- Comment on odour intensity at worst locations, e.g. nil, low, significant;
- Comment on nature/type of odour, e.g. earthy, ammonia, sulphurous, sulphide;
- Wind direction and speed, e.g. nil, light breeze, moderate, very windy;
- Air temperature;
- Suspected location of the odour;
- Suspected cause of the odour; and
- Remedial action: taken or suggested.

Abnormal on-site odour conditions will be reported to the foreman for appropriate action.

 CORPORATION OF THE CITY OF WOOD BUFFALO	RMWB WWTP Operations Plan	Approval No. 689-02-00	Page 2 of 4
4.1.4. (m) Odour Management Protocol		Effective Date: June 1, 2011 Revised Date: N/A	

Recording of off-site odour complaints should ideally be undertaken by one person to help ensure full documentation and consistency in recording. At this time, the administrative secretary is identified as the main complaint registrant. Complaint documentation will include:

- Complainant's name, address, location of odour (if different than address), date/time, telephone number;
- Complainant's comments on the odour, e.g. time(s) of observation, odour level, type of smell, frequency, duration, etc.;
- Wind direction and speed, e.g. nil, light breeze, moderate, very windy;
- Air temperature; and
- Date/time complaint reported by complaint registrant to lead operator.

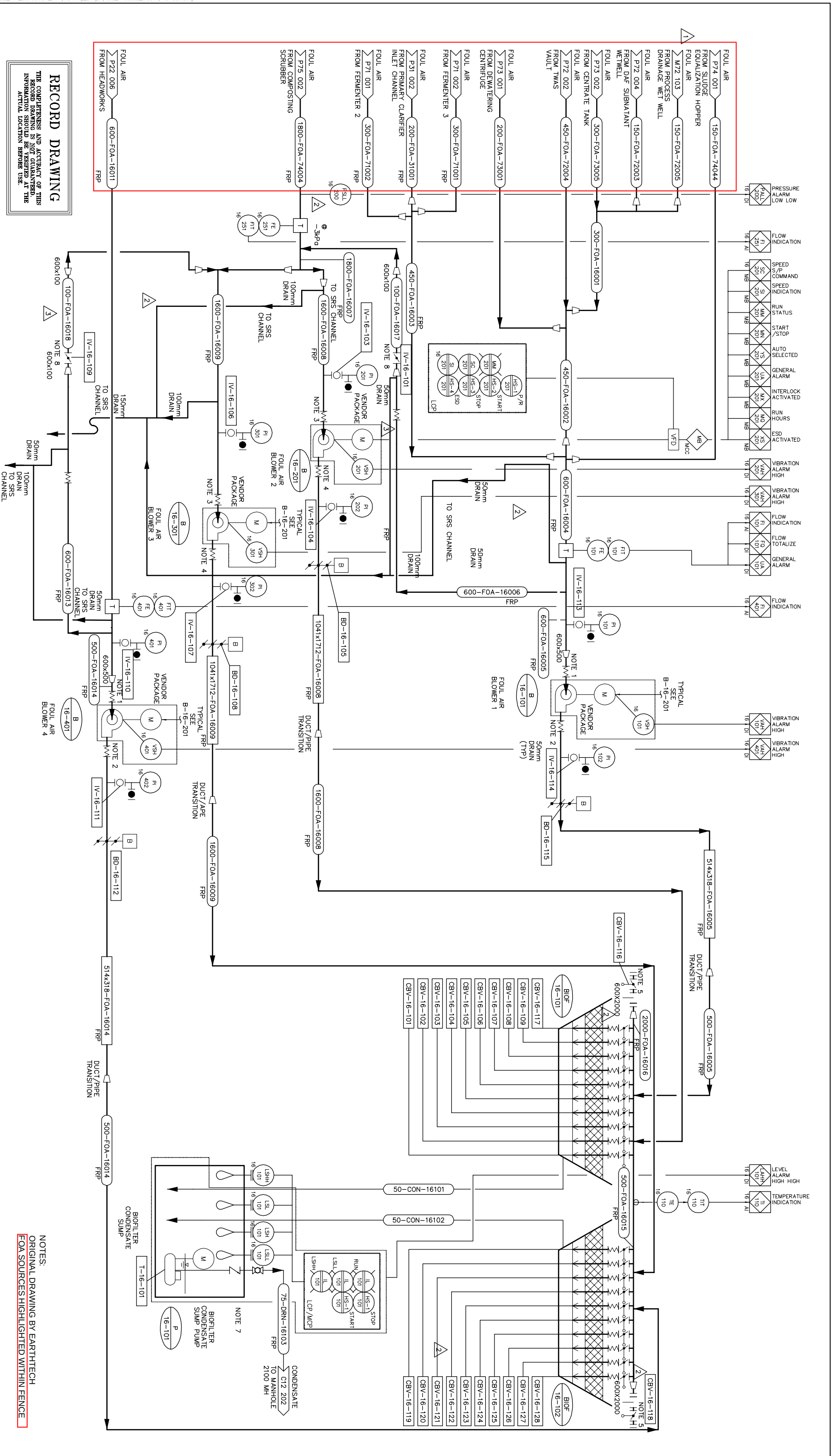
The complaint registrant will verbally report odour complaints to the lead operator who will be responsible for further investigation and remedial action, if required.

Notification and Reporting

Any operational problems which contribute to elevated on-site odours or odour complaints will be documented in the monthly and annual reports.

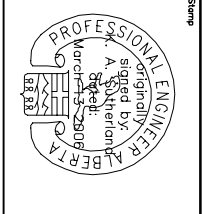
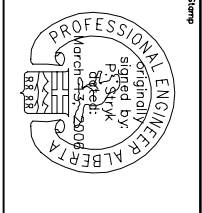
Change History N/A

Appendix B – Drawings Showing Existing FMWWTF and Proposed SRWWTF Odour Sources



1. PROVIDE A 500MM DIAMETER BLIND FLANGE FOR ISOLATION PURPOSES.
2. PROVIDE A 514mm x 318mm BLIND FLANGE FOR ISOLATION PURPOSES.
3. PROVIDE A 1600mm BLIND FLANGE.
4. PROVIDE A 1041mm x 1772mm BLIND FLANGE.
5. BLAST GATE WITH BLIND FLANGE ASSEMBLY.
6. REFER TO SPECIFICATION SECTIONS 11333 AND 11334.
7. PROVIDE TWO SPARE GASKETS FOR EACH LOCATION WHERE A BLIND FLANGE IS SHOWN OR REQUIRED IN THE NOTES SECTION OF THIS DRAWING.
8. DESIGN STANDARD FOR THE BUTTERFLY VALVE IS BRAY SERIES 21, LUG STYLE, CAST IRON BODY, 316 STAINLESS STEEL DISK AND STEM, AND AN EPDM SEAT, OR EQUIVALENT.

No.	Description	Sy	Date
B	RECORD DRAINING	LIS	10.01.29
A	ISSUED FOR CONSTRUCTION	LCC	06.03.24
3	ISSUED FOR ADDENDUM No.3	LPT	05.09.14
2	ISSUED FOR ADDENDUM No.2	LPT	05.09.07
1	ISSUED FOR ADDENDUM 1	LPT	05.08.17
0	ISSUED FOR TENDER	CD	05.07.29

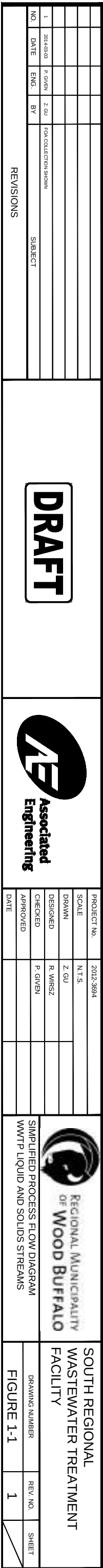


PERMIT TO PRACTICE
EARTH TECH(CANADA) INC.
Signed by: _____
Signature Will Mowrychuk
Date March 24, 2006
PERMIT NUMBER: P07502
The Association of Professional Engineers,
Geodists and Geophysicists of Alberta



REGIONAL MUNICIPALITY OF WOOD BUFFALO 2020-1094 Award 1001-1000-1000 1001-1000-1000		14-702-648-8000 14-702-648-8000 14-702-648-8000 14-702-648-8000	
date 2004.12.13	P/L/P/R/L/C 2004.12.13	Checked Approved Project No. 77020	Scale: NONE

FORT MC MURRAY WATER RECLAMATION FACILITY PROCESS AREA 16 - ODOUR CONTROL BIOFILTER P&ID	Draw No. P16_001 REV B
Sheet	



SUMMARY REPORT

Regional Municipality of Wood Buffalo

Wastewater Master Plan

Wastewater Treatment



September 2014

CONFIDENTIALITY AND © COPYRIGHT

This document is for the sole use of the addressee and Associated Engineering Alberta Ltd. The document contains proprietary and confidential information that shall not be reproduced in any manner or disclosed to or discussed with any other parties without the express written permission of Associated Engineering Alberta Ltd. Information in this document is to be considered the intellectual property of Associated Engineering Alberta Ltd. in accordance with Canadian copyright law.

This report was prepared by Associated Engineering Alberta Ltd. for the account of Regional Municipality of Wood Buffalo Wastewater Master Plan. The material in it reflects Associated Engineering Alberta Ltd.'s best judgement, in the light of the information available to it, at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Associated Engineering Alberta Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

SUMMARY REPORT

Executive Summary

The Regional Municipality of Wood Buffalo (Municipality) initiated a Wastewater Master Plan (WWMP) to develop a strategic plan for the wastewater infrastructure within the UDSR. A key component of assessing the wastewater system for the Municipality is evaluating Wastewater Treatment. This document summarizes the evaluation work completed for the Municipality's existing and future wastewater treatment infrastructure.

This Summary Report summarizes the following main topics that were discussed in a series of Technical Memorandums:

- Study Area
- Wastewater Inputs
 - Influent Waste Streams
- Wastewater Treatment
 - Wastewater Treatment Strategy
 - Existing Wastewater Treatment System
 - Future Wastewater Treatment System
- Wastewater Outputs
 - Effluent Total Loadings
 - Effluent Reuse
 - Solids Management
 - Foul Air Management

Table of Contents

SECTION	PAGE NO.
Executive Summary	i
Table of Contents	ii
List of Tables	iii
List of Figures	iv
List of Abbreviations	v
1 Introduction	1-1
2 Study Area	2-1
2.1 Service Area	2-1
2.2 Population Projections	2-2
3 Wastewater Inputs	3-1
3.1 Introduction	3-1
3.2 Liquid Waste Streams	3-1
3.3 Main Findings	3-11
3.4 Recommendations	3-12
4 Wastewater Treatment	4-1
4.1 Wastewater Treatment Strategy	4-1
4.2 Existing Wastewater Treatment System	4-8
4.3 Regulatory Review	4-11
4.4 Wastewater Treatment Technology Review	4-15
4.5 Main Findings	4-18
4.6 Recommendations	4-21
5 Wastewater Outputs	5-1
5.1 Effluent Total Loadings	5-1
5.2 Effluent Reuse	5-1
5.3 Solids Management	5-5
5.4 Foul Air Management	5-10
5.5 Main Findings	5-13
5.6 Recommendations	5-14
Closure	

List of Tables

	PAGE NO.
Table 2-1	North and South Ultimate Catchment Areas 2-1
Table 2-2	Ultimate Population Projections for UDSR 2-2
Table 2-3	North and South Population Splits 2-3
Table 2-4	25 Year UDSR Population Growth Range 2-4
Table 3-1	Projected Piped Wastewater Flow Projections (ML/d) 3-2
Table 3-2	2012 Fort McMurray WWTF Average Influent Loads 3-2
Table 3-3	Projected Hauled Septage Volumes for FMWWTF (ML/d) 3-4
Table 3-4	2012 Fort McMurray WWTF Average Septage Loads 3-5
Table 3-5	Mud Pit Waste Quantities 3-7
Table 4-1	Centralized vs. Decentralized Treatment Strategies 4-2
Table 4-2	Centralized vs. Decentralized Order of Magnitude Capital Cost Estimate in 2013 Dollars (\$ Millions) 4-7
Table 4-3	Centralized vs. Decentralized Annual O&M Costs in 2013 Dollars (\$ Millions) 4-7
Table 4-4	Centralized vs. Decentralized 25 Year Present Worth in 2013 Dollars (\$ Millions) 4-7
Table 4-5	Current and Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each of the Major Components Out of Service 4-8
Table 4-6	Fort McMurray WWTF Monthly Effluent Quality Summary 2010 to 2013 4-10
Table 4-7	Risk Assessment Metrics 4-11
Table 4-8	Potential Future Changes in Currently Regulated Effluent Constituents 4-13
Table 4-9	Potential Future Addition of Currently Un-Regulated Effluent Constituents 4-14
Table 4-10	Potential Horizon of Future Regulatory Requirements 4-20
Table 5-1	Summary of Athabasca River Water Quality Upstream of Fort McMurray 5-1
Table 5-2	Estimated Total Loads from Fort McMurray's Treated Wastewater Effluent, Stormwater and Snow Storage Systems (kg/d) 5-1
Table 5-3	Estimated Water Quality Impacts on the Athabasca River from Fort McMurray's Discharges Under Typical Low River Flow (February) and Average Annual Flow Conditions 5-4
Table 5-4	Preliminary Assessment of Reuse Water Use Potential for the High Water Customers in Fort McMurray 5-2
Table 5-5	Greenhouse Gases and their Global Warming Potential 5-11
Table 5-6	Relative GHG Emissions (2011 Estimates for USA) 5-12

List of Figures

	PAGE NO.
Figure 2-1 UDSR Population Projection Catchment Areas	2-5
Figure 2-2 UDSR Population Projections	2-7
Figure 3-1 Projected Average Day Piped Wastewater Flows for Fort McMurray	3-3
Figure 3-2 Projected Average Day Hauled Wastewater Flows for Fort McMurray	3-6
Figure 3-3 Fort McMurray WWTF Average Day Flow Projections	3-8
Figure 3-4 Fort McMurray WWTF Average Day BOD Load Projections	3-9
Figure 3-5 Fort McMurray WWTF Average Day TSS Load Projections	3-10
Figure 4-1 Overall Wastewater Conveyance Concepts for Centralized Wastewater Management	4-3
Figure 4-2 Overall Wastewater Conveyance Concept for Decentralized Wastewater Management	4-5
Figure 5-1 Estimated Wastewater Effluent Load Impacts	5-3
Figure 5-2 Water Balance Scenarios	5-3
Figure 5-3 Solids Production Projections (average dry solids, kg/d)	5-8

List of Abbreviations

The following abbreviations are used in this report:

ABBREVIATION	DEFINITION
Municipality	Regional Municipality of Wood Buffalo
AE	Associated Engineering Alberta Ltd.
AESRD	Alberta Environment and Sustainable Resource Development
Fort McMurray WWTF & FMWWTF	Fort McMurray Wastewater Treatment Facility
South Regional WWTF & SRWWTF	South Regional Wastewater Treatment Facility
WWTF	Wastewater Treatment Facility
AGB	Aerobic granular biomass
BNR	Biological nutrient removal
BOD	Biological oxygen demand
BPT	Best Practices Technology
C/I	Commercial/Industrial
CBOD	Chemical and biological oxygen demand
CCME	Canadian Council of Ministers of Environment
CEPT	Chemically-enhanced primary treatment
CH ₄	Methane
CO ₂	Carbon Dioxide
DAF	Dissolved Air Flotation
E.coli	Escherichia coli
EBPR	Enhanced biological phosphorus removal
EDC	Endocrine disrupting compounds
ENM	Engineered Nanomaterial
ESS	Municipality's Engineering Servicing Standards
FOA	Foul Air
GHG	Greenhouse gas
GWP	Global warming potential
H ₂ S	Hydrogen sulphide

**Regional Municipality of Wood Buffalo
Wastewater Master Plan**

ABBREVIATION	DEFINITION
HRAS	High-rate activated sludge
kg/d	Kilograms per day
m ³ /d	Cubic meters per day
mg/L	Milligram per litre
ML/d or MLD	Million litres per day
MSD	Main-stream deammoniafication
N ₂ O	Nitrous Oxide
NH ₃	Ammonia
NH ₃ -N	Ammonia Nitrogen
O&M	Operations and Maintenance
PPCP	Pharmaceuticals and personal care products
PTENR	Post-Treatment Extractive Resource Recovery
R	Residential
SCADA	Supervisory Control and Data Acquisition
TBL	Triple Bottom Line
TLP	Total Loadings Plan
TM	Technical Memorandum
TN	Total nitrogen
TOrCs	Trace organic compounds
TSS	Total suspended solids
UDSR	Urban Development Sub-Region
UV	Ultra-violet (disinfection)
TWAS	Thickened waste activated sludge
VFA	Volatile fatty acids
VOC	Volatile organic compounds
WAS	Waste activated sludge
WMF	Water Management Framework
WQBEL	Water Quality Based Effluent Limits
WWMP	Wastewater Master Plan

SUMMARY REPORT

1 Introduction

There is a significant need to develop a Wastewater Master Plan (WWMP) for the Regional Municipality of Wood Buffalo (the Municipality) to allow strategic planning and efficient operation of the wastewater treatment, the wastewater collection system, and the stormwater management system. In addition to assessing the key wastewater infrastructure components, the WWMP also develops an asset management capital plan and outlines a green initiatives framework for the Municipality.

The Municipality completed a Water Master Plan in 2012 and a Wastewater Collection Master Plan in 2009. The Wastewater Collection Master Plan completed in 2009 identified several upgrades required within the existing wastewater collection system. Since 2009, significant changes have occurred in the planning and development of Fort McMurray, which necessitate an update to the 2009 Wastewater Collection Master Plan. The Municipality commissioned Associated Engineering (AE) in 2011 to complete an updated WWMP.

The WWMP for the Municipality subdivided into 5 legs as follows:

- Wastewater Treatment (Leg A)
- Wastewater Collection System (Leg B)
- Stormwater Management (Leg C)
- Asset Management Capital Planning (Leg D)
- Wastewater Green Initiatives (Leg E)

This document provides a summary of the work that was completed on Wastewater Treatment (Leg A).

The Wastewater Treatment Summary Report is organized as follows:

Section/TM	Title
Section 2 – Study Area	
TM A.1.5	Urban Development Sub-Region Population Projection
Section 3 – Wastewater Inputs	
TM A.1.3	Influent Waste Streams
TM A.2.3.2	Regulatory Upgrade Requirements
Section 4 – Wastewater Treatment	
4.1	Wastewater Treatment Strategy
TM A.2.1.2	Wastewater Treatment Strategy

Regional Municipality of Wood Buffalo Wastewater Master Plan

Section/TM	Title
4.2	Existing Wastewater Treatment System
TM A.2.2.3	Existing Treatment System Capacity
4.3	Future Wastewater Treatment System
TM A.2.2.4	Treatment Technology Review
TM A.2.3.2	Regulatory Upgrade Requirements
Section 5 – Wastewater Outputs	
5.1	Effluent Total Loadings
TM A.3.3.2	Total Loadings Plan
5.2	Effluent Reuse
TM A.3.2.2/3	Reuse Water Definition and Strategy
5.3	Utility Corridors
TM A.3.1.4	South Utility Corridor
5.4	Solids Management
TM A.3.4	Solids Management Review
5.5	Foul Air Management
TM A.3.5	Foul Air Management

SUMMARY REPORT

2 Study Area

A clear understanding of the future growth areas and populations is required to determine proper projections of future infrastructure needs within the region. This section outlines:

- Future growth areas;
- Ultimate population projections for full development of growth areas;
- Annual population growth rates; and
- 25 year population projections.

2.1 SERVICE AREA

The ultimate service area for the Municipality is defined by the proposed Urban Development Sub-Region (UDSR), which was created by the Oil Sands Secretariat and Alberta Environment and Sustainable Resource Development (AESRD). Figure 2-1 illustrates the UDSR boundary, as well as the existing and future development areas identified for the region. The developments, within the UDSR, are separated into two different catchment areas: north and south. The developments are broken out into two different catchments for wastewater management. Section 4.1 outlines this management strategy in more detail. Table 2-1 provides a summary of the ultimate residential (R) and commercial/industrial (C/I) developments associated with each of the catchments.

Table 2-1
North and South Ultimate Catchment Areas

North Development Area	Gross Area (ha)	South Development Area*	Gross Area (ha)
R: Lower Townsite	439	<i>R: Prairie Creek</i>	25
R: Waterways	86	R: Hangingstone	1,553
R: Draper Valley	293	R: Horse River	678
R: Abasand	176	C/I: Airport East Industrial Lands+ Lynton	760
R: Beacon Hill	100	C/I: Southlands Area 1A	470
R: Gregoire (mixed use)	108	C/I: Southlands Area 1B	530
R: Saline Creek	860	C/I: Southlands Area 2	320
R: Saprae Creek/Spruce Valley	552	C/I: Southlands Area 4	218
R: Timberlea	1,001	<i>C/I: Airport West Industrial</i>	70
R: Thickwood	771	<i>C/I: Airport Lands</i>	668
R: Parson's Creek	837	<i>C/I: Mackenzie</i>	295
R: West Growth	1,061	<i>C/I: Gateway + Quarry Ridge</i>	38
R: Forest Heights	924		
C/I: Highway 63 Corridor	322		

** Italicized areas are deemed discretionary, that is they could be included in either the north or the south area.*

Regional Municipality of Wood Buffalo Wastewater Master Plan

Mackenzie, Prairie Creek, Gateway, and Quarry Ridge areas are listed in the south catchment area, even though they are currently situated in the north catchment, under the assumption that flows will be diverted to ensure a stable base flow to the future South Regional Wastewater Treatment Facility (South Regional WWTF) at start-up.

2.2 POPULATION PROJECTIONS

Table 2-2 summarizes the ultimate equivalent population projections for residential and commercial/industrial development areas in the north and south catchments. Ultimate equivalent population projections were estimated for each of the areas based on the following:

- Full development of the areas;
- Review of various past studies;
- Review of gross developable areas within the region; and
- The Municipality's 2009 Engineering Servicing Standards.

**Table 2-2
Ultimate Population Projections for UDSR**

North Catchment	Equivalent Population	South Catchment	Equivalent Population
Lower Townsite	48,000	Airport East Industrial Lands/Lynton	6,200
Waterways	2,700	Southlands:	
Draper Valley	400	Area 1A	5,200
Abasand	6,000	Area 1B	5,900
Beacon Hill	2,600	Area 2	6,800
Gregoire (mixed use)	7,400	Area 4	4,500
Saline Creek	20,000	Airport West Industrial	2,500
Saprae Creek/Spruce Valley	5,000	Airport Lands	6,050
Timberlea	42,000	Mackenzie	6,750
Thickwood	19,200	Gateway/Quarry Ridge (mixed use)	7,500
Parson's Creek	26,000	Prairie Creek	1,250
West Growth	31,000	Hangingstone	42,000
Forest Heights	24,000	Horse	15,000
Highway 63 Corridor	7,200		
Total Commercial/Industrial	7,200		
Total North Catchment	241,500	Total South Catchment	109,650
TOTAL UDSR (North + South)			351,150

For infrastructure planning it is important to evaluate equivalent populations for an area. Equivalent populations indicate residential as well as commercial/industrial population projections.

Commercial/industrial population projections are important, as these areas contribute to water demands and wastewater loadings, during periods of operation; therefore, population estimates are even more important, especially when planning water and wastewater systems within communities. Based on the review completed, the ultimate UDSR equivalent population, when all developments are built out, is estimated to be 351,150 people.

Past municipal census data indicates that the Municipality has experienced a range of 3.2% to 5.9% annual population growth between 5 and 10 years. With this, AE proposed the following range of population projection rates for the UDSR. The Municipality agreed to these projection rates at the November 18, 2013 workshop:

- Low 3.0% annual increase
- Medium 4.0% annual increase
- High 5.0% annual increase

Figure 2-2 illustrates that the equivalent population of the Municipality will range between 148,900 and 191,500 people in the UDSR within 25 years based on the annual growth rates identified.

To determine the growth in the north and south catchments, AE went through the exercise of estimating development in each of the development areas. This exercise was based on discussions that took place during the March, July, and October workshops regarding the areas that are under development and/or are likely to be developed. Table 2-3 summarizes the projected population split between north and south catchments in 5 year steps. The ultimate population split between the north and south is 69% and 31%, respectively.

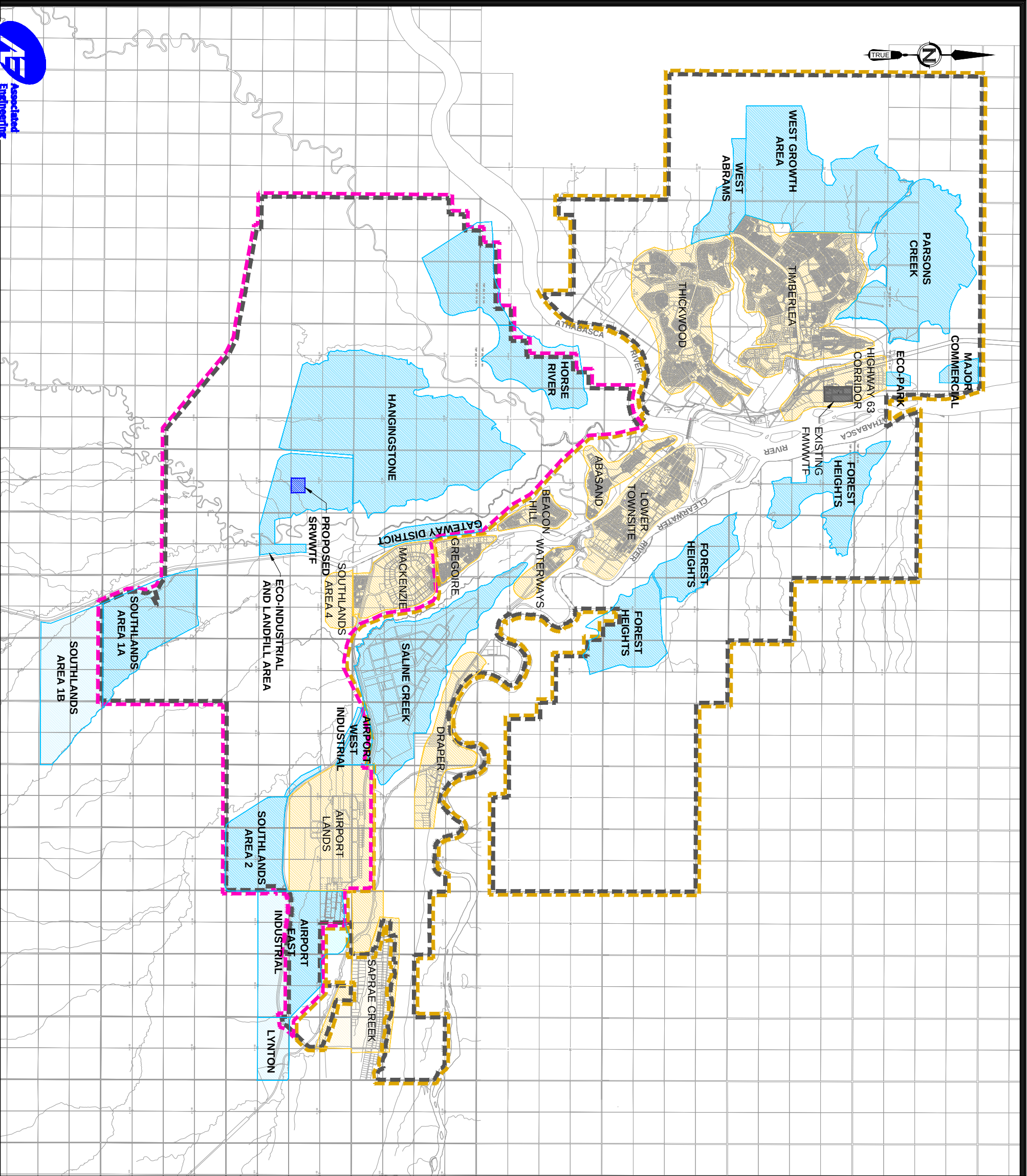
Table 2-3
North and South Population Splits

Catchment	2013	2018	2023	2028	2033	2038
North	100%	85%	75%	65%	65%	65%
South	0%	15%	25%	35%	35%	35%

Table 2-4 summarizes the 25 year population projections for the north and south catchments based on the above population split and three growth ranges.

Table 2-4
25 Year UDSR Population Growth Range

Catchment	2013	2018	2023	2028	2033	2038
3.0% Growth (low growth)						
North	85,100	83,215	82,950	80,210	88,530	96,785
South	—	14,685	27,650	43,190	47,670	52,115
UDSR 3.0%	85,100	97,900	110,600	123,400	136,200	148,900
4.0% Growth (medium growth)						
North	85,100	86,785	89,325	88,530	99,580	110,630
South	—	15,315	29,775	47,670	53,620	59,570
UDSR 4.0%	85,100	102,100	119,100	136,200	153,200	170,200
5.0% Growth (high growth)						
North	85,100	90,440	95,775	96,785	110,630	124,475
South	—	15,960	31,925	52,115	59,570	67,025
UDSR 5.0%	85,100	106,400	127,700	148,900	170,200	191,500



REGIONAL MUNICIPALITY
OF WOOD BUFFALO

UDSR POPULATION PROJECTION

CATCHMENT AREAS

LEGEND:

- SOUTH CATCHMENT BOUNDARY
- NORTH CATCHMENT BOUNDARY
- AESRD URBAN DEVELOPMENT
- SUB-REGION (UDSR)

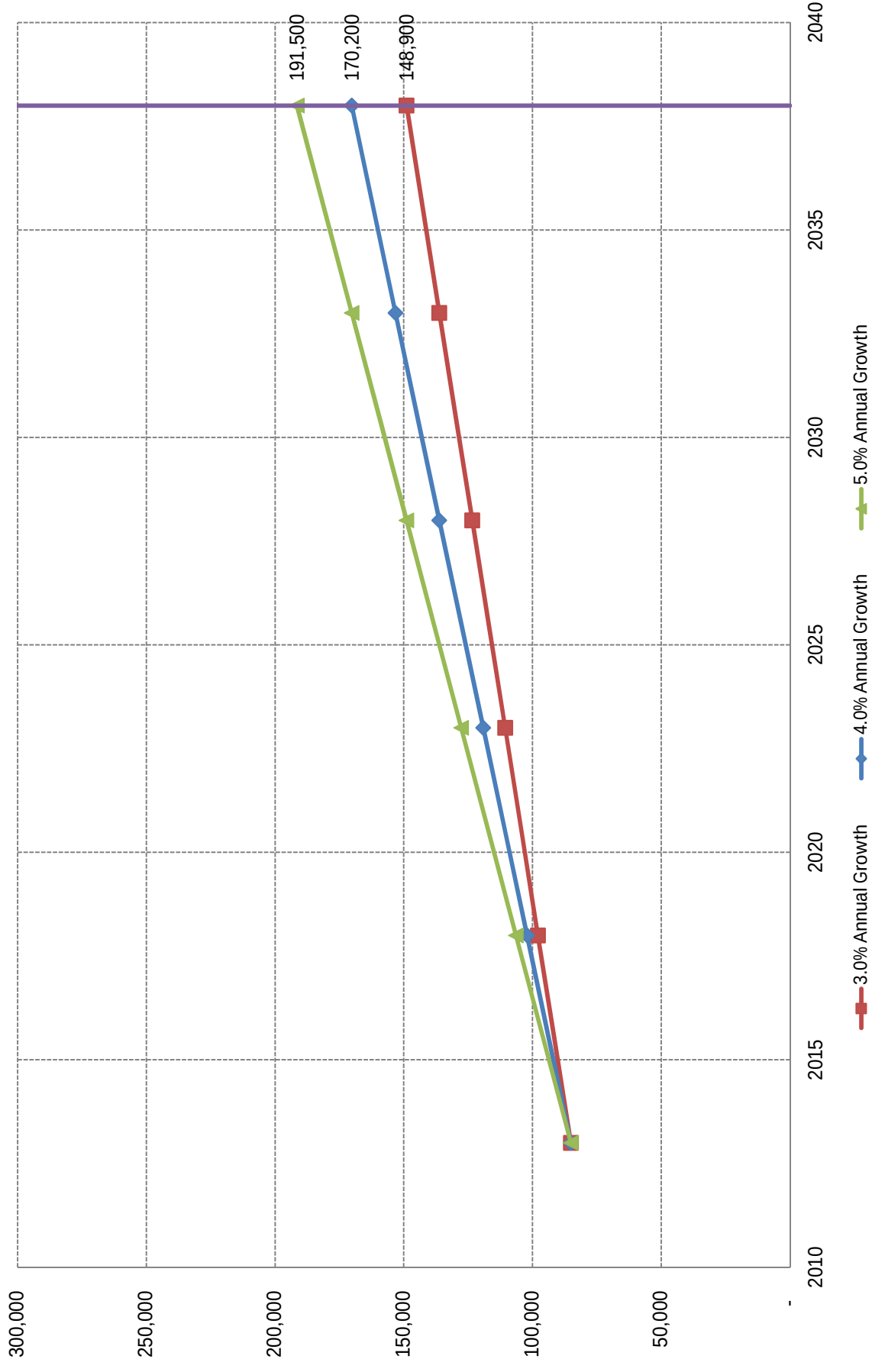
DEVELOPMENT AREAS:

- EXISTING DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS
- PROPOSED DEVELOPMENT AREAS OUTSIDE OF UDSR

SCALE: 1:100,000

JANUARY, 2014

Figure 2-2
Population Projections - UDSR



SUMMARY REPORT

3 Wastewater Inputs

3.1 INTRODUCTION

The main liquid wastewater stream at the Fort McMurray Wastewater Treatment Facility (WWTF) is comprised:

- Piped wastewater from the urban service area;
- Hauled septage from areas over a 150 km stretch (reaching from north of Fort MacKay to south of Conklin);
- Hydro-vac waste; and
- Other high solids content wastes hauled to the mud pit at the WWTF site.

The piped wastewater, septage (with or without lagoon pre-treatment), and periodic decant from the mud pit are combined for treatment at the existing Fort McMurray WWTF.

Sections 3.2.1 to 3.2.4 summarize the current and 25-year projections of wastewater flows and loads, as well as their distribution between north and south catchments. This information provides a basis for assessing the Municipality's current and future wastewater treatment approaches, as well as the approximate timing for a future WWTF to service growth areas in the south catchment.

3.2 LIQUID WASTE STREAMS

3.2.1 Piped Wastewater

In 2012, the Fort McMurray WWTF treated an average flow in the order of 25 MLD. This represents a per capita flow in the order of 300 L/c/d, which is approximately 60 L/c/d less than the Municipality's Engineering Servicing Standards (ESS), which outlines a design value of 360 L/c/d.

Table 3-1 and Figure 3-1 show the piped wastewater flow projections over a range of annual linear population/flow growth rates for a 25-year planning horizon. The flow projections are also broken down into flows for the south catchment, north catchment, and the total UDSR assuming the population projections in Section 2 and an equivalent average unit wastewater generation of 300 L/c/d for both existing and new developments.

The North and South projections reflect the flows that the Fort McMurray WWTF and the South Regional WWTF, respectively, would have to treat if and when a future South Regional WWTF is commissioned.

Table 3-2 summarizes average 2012 piped influent concentrations and average loads for various parameters.

Table 3-1
Projected Piped Wastewater Flow Projections (ML/d)

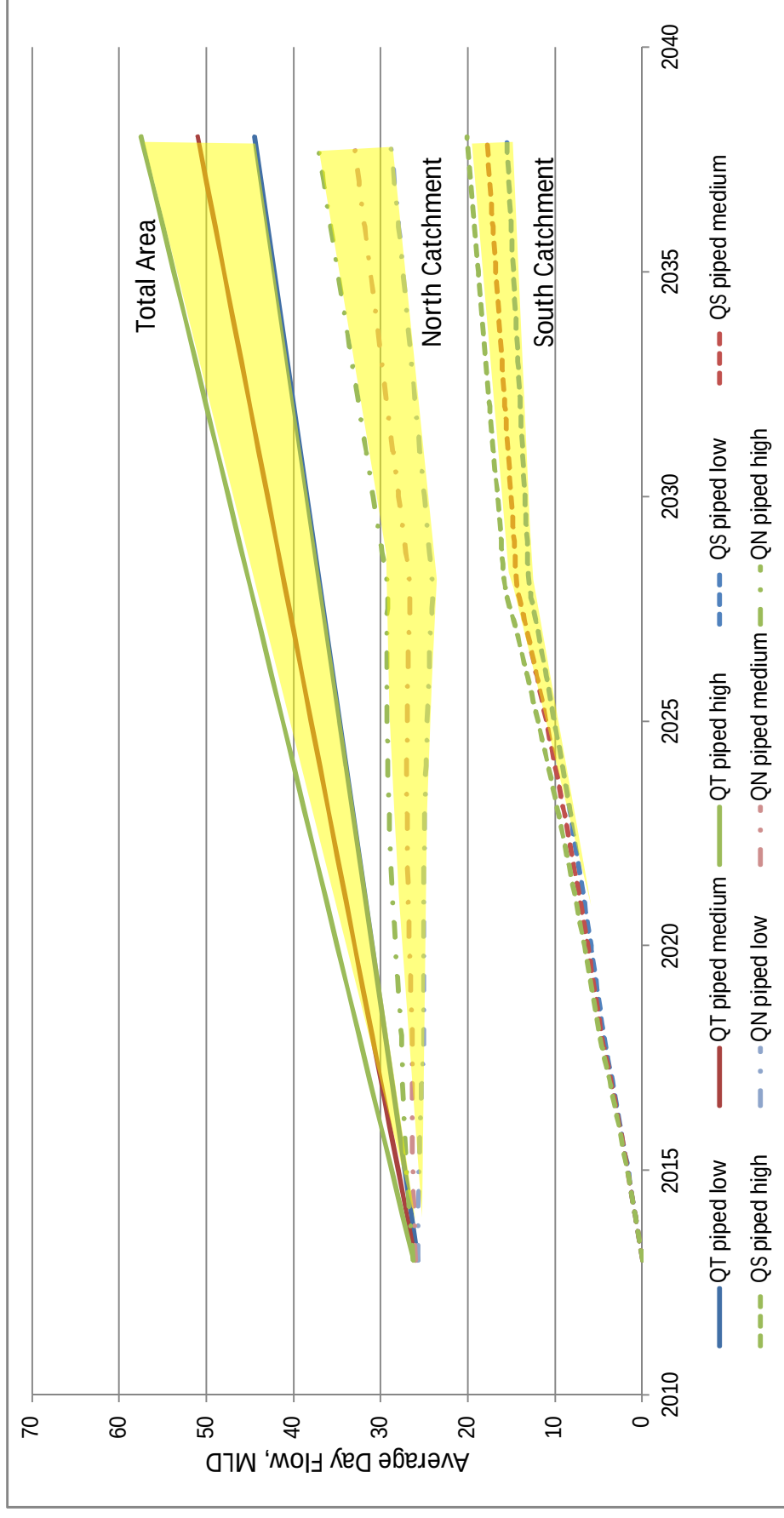
Catchment	2013	2018	2023	2028	2033	2038
3.0% Growth (low growth)						
North	25.8	25.1	24.9	24.1	26.5	28.9
South	0.0	4.4	8.3	13.0	14.3	15.6
UDSR 3.0%	25.8	29.5	33.3	37.0	40.8	44.5
4.0% Growth (medium growth)						
North	26.0	26.4	27.0	26.7	29.9	33.2
South	0.0	4.7	9.0	14.4	16.1	17.9
UDSR 4.0%	26.0	31.0	36.0	41.0	46.0	51.0
5.0% Growth (high growth)						
North	26.3	27.6	29.1	29.3	33.3	37.4
South	0.0	4.9	9.7	15.8	17.9	20.1
UDSR 5.0%	26.3	32.5	38.8	45.0	51.3	57.5

Table 3-2
2012 Fort McMurray WWTF Average Influent Loads

Parameter	Concentration mg/L*	Load kg/d
BOD	207	5,283
TSS	280	7,181
Total Phosphorus	3.6	91
OPO ₄ -P	1.8	47
NH ₃ -N	29.8	726
COD	482	12,657
pH	7.6	n/a

* Except pH

Figure 3-1



3.2.2 Septage

The septage haulage to the Fort McMurray WWTF in 2012 averaged 2,310 m³/d (2.31 ML/d). Commencing in 2015, the Municipality plans to divert an estimated 40% of the septage received to the Anzac WWTF which is under construction. Therefore, AE has assumed the Fort McMurray WWTF septage loads will be reduced to 60% of the projected total septage loads commencing 2015. AE has also assumed that the hauled wastewater will increase at rates mirroring the piped system population/flow increases. With the southern hauled septage being diverted, the north facility would see an initial reduction in septage volumes, followed by gradual increases back to the initial levels and beyond.

With these assumptions, the average projected hauled septage volumes (ML/d) to the Fort McMurray WWTF are shown in Table 3-3 and Figure 3-2.

**Table 3-3
Projected Hauled Septage Volumes for FMWWTF (ML/d)**

Catchment	2013	2018	2023	2028	2033	2038
3.0% Growth (Low growth)						
North	2.4	1.6	1.8	2.1	2.3	2.5
4.0% Growth (Medium growth)						
North	2.4	1.7	2.0	2.3	2.6	2.8
5.0% Growth (High growth)						
North	2.4	1.8	2.1	2.5	2.8	3.2

In 2009, AE completed a Septage Study for the Municipality. In this Study, AE reported that constituent concentrations in the septage hauled to Fort McMurray's septage lagoons were significantly higher than for the piped wastewater. Consequently, the septage loads are markedly higher per unit volume. Table 3-4 summarizes the estimated septage load concentrations for 2012.

Table 3-4
2012 Fort McMurray WWTF Average Septage Loads

Parameter ^a	Concentration mg/L ^b	Loading Factor ^c	Load ^d kg/d
BOD	700	3.4	1,600
TSS	1,700	6.6	3,900
TP	40	6.8	95
TKN	150	4.2	340
COD	2,200	4.9	5,100
pH	7.0 – 9.0 range	n/a	n/a

^a BOD – biochemical oxygen demand, TSS – total suspended solids, TP – total phosphorus, TKN – total Kjeldahl nitrogen, COD – chemical oxygen demand.

^b Rounded average concentrations in milligrams per litre except for pH units shown as a range.

^c Rounding loading factors reported by AE (Fort McMurray Hauled Wastewater Study, 2009), reflecting the proportionately higher strength of septage relative to piped wastewater.

^d Estimated 2012 loads based on 2009 average septage concentrations and 2012 average septage volume (2.31 ML/d).

3.2.3 Hydro-Vac Type Wastes

The Municipality receives hauled hydro-vac waste to the Fort McMurray WWTF. Hydro-vac waste is not suitable for direct discharge at the wastewater treatment facility as it is typically inert material. Sources of hydro-vac wastes may include industrial cleaning, waste removal, day-lighting, trenching, post hole digging, and spill clean-up.

Hydro-vac and other liquid wastes, with high inert solids contents, are hauled to a mud pit (approximately 30,000 m² area) at the Fort McMurray WWTF. Adjacent to the mud pit is an area that is used for drying. Generally, most of the liquid portion of the hydrovac waste arriving is drained directly into the mud pit. After a period of decanting the liquid from the mud pit, the solids are excavated and further dried at the drying area. Any solids portions of the hydro-vac wastes that arrive at the mud pit are generally deposited directly into the adjacent drying area. This waste has been accumulating except for a portion which was used to supplement the fill requirements for the 2013 septage system construction. The drying area is rapidly becoming full; therefore, the present practice is not sustainable and a long term management approach for these wastes is required.

Figure 3-2
Projected Average Day Hauled Wastewater Flows for Fort McMurray

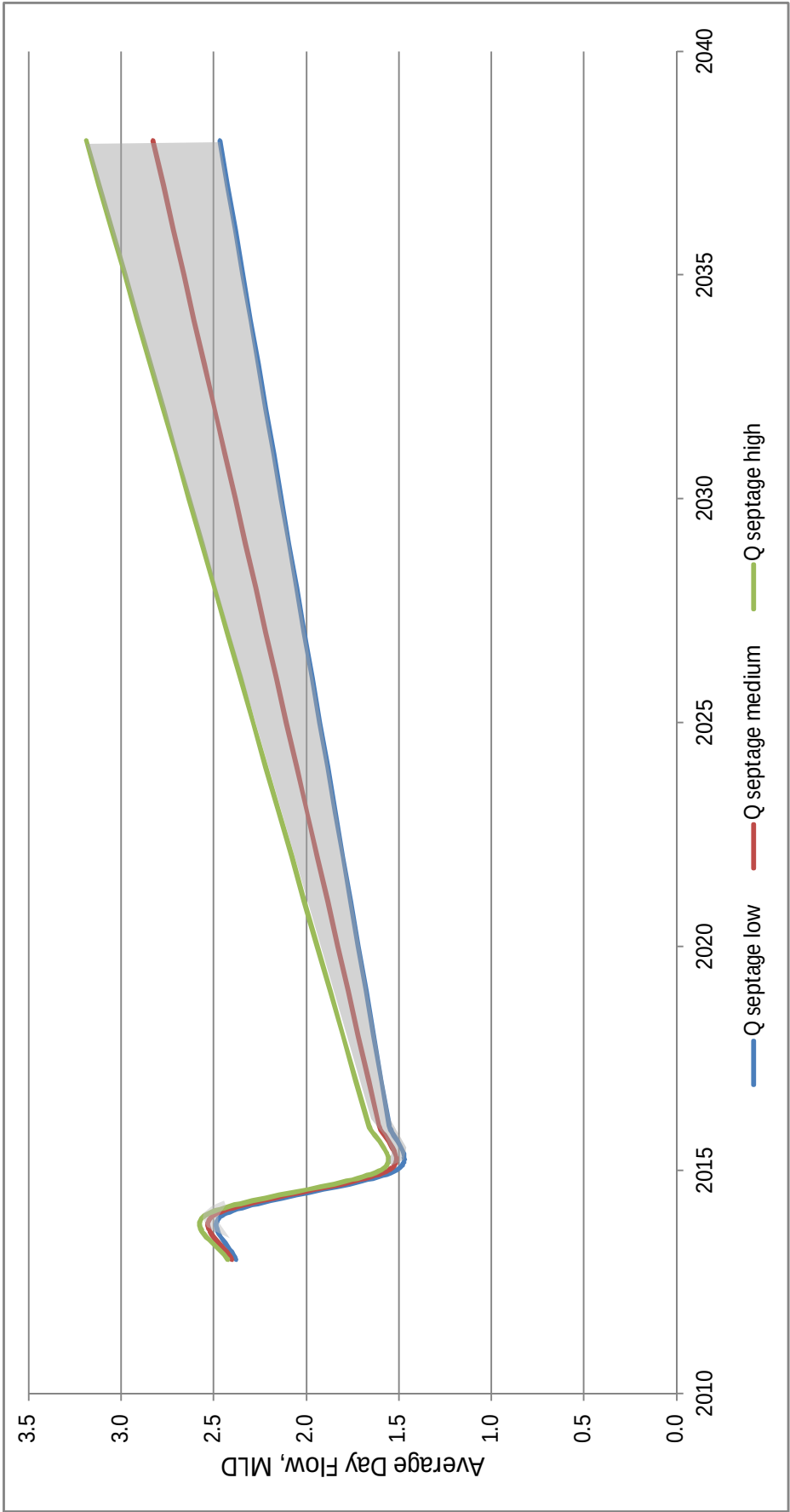


Table 3-5 summarizes available 2011 and 2012 data on wastes hauled to the mud pit. The data reviewed varied significantly between the two years. For 2012, the Municipality's records show that approximately 90,000 m³ of wastes were deposited in the 120,000 m³ containment area. Since much of the pit cannot be accessed from the bank for a clean-out, it is not surprising that the pit had to be cleaned on two occasions in 2012.

**Table 3-5
Mud Pit Waste Quantities**

Year	Trucks #	Volume m ³
2011	3,919	51,150
2012	6,811	90,700

The haulage volumes to the mud pit almost doubled between 2011 and 2012. This may be a reflection of increased construction activity. Certainly, this magnitude of yearly increase cannot be expected to continue into the future. Future haulage volumes will also likely reflect the level of construction activity in the region.

It is estimated that about 60,000 m³ of water was decanted from the mud pit and returned via the lagoons for treatment at the WWTF in 2012. The Municipality indicated that return pumping to the plant lasted about three weeks, so this potentially could account for a 3,000 m³/d influent flow increase to the plant (about 12% of the current plant flow) during return pumping, unless the lagoons were used to buffer the return rates. On an annual basis, the quantity of water from the mud pit is relatively insignificant, less than 1% of the Fort McMurray WWTF flow.

The ultimate disposal location for mud pit wastes would likely be the landfill. Prior to landfilling, the wastes would need to be dried sufficiently to pass the paint filter test. Prior to this occurring, the landfill would need to advise if the constituent concentrations meet their acceptance criteria.

Further investigations of mud pit waste characteristics and management practices are recommended to address short-term and longer term hydro-vac waste management approaches at Fort McMurray WWTF or at the landfill site.

3.2.4 Combined Piped and Septage Wastes

Figure 3-3 shows the average day total piped and trucked septage projections according to the low, medium, and high growth rates for the Fort McMurray area, assuming that 40% of the septage is diverted to Anzac starting in 2015.

Figure 3-4 shows the average day influent BOD load projections for Fort McMurray, along with the estimated impact of direct septage handling for low, medium, and high growth rates. Figure 3-5 shows the same types of projections for Total Suspended Solids (TSS).

Figure 3-3
Fort McMurray WWTF Average Day Total Flow Projections

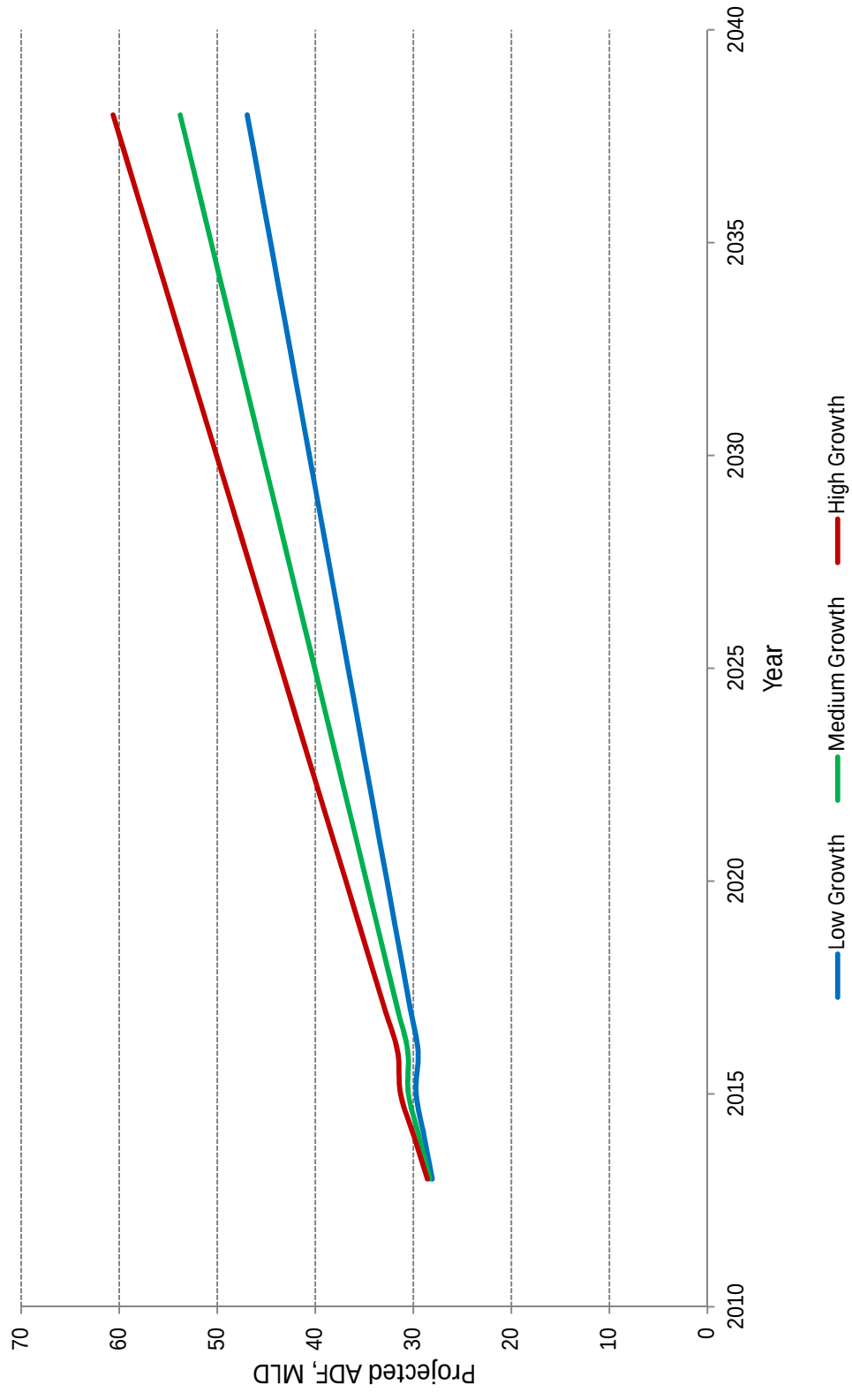


Figure 3-4
Fort McMurray WWTF Average Day BOD Load Projections

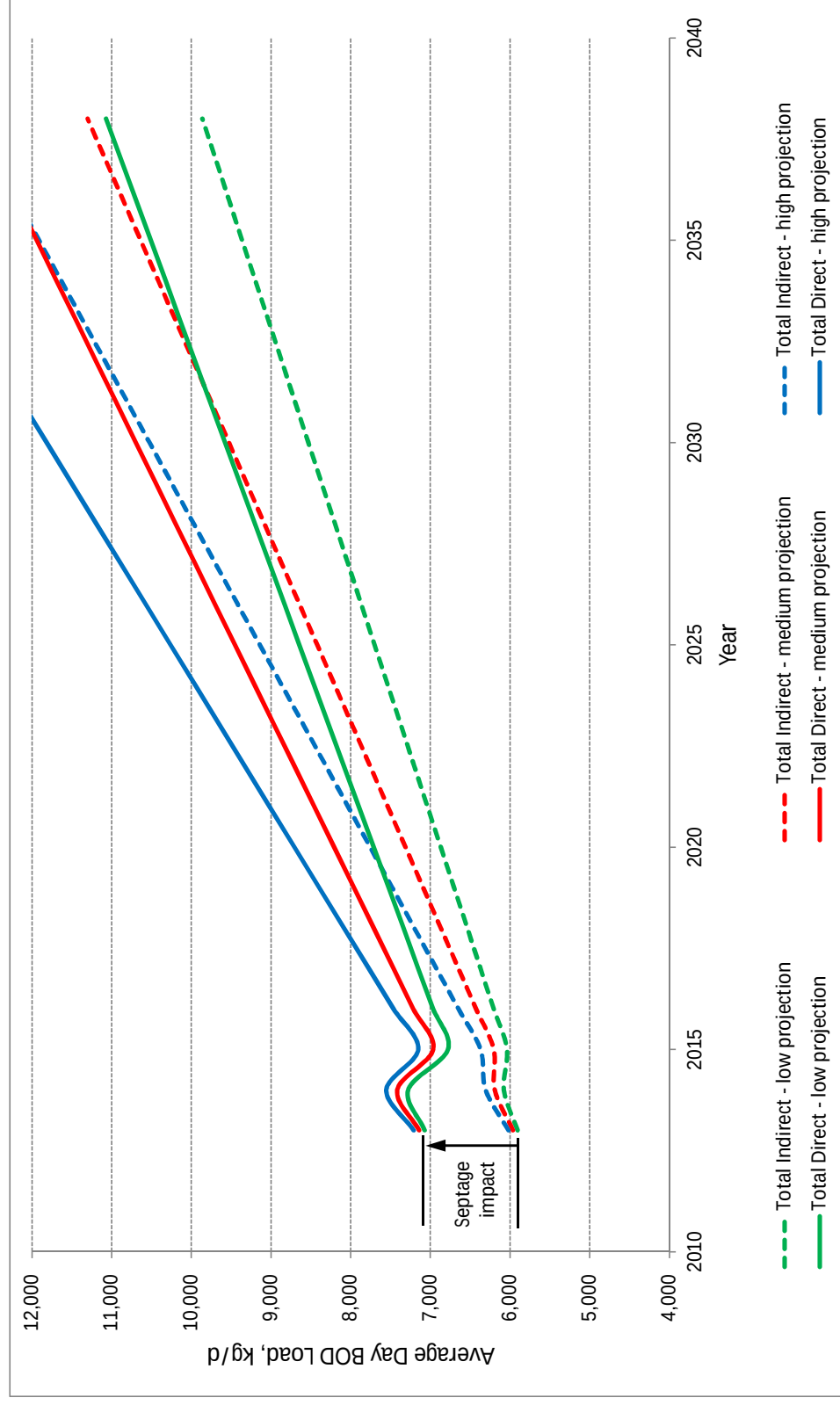
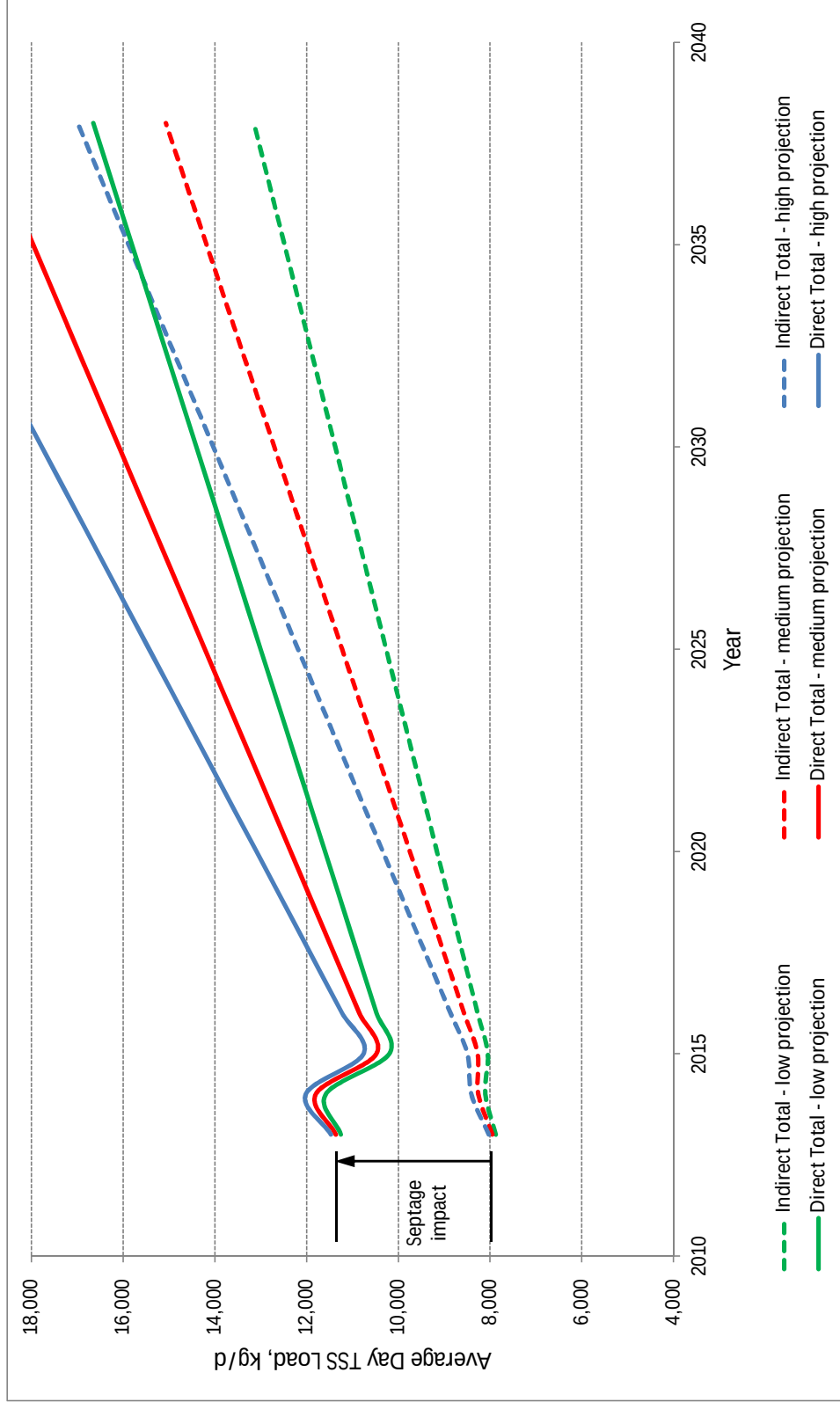


Figure 3-5
Fort McMurray WWTF Average Day TSS Load Projections



3.3 MAIN FINDINGS

3.3.1 Piped System

- **Piped Wastewater Flows:** The 2012 effluent flow monitoring data for the Fort McMurray WWTF shows that the average day flow was around 25 MLD, including an estimated 3 MLD decanted water from the septage lagoons. The estimated flow based on ESS per capita wastewater generation plus septage decant is approximately 33 MLD, or about 30% greater. Therefore, there is either an error in the reported effluent flow data, or the ESS per capita generation values are too conservative for the existing developments.
- **Wastewater Characteristics:** The 2012 piped influent wastewater concentrations were significantly weaker than the 2009 septage study concentrations. Very little data is available on hydro-vac waste characteristics; therefore, more sampling and analysis would be desirable.
- **South Regional WWTF Impact:** With a possible future South Regional WWTF, the flows and loads to the Fort McMurray WWTF could be reduced by an estimated 15%. In the longer term (2038), the South Regional WWTF may handle an estimated 35% of the piped wastewater.
- **Flow Peaks:** Based on 2010-2012 effluent flow data, the Maximum Day Flow: Average Day Flow ratio was approximately 2:1 and the treated effluent Peak Hour Flow: Average Day Flow ratio was approximately 3.1:1. Actual influent flow peaks may have been greater.

3.3.2 Septage

- **Septage Service Area:** The Fort McMurray WWTF currently receives septage from a wide area both north and south of the UDSR. In the future, the Anzac and Conklin WWTFs will serve the south septage haulers. The Fort McMurray WWTF will serve the north and some local septage haulers. A possible future South Regional WWTF could serve the remainder of the local septage haulers.
- **Wastewater Loads:** Currently, the septage lagoons provide a buffer between the septage discharge and the main treatment facility. However, when the septage is blended directly with the piped wastewater in the near future, it appears that the loads will be much greater (e.g., perhaps 20% higher for BOD and more than 40% higher for TSS).
- **Short-term Reduced Wastewater Volumes and Loads:** Once the Anzac and Conklin WWTFs are operational, the septage haul to the Fort McMurray WWTF will initially be reduced by approximately 40%.
- **Stand-alone North Septage Facility:** The construction of a stand-alone septage treatment facility in the vicinity of Fort McKay could reduce the septage loads on the Fort McMurray WWTF by a further 50% (an estimated 10% of the total septage loads would then be treated at the Fort McMurray WWTF).

3.3.3 Hydro-Vac Type Wastes

- **Mud Pit Service Area:** The mud pit at the Fort McMurray WWTF primarily services hydro-vac waste haulers. The service area currently is not known.
- **Hydro-Vac Wastewater Quantities:** The estimated 2012 hydro-vac type wastewater volume totaled 90,700 m³. The return of the decanted water from the mud pit to the Fort McMurray WWTF is insignificant on an annual basis (<1% of plant flow), but the peak loading may be over 10% of the plant flow during return pumping.
- **Hydro-Vac Waste Management:** The current mud pit and drying areas do not provide a sustainable solution.

3.4 RECOMMENDATIONS

The following sections contain AE's recommendations for each of the listed items.

3.4.1 Piped Wastewater

- **Influent Flows:** Influent flows should be verified.
- **Flow Projections:** Future projections of wastewater flows should fully consider baseline per capita flow contributions which appear to be about 300 L/c/d, significantly less than the 360 L/c/d ESS value. Use of the ESS value should be restricted to individual new developments.

3.4.2 Septage

- **Septage Characteristics:** More up-to-date septage characterization work should be undertaken in view of the significant loading contribution from septage. There may be a need to restrict high load septage haulers or require them to discharge to the septage lagoon to provide a treatment buffer if necessary.
- **Impact of Direct Discharge:** The septage characterization work should also evaluate and compare direct septage discharges versus indirect discharge via the septage pond.
- **Return Pumping:** The Operations Plan should recognize the additional hydraulic and constituent loads that are placed on the Fort McMurray WWTF during return pumping from Cell 1.

3.4.3 Hydro-Vac Type Wastes

- **Mud Pit Wastes:** Further study should be undertaken with the objective of developing a sustainable plan for managing these wastes. This should include:
 - Confirmation of Total Solids concentrations of the wastes being discharged, stored in the mud pit, and following drying;
 - Confirmation of the decant loads and the possible need to attenuate the return flows to the Fort McMurray WWTF;
 - Review of sustainable options (e.g. landfilling and tour of other Alberta facilities); and
 - Preparation of a conceptual design report.

4 Wastewater Treatment

4.1 WASTEWATER TREATMENT STRATEGY

4.1.1 Background

The Wastewater Treatment Strategy task evaluates centralized and decentralized management strategies for the Municipality to help determine which solution is better suited to their needs.

In 2012 AE completed a Wastewater Management Concept for new commercial/industrial developments in the south. However, the objective of the study was to develop a strategy to manage future wastewater generation from the south developments. In the South Management Concept Study, AE assessed centralized versus decentralized treatment for the south region. With this, AE assessed the advantages and disadvantages of implementing a single wastewater treatment facility (WWTF), five WWTFs or three WWTFs to manage wastewater generation in the south developments. In addition to evaluating the three independent wastewater management options in the south, AE also assessed the feasibility of bringing the south wastewater to the existing Fort McMurray WWTF, in the north, for a truly centralized wastewater management strategy.. The evaluation included a triple bottom line (TBL) - environmental, social, and economic - and risk assessment of centralized versus decentralized wastewater management. The option of bringing the south wastewater to the existing, north, WWTF was not evaluated as part of the TBL + risk. Results of the TBL + risk assessment favored centralized wastewater management for the south.

To compare a centralized south WWTF to one centralized WWTF in the north, AE subsequently completed a detailed cost analysis which revealed that a new South Regional WWTF was more economical for the Municipality, based upon information available during the Concept Study. While working on the South Regional Wastewater Management Concept, it was noted that the logistics of bringing wastewater from the south developments to the existing Fort McMurray WWTF would be challenging due to river crossings, restricted pipeline capacities, distance, and reliability.

4.1.2 Centralized Wastewater Management Strategy

Centralized wastewater management involves bringing all wastewater generated in the UDSR to the existing Fort McMurray WWTF for treatment. Figure 4-1 highlights three overall wastewater conveyance concepts for centralized wastewater management.

4.1.3 Decentralized Wastewater Management Strategy

Decentralized wastewater management defines two wastewater catchments (north and south) each with a WWTF. Figure 4-2 highlights an overall wastewater conveyance concept for a decentralized wastewater management strategy.

4.1.4 Centralized vs. Decentralized Comparison Model

The main difference between centralized and decentralized treatment strategies for the UDSR is defined by wastewater generation in the south developments. Regardless of a centralized or decentralized approach, the collection and treatment of the wastewater generated in the north would remain the same. Table 4-1 summarizes the main collection and treatment differences for the south developments in centralized and decentralized treatment strategies.

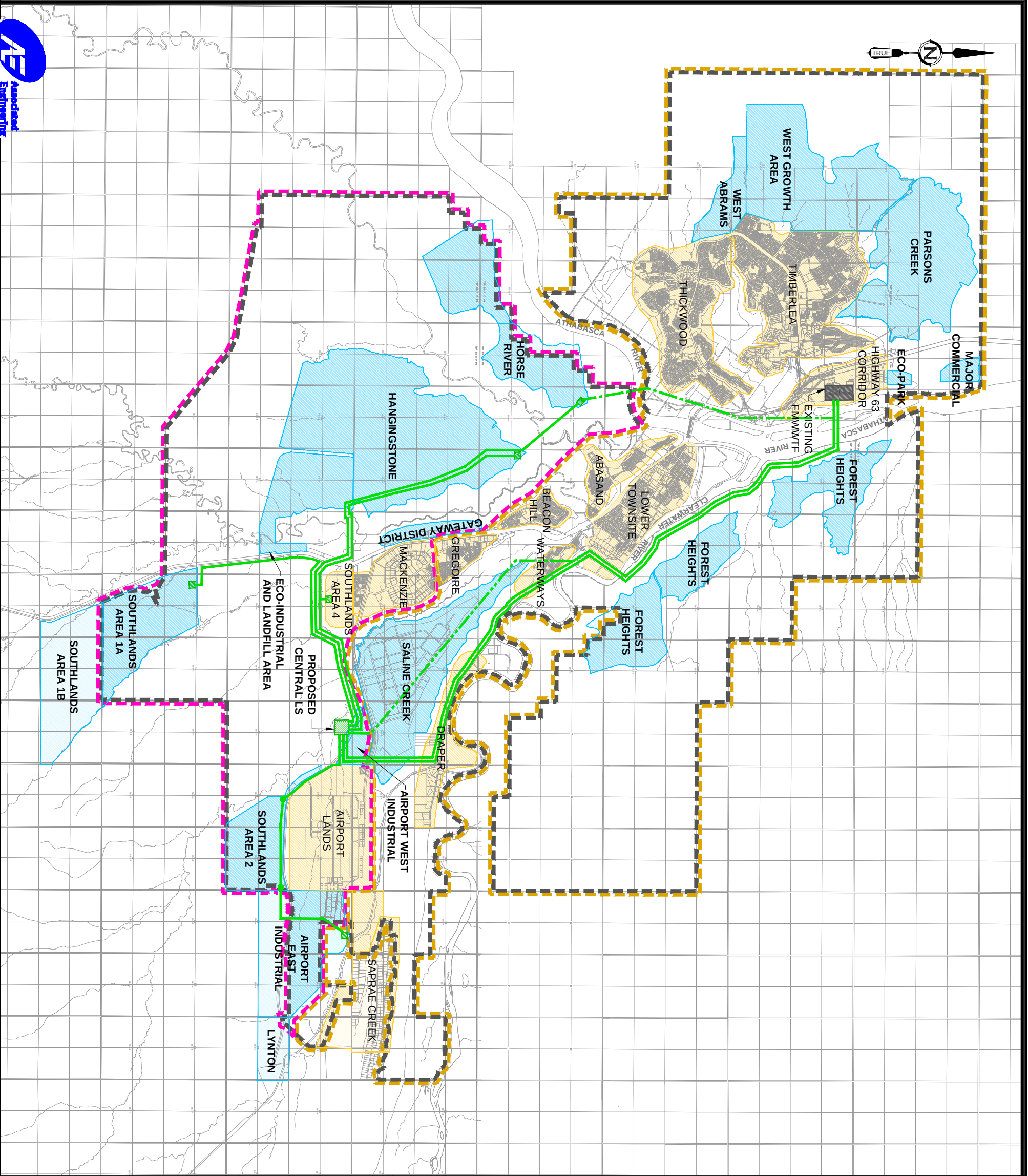
**Table 4-1
Centralized vs. Decentralized Treatment Strategies**

Centralized Wastewater Treatment	Decentralized Wastewater Treatment
• 14,000 m of collection gravity sewer main • 26,000 m of collection force main • Collect south wastewater to a central lift stations and pump to the Fort McMurray WWTF • 18,500 m of twinned force main from the south central lift station to Fort McMurray WWTF • 2 pipeline crossings under the Clearwater River • 2-4 pipeline crossings under the Athabasca River • Single recycled water hub to distribute to north and south users • Fewer operators required as all equipment is at a central location	• 5,000 m of collection gravity sewer main • 36,000 m of collection force main • Collect south wastewater to a new south regional WWTF • New conventional South Regional WWTF at the existing landfill site • Use existing pipeline to outfall to recycle effluent to Athabasca River via existing Fort McMurray WWTF outfall structure • Provides a level of redundant wastewater treatment (truck haul only) • Allows flexibility for wastewater treatment in the future • Allows for flexibility to implement new technologies in the future • Increases longevity of existing Fort McMurray WWTF for future growth in the north

4.1.5 Capital Cost Estimates

Table 4-2 summarizes the Order of Magnitude capital cost estimates for the comparison of centralized versus decentralized wastewater treatment. At this level of evaluation, there have been several assumptions, which may impact the economic evaluation. For example, it has been assumed that a new outfall would not be required for a new South Regional WWTF in decentralized treatment. Should an outfall be required, there would be an economic impact on the decentralized treatment.

The estimated capital cost of a decentralized system is approximately \$75 million less expensive than the capital cost of bringing all wastewater generated in the UDSR to the existing Fort McMurray WWTF site and expanding the facility.



WASTEWATER MASTER PLAN

CENTRALIZED WASTEWATER MANAGEMENT STRATEGY

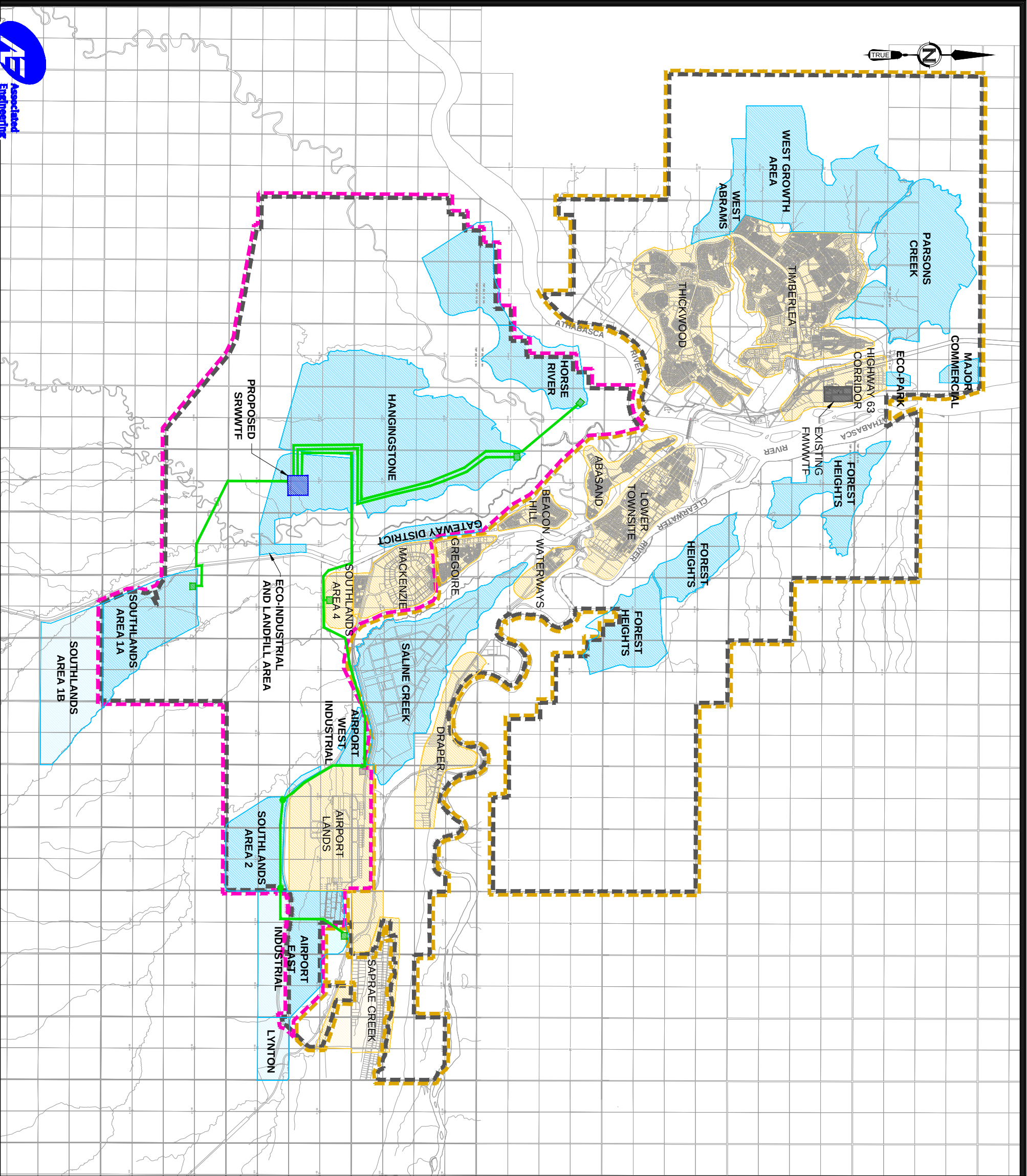
LEGEND:

- CONCEPTUAL LIFT STATION
 - WMWP SOUTH CATCHMENT BOUNDARY
 - WMWP NORTH CATCHMENT BOUNDARY
 - AESRD URBAN DEVELOPMENT SUB-REGION (UDSR)
 - CONCEPTUAL GRAVITY MAIN
 - CONCEPTUAL FORCE MAIN ALTERNATE 1
 - CONCEPTUAL FORCE MAIN ALTERNATE 2
 - CONCEPTUAL FORCE MAIN ALTERNATE 3
- DEVELOPMENT AREAS:
- EXISTING DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS OUTSIDE OF UDSR

SCALE: 1:100,000

JANUARY, 2014

FIGURE 3-1



WASTEWATER MASTER PLAN

DECENTRALIZED WASTEWATER MANAGEMENT STRATEGY

LEGEND:

- CONCEPTUAL LIFT STATION
 - CONCEPTUAL SRWWTF
 - WMMP SOUTH CATCHMENT BOUNDARY
 - WMMP NORTH CATCHMENT BOUNDARY
 - AESRD URBAN DEVELOPMENT SUB-REGION (UDSR)
 - CONCEPTUAL GRAVITY MAIN
 - CONCEPTUAL FORCE MAIN
- DEVELOPMENT AREAS:
- EXISTING DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS
 - PROPOSED DEVELOPMENT AREAS OUTSIDE OF UDSR

SCALE: 1:100,000

JANUARY, 2014

FIGURE 4-1

Table 4-2
Centralized vs. Decentralized Order of Magnitude
Capital Cost Estimate in 2013 Dollars (\$ Millions)

Wastewater Strategy	Phase 1 (20 MLD)	Phase 2 (+10 MLD)	Total (30 MLD)
Centralized	260	205	465
Decentralized	235	155	390

4.1.6 Operating and Maintenance Costs

Table 4-3 summarizes the estimated annual O&M costs in 2013 dollars for centralized and decentralized wastewater management strategies.

Table 4-3
Centralized vs. Decentralized Annual O&M
Costs in 2013 Dollars (\$ Millions)

Wastewater Strategy	Phase 1 (20 MLD)	Phase 2 (+10 MLD)
Centralized	7.5	16.5
Decentralized	9.5	18.5

O&M costs for a decentralized system are higher compared to a centralized system due to increased staff, additional equipment maintenance, etc.

4.1.7 Lifecycle Cost Model

Table 4-4 outlines the estimated present value of the centralized and decentralized wastewater management strategies. The lifecycle cost model incorporates the phased capital, annual O&M costs, as well as salvage value. The present worth estimates are based on annual costs of borrowing at 6.25%, inflation rate at 2.5%, effective net present value discount rate at 3.75% ($6.25\% - 2.5\% = 3.75\%$), and an analysis period of 25 years.

Table 4-4
Centralized vs. Decentralized 25 Year Present
Worth in 2013 Dollars (\$ Millions)

Wastewater Strategy	25 Year Present Worth
Centralized	553.0
Decentralized	551.0

Regional Municipality of Wood Buffalo Wastewater Master Plan

The lifecycle cost model indicates that the two management strategies essentially have equivalent 25 year present worth costs at this level of analysis.

4.2 EXISTING WASTEWATER TREATMENT SYSTEM

4.2.1 Review of Current Fort McMurray WWTF Capacity

Table 4-5 shows the estimated firm capacities of individual processes at the Fort McMurray WWTF (recent – 2013 and near term – 2018). Firm capacities are based on:

- (a) Estimated design values with the largest component out of service
- (b) Flows and loads to the facility will increase at the high growth rate (5% linear)
- (c) At least, 60% of the septage load will be treated directly at the facility (the remaining 40% will be trucked for treatment at Anzac or Conklin).

Percentage loadings less than 80% of design capacity are shaded **GREEN**, those between 80% and 99% of design capacity are shaded **YELLOW**, and those at 100% or greater of design capacity are shaded **RED**.

The table shows that some of the major processes can treat the flows with one of their components out of service, but others (shaded RED) may have difficulty under peak loading conditions. The direct addition of high strength septage with the incoming piped system flows contributes higher organic and solids loads per unit volume and, therefore, impacts the capacity proportionately more than the piped system flow. With plant optimization, e.g., improved septage load management, the plant may effectively treat greater flows.

Table 4-5
Current and Near-Term Projections of Component Capacities Relative to Their Firm Capacities with One of Each of the Major Components Out of Service

Component	2013	2018
	% of Total	% of Total
Equivalent Population	129,400	139,100
Liquid Stream		
Influent Fine Screens	154%	160%
Grit Tank	>100%	>100%
Influent Pumps	78%	95%
Primary Clarifiers	63%	77%
Bioreactors	92%	102%
Process Air Blowers	79%	87%
Secondary Clarifiers	84%	102%
UV Disinfection	126%	154%

Component	2013	2018
	% of Total	% of Total
Equivalent Population	129,400	139,100
Solids Stream & Other		
Fermenters	118%	130%
DAF - WAS Thickening	118%	130%
Centrifuges - Raw Solids Dewatering	102%	106%
Centrifuged Solids Conveyor System	34%	35%
Raw Compost Mixer	77%	80%
Raw Compost Conveyor	77%	80%
Compost Tunnels	77%	80%
Foul Air Blowers	77%	80%
Stage 1 Wet Scrubber	77%	80%
Stage 2 Biofilters	154%	160%

Notes:

< 80% of capacity

80% to 99% of design capacity

≥ 100% of design capacity

1. Equivalent population based on high wastewater projections and 6.6 TSS load factor for direct septage discharge.
2. For illustration of firm capacities, largest unit process of each type is assumed to be out of operation except for the following single components which are assumed to remain in operation: solids conveyor system, raw compost mixer, and raw compost conveyor.
3. Conveyor assessment based on upgraded conveyors (to be tendered).

4.2.2 Effluent Quality Review

The Municipality's Approval for the Fort McMurray WWTF (Approval No. 689-02-00), under the Environmental Protection and Enhancement Act, is dated February 25, 2009. The current approval limits are applicable until June 30, 2015. Future, more stringent limits become effective July 1, 2015. The facility has consistently met the current approval limits, but not all of the more stringent future limits as indicated in Table 4-6.

4.2.3 Risk Assessment

AE facilitated a redundancy risk assessment workshop with six individuals from the Municipality's WWTF Operations Team. The main purpose of the workshop was to identify and assess risks associated with the possible loss of a major process component either through a planned maintenance shutdown or through an unexpected failure. With the loss of a major component, the facility's total available capacity is reduced to its firm capacity.

Regional Municipality of Wood Buffalo Wastewater Master Plan

Table 4-7 shows the risk assessment metrics that were utilized in the evaluation of redundancy risks. The probability of identified risks occurring was evaluated ranging from “rare” to “almost certain” and assigned corresponding numerical values between “1” and “100”. In addition, the severity of the risks occurring was evaluated ranging from “insignificant” to “extreme” and assigned corresponding numerical values between “5” and “700”. The risk factor consequence was numerically determined as the product of “Probability” and “Severity”. Lower consequence scores were classified as “Negligible” and visually indicated as **GREEN**; medium consequence scores were classified as “Medium” and visually indicated as **YELLOW**; higher consequence scores were classified as “Critical” and visually indicated as **RED**.

**Table 4-6
Fort McMurray WWTF Monthly Effluent Quality Summary 2010 to 2013**

Parameter	Units	Avg. ^a	Max. ^b	Current/ Future Limit	% Above Future Limit
CBOD	mg/L	3.3	5.7	20/10	0%
Total Suspended Solids (TSS)	mg/L	5.9	16.5	20/10	7% ^c
Total Phosphorus (TP)	mg/L	0.43	0.82	1.0/0.5	39% ^d
Ammonia-Nitrogen (NH ₃ -N)					
• Winter (Oct 1 – Jun 30)	mg/L	0.70	5.85	10/6	0%
• Summer (Jul 1 – Sep 30)	mg/L	0.57	2.33	5/3	0%
pH	pH Units	7.24	7.44	6.5-9.5	0%
<i>E. Coli</i>	CFU/100 mL	38	151	200/200	0%

^a Except for *E. coli*, indicated values are the average of monthly averages based on daily composite samples.

For *E. coli*, values are the average of monthly geometric means based on grab samples 5 days per week.

^b Except for *E. coli*, indicated values are the maximum of all monthly averages based on daily composite samples.

For *E. coli*, values are the maximum of monthly geometric means based on grab samples 5 days per week.

^c Note 3 of 41 monthly average TSS values exceeded the future TSS limit.

^d Note 16 of 41 monthly average TP values exceeded the future TP limit.

Table 4-7
Risk Assessment Metrics

		Severity				
		Insignificant 5	Minor 15	Moderate 50	Major 200	Extreme 700
Rare	1	5	15	50	200	700
Unlikely	10	50	150	500	2,000	7,000
Possible	25	125	375	1,250	5,000	17,500
Likely	50	250	750	2,500	10,000	35,000
Almost Certain	100	500	1,500	5,000	20,000	70,000

During the risk assessment, the Municipality identified and evaluated 29 redundancy risks based on the estimated firm capacities with 2013 loadings including direct septage discharges to the Fort McMurray WWTF. Of the 29 risks, seven (7) were determined to be critical risks, 19 were determined to be medium risks, and three (3) were determined to be negligible risks.

The seven **CRITICAL** risk consequences clearly prioritize areas for which the Municipality should focus, including:

- **Vortex grit chamber:** single grit chamber out of service for maintenance: operations impact.
- **Bioreactors:** capacity reduction with one bioreactor out of service: effluent quality deterioration.
- **Secondary clarifiers:** exceedance of the 2015 TSS or TP limits without filtration: inadequate future effluent quality.
- **Raw compost mixer:** failure of single raw compost mixer: operations impact.
- **Foul air blowers:** explosion requiring complete shutdown of compost system: operations impact.
- **Foul air wet scrubber:** failure requiring termination of compost operations.
- **SCADA:** failure (no backup; manual operation not possible through entire plant): operations impact to the aeration system and automatic processes.

4.3 REGULATORY REVIEW

As part of the WWMP, AE summarized potential, more distant effluent quality requirements beyond the year 2015 obligations contained in the Municipality's existing AESRD Approval #689-02-00. This review provides perspective for the general trends being observed in the wastewater industry at this time. The objective of reviewing future regulatory requirements is to identify key viewpoints in the Wastewater Master Plan (WWMP) for the Municipality to evaluate during more advanced planning of its WWTFs.

4.3.1 Current Approval

Table 4-6 summarizes the existing AESRD Approval #689-02-00 effluent quality requirements that came into effect in February 2009, as well as more stringent requirements that will come into effect in July 2015.

4.3.2 Drivers for Change

The wastewater industry is noting future changes, beyond those shown for the regulated effluent constituents, will be due to either:

- A scientific reason that is identified from site-specific “water quality based effluent limits” (WQBEL) initiatives; or
- The advancement of the wastewater industry’s “best practicable technology” (BPT) as adopted-in-principal by a regulator(s).

In general terms, the WQBEL approach recognizes the site-specific nuances of a receiving water body and considers the allowable end-of-pipe effluent constituent concentrations and/or effluent mass loadings. The definition of what is allowable is based in part on surface water quality standards and objectives, potential cumulative effects, and other water uses and effluent discharges within the watershed.

Alternatively, the BPT approach establishes end-of-pipe effluent quality requirements based on established and proven treatment technologies.

4.3.3 Potential Changes in Currently Regulated Effluent Constituents

Table 4-8 summarizes potential future changes in currently regulated effluent constituents. Of the currently regulated constituents shown in the table, total phosphorus (TP) is likely of most importance to the Municipality. Already the indicated 2015 TP limit has been replaced as a BPT value in a number of other jurisdictions that have sensitive receiving waters (≤ 0.25 mg/L in British Columbia, 0.15 mg/L for Parks Canada, and ≤ 0.10 mg/L for some Ontario communities).

However, lowering the TP limits may be reaching the point of diminishing returns where using “... chemically-intensive, resource-intensive, high sludge production and costly technologies to remove small amounts of P ...” is at odds with the overall sustainability of the intent.

Table 4-8
Potential Future Changes in Currently Regulated Effluent Constituents

Parameter	2015 Limit ^a	Future Effluent Limit?	Comments
CBOD	≤ 10 mg/L	≤ 10 mg/L	CBOD & TSS are already low (at a level stipulated for some forms of reclaimed water use). However TSS may have to be lowered to meet lower TP limits.
TSS	≤ 10 mg/L	≤ 10 mg/L	
Total Phosphorus (TP)	< 0.50 mg/L	≤ 0.10 mg/L	Current technologies can achieve the lower limit but this requires significant resources - may be contrary to sustainability objectives.
Ammonia-Nitrogen • Oct 1 to Jun 30 • Jul 1 – Sep 30	< 6.0 mg/L < 3.0 mg/L	May require lowering if TN becomes regulated	Current technologies can achieve substantially lower effluent ammonia levels. Effluent total nitrogen (TN, refer to Table 3-6) is a more complex question.
<i>E. coli</i>	≤ 200 per 100 mL	Lower	Possible future reduction within a decade.

^a Based on monthly arithmetic means for all parameters except *E. coli* which is based on a monthly geometric mean.

4.3.4 Potential Future Addition of Currently Un-Regulated Effluent Constituents

We have identified four main categories of currently un-regulated constituents which may potentially be regulated in future:

- Microbial Indicators
- Trace Organic Compounds (TOCs)
- Total Nitrogen
- Engineered Nanomaterials (ENMs)

Table 4-9 provides a summary for these constituents.

**Table 4-9
Potential Future Addition of Currently Un-Regulated Effluent Constituents**

Parameter	Comments
Microbial Indicators	Enterococci may be included as a microbiological indicator perhaps within a decade.
Trace Organic Compounds (TOCs)	Regulator might implement some kind of TOC monitoring requirement within a decade. A possible future TOC appears more distant and likely beyond a decade.
Total Nitrogen	AESRD is considering a 15 mg N/L limit for larger municipalities. AESRD may implement a TN monitoring requirement followed by a TN limit within a decade.
Engineered Nanomaterials (ENMs)	Future regulation of effluent quality with respect to ENMs will not likely occur within the next decade, if at all. ENM regulation may be more inclined to biosolids quality (especially in terms of nano-silver particles) rather than effluent quality.

With respect to microbial indicators, *Pseudomonas aeruginosa* is recognized as an indicator for non-gastrointestinal infections (e.g., ear and skin infections) associated with water contact recreation. USEPA (2012) has added Enterococci to its recommended freshwater recreational contact criteria.

Trace organic compounds include pharmaceuticals and personal care products (PPCPs) which are recognized for their potential to disrupt endocrine function in organisms. However, the list of potential endocrine disrupting compounds (EDCs) extends beyond these products to include pesticides, surfactants, plasticizers, and naturally occurring and synthetic hormones.

Total nitrogen (TN) is typically defined as the aggregate measure of the forms of nitrogen (organic nitrogen + ammonia/ammonium + nitrite + nitrate). WQBEL-approaches are often used to establish effluent concentration and/or loading limits to control in-situ eutrophication. TN discharges may also be of concern with respect to increased greenhouse gas (GHG) emissions and the associated climate changes. This relates to the possible transformation of effluent containing nitrogen to nitrous oxide (N₂O), a powerful GHG with a global warming potential approximately 300 x that of carbon dioxide.

Engineered nanomaterials (ENMs) are gaining the attention of the wastewater industry from their potential toxicity effects. ENMs are defined as being < 100 nm in size in at least one dimension. ENMs are applied in consumer products, foods, and industrial applications, such as inks, paints, and coatings.

4.4 WASTEWATER TREATMENT TECHNOLOGY REVIEW

This section identifies key technical drivers that could significantly influence the Municipality's near- and longer-term decision-making with respect to its wastewater treatment technologies. Three key contexts to this include:

- Future more stringent effluent quality standards
- Using more efficient processes in future
- Future resource (e.g. nutrient) recovery

These dimensions all point to the need to future-proof the Municipality's wastewater infrastructure investments.

4.4.1 Future More Stringent Effluent Quality Standards

The key messages from the review of possible more stringent future effluent quality standards are outlined below with treatment technology reviews.

- **Total Phosphorus:** Optimization opportunities may exist to reduce effluent ortho-phosphate levels and could assist in meeting the Year 2015 total phosphorus limit of 0.5 mg/L (as P). The low P content of effluent TSS suggests water treatment facility's discharge of alum sludge may be notably affecting WWTF operations and performance. The combination of in-place enhanced biological phosphorus removal (optimized), chemical precipitation (as necessary), and new effluent filtration facilities to meet Year 2015 Approval requirements would provide regulatory "future-proofing" down to effluent total phosphorus levels in the order of 0.1 mg/L total P.
- **Ammonia:** The Fort McMurray WWTF technology has demonstrated capability to produce very low effluent ammonia levels and in general could likely accommodate further tightening of regulatory limits. The key to the above point is managing wet-weather flows, and potentially septage loading, through flow/load equalization. Operational measures such as increased bioreactor DO levels and increasing the bioreactor aerated mass fraction through use of anoxic/aerobic swing zones may be mitigation actions of particular relevance for the wet-weather flow situation.
- **Total Suspended Solids and Carbonaceous Biochemical Oxygen Demand:** The Municipality has a number of filtration technology alternatives available in terms of meeting Year 2015 Approval TSS and BOD limits simultaneous with achieving the 0.5 mg P/L total phosphorus limit.
- **E. Coli:** The Fort McMurray WWTF disinfection technology in general is suitable for achieving potentially reduced effluent E. coli levels suggested by the Regulatory Review, which could be required in the relative near-term (within a 10 year horizon). Capacity-related constraints of the existing system in this context, if they exist, will be mitigated in part and potentially entirely if effluent filtration is implemented.
- **Enterococci:** The Fort McMurray WWTF disinfection technology in general is suitable for achieving potential future effluent Enterococci levels, which could be required in the relative near-term (within a 10 year horizon).

- **Trace Organic Compounds:** The Fort McMurray WWTF already utilizes “core” technologies that provide some level of future-proofing against a future effluent total organic carbon (TOC) requirement. Long-range facility planning should leave room, both in footprint area and in the hydraulic profile, to accommodate additional physical/chemical unit processes and their supporting equipment and systems that may be needed in the longer-term (beyond a 10 year horizon) to meet possible more stringent future regulatory requirements.
- **Total Nitrogen:** The Fort McMurray WWTF process technology, with some optimization, can likely produce effluent with consistently lower effluent total nitrogen concentrations in the 5 to 10 mg N/L range, and thus below a 15 mg N/L limit that may be implemented by AESRD in the relative near-term. Achieving lower effluent total nitrogen levels (e.g. 3 mg N/L) would require a post-denitrification system; further reductions, because of recalcitrant dissolved organic nitrogen, would likely require add-on physical/chemical unit processes. Any such future GHG-related total nitrogen regulatory requirement could be several decades in the future, if at all, and so the need to consider future footprint and hydraulic profile considerations in the shorter-term is limited.
- **Engineered Nanomaterials:** The Fort McMurray WWTF already utilizes “core” technologies that provide some level of future-proofing against a future effluent ENM requirement that might be implemented by a regulatory agency. Membrane filtration may prove advantageous in this context relative to other available filtration technologies, but issues such as fouling are currently not well understood in an ENM context. Any such future regulatory requirement could be several decades in the future, if at all, and so near-term filtration technology decisions can be made in relative isolation of the ENM topic.

In summary, with respect to the currently regulated effluent quality parameters (total phosphorus, ammonia, total suspended solids, carbonaceous biochemical oxygen demand, and *E. Coli*), a future tightening of the July 2015 Approval requirements would most likely impact the existing WWTF from an operations perspective (e.g. fermenter/ bioreactor operation, chemical addition for P removal) rather than requiring capital-intensive outright technology change or addition. Minor capital works (e.g., bioreactor swing zone, lagoon equalization system) improvements might be needed. These conclusions are predicated on the assumption, which remains to be confirmed, that effluent filtration will be needed to meet the Year 2015 TP limits in Approval #689-02-00.

With respect to currently un-regulated effluent constituents (Enterococci, total organic carbon, total nitrogen, and engineered nanomaterials), the Fort McMurray WWTF already utilizes “core” technologies that position it favourably for the kinds of regulatory changes considered. TOC represents what will likely be the effluent constituent of most significance to the Municipality in the longer term. This would probably require the addition of unit processes downstream of those currently in use or planned for future facilities.

Tertiary filtration is the unit process of most immediacy to the Municipality in light of the TP issue and the 2015 Approval requirements for both the existing Fort McMurray WWTF. Different alternatives are available (e.g., deep-bed granular media filtration; rotating-disk, cloth-media surface filtration) to satisfy this single need but membrane filtration likely has the greatest ability to accommodate diverse future requirements.

4.4.2 Future Treatment Technologies

Below is a list of possible wastewater treatment technologies that could be utilized by the Municipality.

- **Aerobic Granular Biomass:**
 - Aerobic granular biomass (AGB) technology has already seen full-scale implementation in both the municipal and industrial sectors and its purported advantages are difficult to ignore.
 - Sufficient industry AGB experience, to enable confident decision-making, will likely be available in the relative near-term and at the point in time (e.g., 10 years from now) when the Municipality will need to make technology choices for an expanded Fort McMurray WWTF or new South Regional WWTF.
 - The Municipality can use a risk assessment-based future uncertainty analysis framework to inform such technology decisions for AGB and other technologies.
- **Main-stream Deammonification**
 - Main-stream deammonification (MSD) is another technology that the Municipality ought to consider earnestly for its potential benefits should it be successfully developed and implemented in a municipal setting.
 - While the timeline where sufficient industry MSD information would be available to enable confident decision-making for the Municipality's WWTFs is likely in the order of a decade from now, if proven applicable, nearer-term WWTF decisions the Municipality needs to make should give consideration in terms of future adaptation or transition to MSD and other technology.
 - Connected with MSD technologies are complementary technologies such as high-rate activated sludge (HRAS), with potential integration of enhanced biological phosphorus removal (EBPR), and chemically-enhanced primary treatment (CEPT) that would further maximize the benefits of moving to MSD and simultaneously need to be considered with MSD.
- **Main-stream Resource Recovery**
 - Urine separation as an at-source, main-stream resource recovery strategy can have a significant impact on WWTF design and operation depending on the extent of urine diversion achieved.
 - Given the existing infrastructure associated with the Fort McMurray WWTF, technology-related decisions for this WWTF that the Municipality will need to make in the foreseeable future appear reasonably insensitive to the influences of urine separation should the Municipality wish to adopt such a wastewater management strategy.
 - Conversely, urine separation could significantly influence the proposed South Regional WWTF technology decisions, because of its greenfield nature, depending on the extent of separation the Municipality might wish to pursue under such a strategy if so adopted.
 - The Municipality can use a risk assessment-based future uncertainty analysis framework to inform such technology decisions.

- **Post-Treatment Extractive Resource Recovery (PTENR)**
 - PTENR technologies are still very early in their development stages and, perhaps more importantly, the commercial market (i.e., oil sand-related reclamation activities) for the resultant products is presumably largely unknown at this time.
 - This situation may change over time and, given the range of potential PTENR benefits, it would be prudent for the Municipality to consider it in its WWTF decision-making.

4.5 MAIN FINDINGS

4.5.1 Wastewater Treatment Strategy

- Based on the equivalent life cycle cost evaluations for centralized and decentralized wastewater systems, the optimal wastewater treatment strategy for the Municipality is not clear.
- Several non-economic factors have been identified as advantages or disadvantages for either strategy. To quantify the non-economic factors, a detailed Triple Bottom Line + Risk assessment could be completed.
- The Municipality has agreed that implementing a decentralized wastewater treatment system seems to make sense. This is supported by the non-economic evaluation completed on the past South Wastewater Management Concept.

4.5.2 Existing Wastewater Treatment System

- **Firm Hydraulic Capacity:**
 - The firm hydraulic capacity currently may be approached or exceeded for some major processes with the largest unit process of each type out of service, including: UV disinfection, fermenters, DAF, centrifuges, Stage 1 wet scrubber, and Stage 2 biofilters.
 - In addition, the possible need to remove other single components from service could impact the hydraulic capacity, including: influent conduit and Parshall flume, vortex grit chamber, effluent conduit and Parshall flume, centrifuged solids conveyor system, raw compost mixer, and raw compost conveyor.
- **Load Capacity:**
 - The rated hydraulic capacities will be reduced if higher strength wastewater from direct handling of septage contributes to higher loads than accommodated by the design.
- **Firm Recent (2013) Load Capacity:**
 - Several processes appear at risk of having their design loads exceeded with direct septage addition during peak flow or loading events if a critical component is out of service.
- **Firm Near-Term (2018) Load Capacity:**
 - The risks increase. These include possible excessive loads applied to the influent fine screens, grit tank, UV disinfection, fermenters, DAF, and Stage 2 biofilters. Therefore, full build-out of Fort McMurray WWTF will be necessary if the performance of the installed equipment does not show that the component capacities are significantly higher than design values.

- **Firm Near-Term (2018) Full Build-Out Load Capacity:**
 - With full build-out, two processes (grit removal and UV disinfection) appear at risk of overloading, during peak flow or loading events, if one of the major units is out of service (i.e., one of two UV banks and/or the one grit tank).
- **Redundancy Risks:**
 - There are several major processes that rely on all components to be operating effectively to provide full treatment. In addition, there are a number of single components (e.g., sludge conveyors), which should they fail, satisfactory operations would be challenged.
- **Effluent Quality:**
 - The Fort McMurray WWTF has been in full compliance with its approval limits. However, it appears probable that the future 2015 Approval limits will not be met unless appropriate actions are taken. In particular, effluent filtration should improve TSS and TP removal, as well as UV-transmittance for improved disinfection. Effluent filtration may have to be preceded by coagulation/flocculation to precipitate dissolved phosphorus.
- **Priority Areas:**
 - The Municipality identified the following priority areas for upgrade or operations optimization:
 - Vortex grit chamber
 - Bioreactors
 - Secondary clarifiers
 - Raw compost mixer
 - Foul air blowers
 - Foul air wet scrubber
 - SCADA

4.5.3 Regulatory Review

- **Drivers for Change:**

The main drivers from change are either:

 - Scientific reasons identified from site-specific WQBEL or
 - The advancement of the wastewater industry's (BPT)
- **Potential Changes in Currently Regulated Effluent Constituents:**
 - It is likely that the Provinces effluent *E. coli* requirements will become more stringent in the future with increased wastewater industry transition from fecal coliform to *E. coli* as the disinfection efficiency indicator organism of choice. It is likely that the horizon of such a change could be within a decade.
- **Potential Future Addition of Currently Un-Regulated Effluent Constituents:**
 - It would be reasonable to assume that AESRD will expand the Approval #689-02-00 list of regulated effluent constituents at some point to include Enterococci as a microbiological indicator, and total nitrogen in an eutrophication context. Such a change could plausibly be expected within a decade.

- It is a realistic for a trace organic compound monitoring requirement, associated with organism endocrine, to be implemented within a decade as well.
- Likely more distant (i.e. decade plus) are actual regulatory requirements for trace organic compounds.
- Given the current knowledge and relative infancy of it, total nitrogen (from a greenhouse gas emission perspective) and engineered nanomaterials may well have an even longer timeline before a regulatory requirement comes into place.
- Table 4-10 summarizes the potential timelines noted above.

**Table 4-10
Potential Horizon of Future Regulatory Requirements**

Effluent Constituent	Horizon Within 10 Years	Horizon Beyond 10 Years
<i>E. coli</i>	Lower effluent limit	
<i>Enterococci</i>	Addition as a regulated constituent	
Trace Organic Compounds	Constituent(s) monitoring requirement	Addition as a regulated constituent(s)
Total Nitrogen (GHG context)		Addition as a regulated constituent
Total Nitrogen (eutrophication context)	Addition as a regulated constituent	Addition as a regulated constituent
Engineered Nanomaterials		Addition as a regulated constituent(s)

4.5.4 Treatment Technology Review

- **Immediate Technology Upgrade:** Tertiary filtration is required at the Fort McMurray WWTF to address TP issue and the 2015 Approval requirements. There are several filtration technologies available, such as:
 - Deep-bed granular media filtration;
 - Rotating-disk;
 - Cloth-media surface filtration; and
 - Membrane filtration.

4.6 RECOMMENDATIONS

4.6.1 Wastewater Treatment Strategy

- **Wastewater Management Strategy:** move forward with development of a decentralized wastewater treatment strategy for north and south wastewater collection. This includes continual operation of the Fort McMurray WWTF and construction of a South Regional WWTF.

4.6.2 Existing Wastewater Treatment System

- **Septage Impacts:** Closely monitor the planned direct discharge of septage loads and be prepared to implement appropriate measures to ensure the WWTF is not overloaded.
- **Effluent Quality:**
 - Consider the future 2015 limits as target limits to gain improved operation experience.
 - Commence planning, design, construction, commissioning, and operation of a filtration facility as soon as possible to provide reasonable assurance of meeting the future limits.
 - Commence communications with Alberta Environment and Sustainable Resource Development (AESRD) and seek an Approval amendment or authorization to consider the more stringent limits are target limits rather than fixed limits until the filtration facility is commissioned and operating reliably.
- **Prioritization of Improvements:** In addition to the recommended filtration upgrade, develop a prioritized plan of action mainly focusing on the items identified with critical risk consequences, including:
 - Vortex grit chamber – operations procedures;
 - Bioreactors – full build-out (4th bioreactor);
 - Secondary clarifiers – full build-out (4th secondary clarifier);
 - Raw compost mixer – operational procedures;
 - Foul air blowers – replacement (in progress);
 - Foul air wet scrubber – operational procedures;
 - SCADA –backup; and
 - Other redundancy risks – operational procedures.

4.6.3 Regulatory Review

- **Monitor Regulatory Changes:** Integral to future WWTF and WQBEL studies conducted by the Municipality will be ongoing review of potential regulatory changes discussed. Similarly, the Municipality needs to remain in tune with the national perspective captured in Canadian Council of Ministers of Environment (CCME) and Environment Canada initiatives as they will be important in future planning activities.
- **AESRD:** As a key regulator of the Municipality's WWTFs and the Municipality will be served well by maintaining an intentional line of communication with its staff in terms of the general topics discussed in this document. Concurrently, the Municipality should be proactive in bringing broader sustainability aspects to AESRD to inform its Approval discussions.

4.6.4 Treatment Technology Review

- We offer the following strategy to guide the Municipality in its ongoing planning and decision-making in light of technology change:
 - Develop a conservative plan for cash flow and land area requirements.
 - Formulate a future uncertainty analysis that can be integrated with a triple-bottom-line (TBL) evaluation to assist in technology decision-making.
 - Regularly review technology developments to enable appropriate decision-making near the time of implementation.
 - Plan and design WWTFs for adaptation, to accommodate core technology change/transition.
- **Filtration:** AE recommends for the Municipality to implement tertiary filtration in the near future to address TP issue and the 2015 Approval requirements.

SUMMARY REPORT

5 Wastewater Outputs

5.1 EFFLUENT TOTAL LOADINGS

In addition to Fort McMurray's WWTF which discharges treated effluent to the Athabasca River, there are more than 40 stormwater outfalls which discharge directly to the river or via local tributaries to the river. The stormwater discharges include rainfall and snow melt runoff, about 30% of which is attenuated through stormwater management ponds. The Municipality plans to construct stormwater management ponds to all future development areas.

5.1.1 Athabasca River at Fort McMurray

Table 5-1 summarizes available water quality data for three key parameters (total suspended solids, total phosphorus, and ammonia-nitrogen).

Table 5-1
Summary of Athabasca River Water Quality Upstream of Fort McMurray

Parameter	February Average/Median	Annual Average/Median
TSS	2.4/1	61/6
TP	0.028/0.023	0.062/0.029
NH ₃ -N	0.060/0.029	0.039/0.070

5.1.2 Total Urban Loadings

Table 5-2 presents estimated average projected (2013-2038) loads from the Municipality's combined discharges on the Athabasca River at Fort McMurray, under low river flow conditions, as well as annual average conditions.

Table 5-2
**Estimated Total Loads from Fort McMurray's
Treated Wastewater Effluent, Stormwater and Snow Storage Systems (kg/d)**

Time/Parameter	2013	2023	2038
February (low river flow condition)			
TSS	520	364	520
TP	26	18.2	26
NH ₃ -N	156	218	312

Time/Parameter	2013	2023	2038
Annual (average river flow conditions)			
TSS	1,453	1,609	2,037
TP	18	15	21
NH ₃ -N	35	49	69

NOTE: Annual river load contributions from Fort McMurray's stormwater and snow storage sites to be determined through future monitoring. For purpose of the report, estimates are used.

5.1.3 River Water Quality Impacts

Figure 5-1 graphically illustrates the estimated loading impacts for the three parameters, during low flow conditions (winter) and average annual flow conditions.

Table 5-3 shows the estimated average river water quality impacts associated with the Fort McMurray effluent discharges, during the river low flow period (February) and average annual conditions.

During the low flow condition, the river water quality guidelines for the three parameters are maintained in all cases. During the average annual flow condition, the water quality guidelines for TSS and NH₃-N are also met; however, the water quality guideline for total phosphorus is exceeded because the upstream concentration (before Fort McMurray's discharges) already exceeds the guideline. The estimated 25-year projected annual change in TSS concentration shows a marginal improvement due to the relatively lower TSS of the discharges. The total phosphorus concentration shows a 0.3% increase and the ammonia-N concentration shows a 4.3% increase. The estimates will require updating once the results of stormwater and snow storage site monitoring become available.

Figure 5-1
Estimated Wastewater Effluent Load Impacts

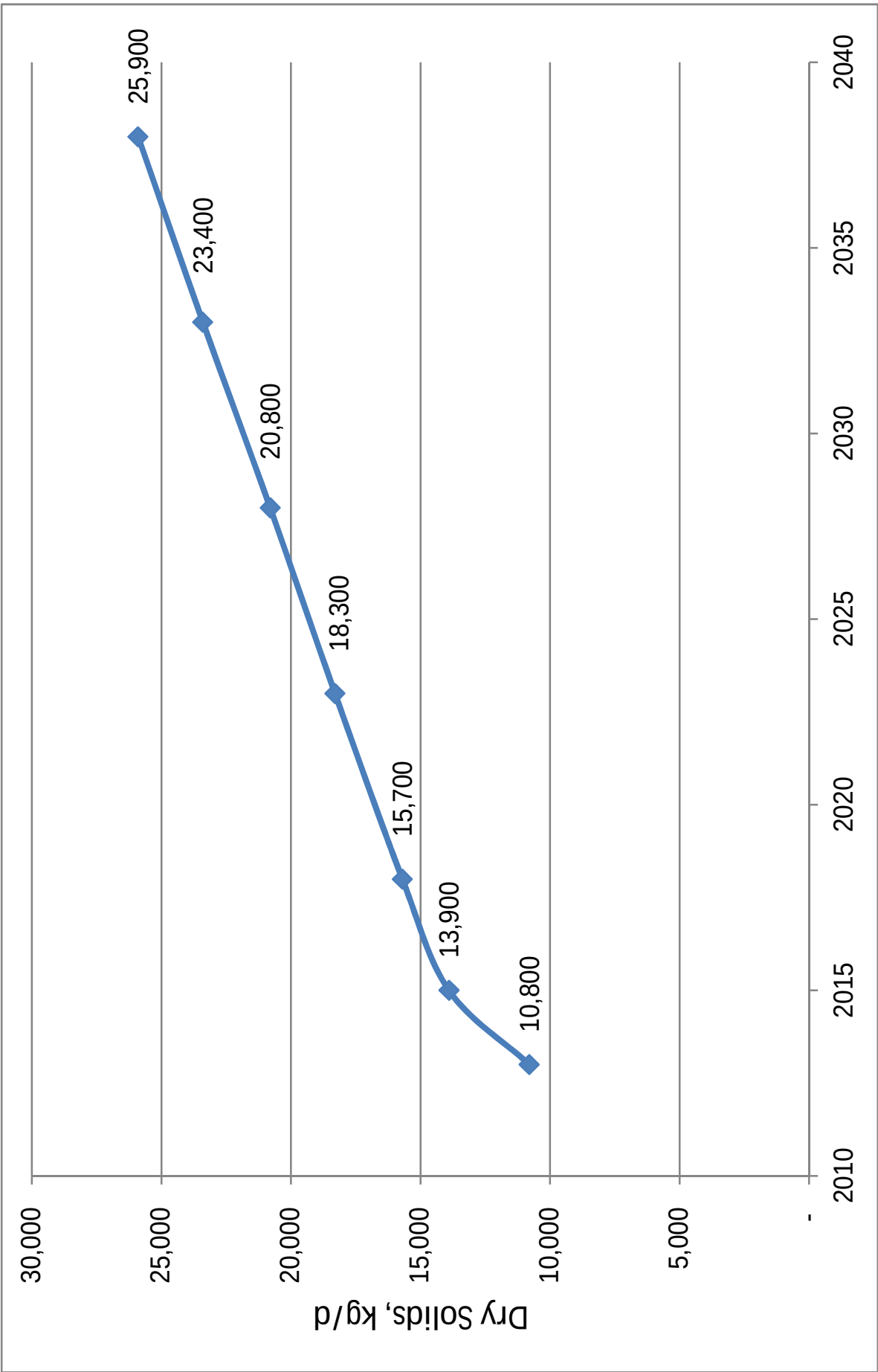


Table 5-3
Estimated Water Quality Impacts on the Athabasca River from Fort McMurray's Discharges
Under Typical Low River Flow (February) and Average Annual Flow Conditions

Year/ Parameter	Water Quality Guideline	Low Flow Upstream River		Low Flow Downstream River		Average Annual Flow Upstream River		Average Annual Flow Downstream River	
		Concentration (mg/L)		Estimated Concentration (mg/L)	% Increase	Concentration (mg/L)		Estimated Concentration (mg/L)	% Increase
2013									
TSS	≤ 10 mg/L increase over background value	2.38		2.44	2.7%	117.4		117.3	-0.05%
TP	0.05 mg/L	0.028		0.031	9.5%	0.0973		0.0976*	0.3%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0 0.715 mg/L at 15°C and pH 8.0	0.060		0.077	28.0%	0.036		0.037	2.2%
2023									
TSS	≤ 10 mg/L increase over background value	2.38		2.42	1.9%	117.4		117.3	-0.09%
TP	0.050 mg/L	0.028		0.030	6.4%	0.0973		0.0975*	0.2%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0 0.715 mg/L at 15°C and pH 8.0	0.060		0.083	39.1%	0.036		0.0370	3.0%
2038									
TSS	≤ 10 mg/L increase over background value	2.38		2.44	2.4%	117.4		117.2	-0.14%
TP	0.050 mg/L	0.028		0.031	9.1%	0.0973		0.0976*	0.3%
NH ₃ -N	1.92 mg/L at 0°C and pH 8.0 0.715 mg/L at 15°C and pH 8.0	0.060		0.093	55.8%	0.036		0.0375	4.3%

*NOTE: **Bolded** values exceed the most stringent of the surface water quality guidelines (CCME or AESRD).

SUMMARY REPORT

5.2 EFFLUENT REUSE

5.2.1 Reuse Water Drivers

The Municipality's main drivers for effluent water reuse are water conservation and overall environmental benefits. The Municipality has embarked on a water conservation program which will gradually reduce the average potable water per capita water demands. Water reuse is a form of water conservation in that it reduces the demands placed on the potable water treatment facility.

Environmental benefits of water reuse for the Municipality include lower raw water withdrawal volumes from the Athabasca River, maximized use of treated effluent as a resource rather than a waste, lower effluent loads discharged to the Athabasca River, and net reductions of greenhouse gases.

5.2.2 Reuse Water Applications

Water that is reclaimed for reuse may be categorized as consumptive or non-consumptive. Consumptive reuse applications (e.g., irrigation) do not return water back to the wastewater collection system for re-treatment. Non-consumptive re-use applications (e.g., toilet flushing) do return water back to the wastewater collection system for re-treatment.

Other reuse water concepts include decentralized greywater collection, treatment and reuse (e.g., toilet flushing); indirect potable reuse; and direct potable reuse. The latter two concepts are considerations only for locations with severe water shortages and, therefore, they are not currently applicable to Fort McMurray.

5.2.3 Fort McMurray Water Consumption Review

AE reviewed the Municipality's 2008-2013 water records to determine that the average potable water supply of 30.61 ML/d was distributed approximately as follows:

• Regional Piped Portion	1.9%
• Trucked Potable Portion	12.8%
• Trucked Non-Potable Portion	0.9%
• Piped within Fort McMurray	<u>84.4%</u>
• WTP Total Water Supply (30.61 ML/d)	100.0%

The trucked non-potable water supply may be a candidate use for reuse water supply, however it represents <1% of the total potable water supply. On the other hand, a portion of the 12.8% trucked water supply may be a candidate for reuse water supply, subject to an in depth survey and analysis of end uses.

With respect to the piped water within Fort McMurray, the Municipality provided some 2013 metered potable water records for 31 high water use customers (those who used >2,000 m³/month or about 66 m³/d over the first half of 2013). Review of customer type appeared to show little potential for reuse water from existing customers. Commercial customers, such as trucking/rental companies, as well as a park, were

considered to have some potential for water reuse. Condominium corporations, hotels and the like were considered to have no immediate potential for significant reuse water. The remaining customers were classified as “Unknown”. Table 5-4 summarizes this analysis.

**Table 5-4
Preliminary Assessment of Reuse Water Use Potential for the
High Water Customers in Fort McMurray**

Potential	Number of Top Customers	Average Day Potable Water Use (m³/d)
Some Potential	3	996*
Unknown Potential	9	1,233*
No Potential	19	2,083
Totals	31	4,312

* The portion of potable water consumption that might be displaced by reuse water use is not known at this time.

5.2.4 Reuse Water Balance

Figure 5-2 illustrates a hypothetical reuse water balance that would apply if the effluent from the WWTF met 10% of the non-consumptive reuse water use demand and 25% of the consumptive reuse water demand. This example and supplementary analyses shows that:

- Non-consumptive water reuse proportionately reduces the required water treatment plant production (10% reduction in this illustration).
- Both non-consumptive and consumptive water reuse proportionately impact the effluent volumes returned to the Athabasca River (10% + 25% = 35% reduction in this illustration).
- For the Municipality to achieve its ultimate objective of 100% water reuse, any combination of consumptive and non-consumptive water reuses totalling 100% of the WWTF effluent volume will be required.

5.2.5 Reuse Water Quality Requirements

At this time, AE anticipates that the water quality from the Fort McMurray WWTF, following filtration and chlorine disinfection will meet the applicable regulatory requirements and the specific needs of most users who may connect through a distribution network. Where water quality requirements of specific users may be more stringent, then the onus should be on the specific users to provide additional treatment.

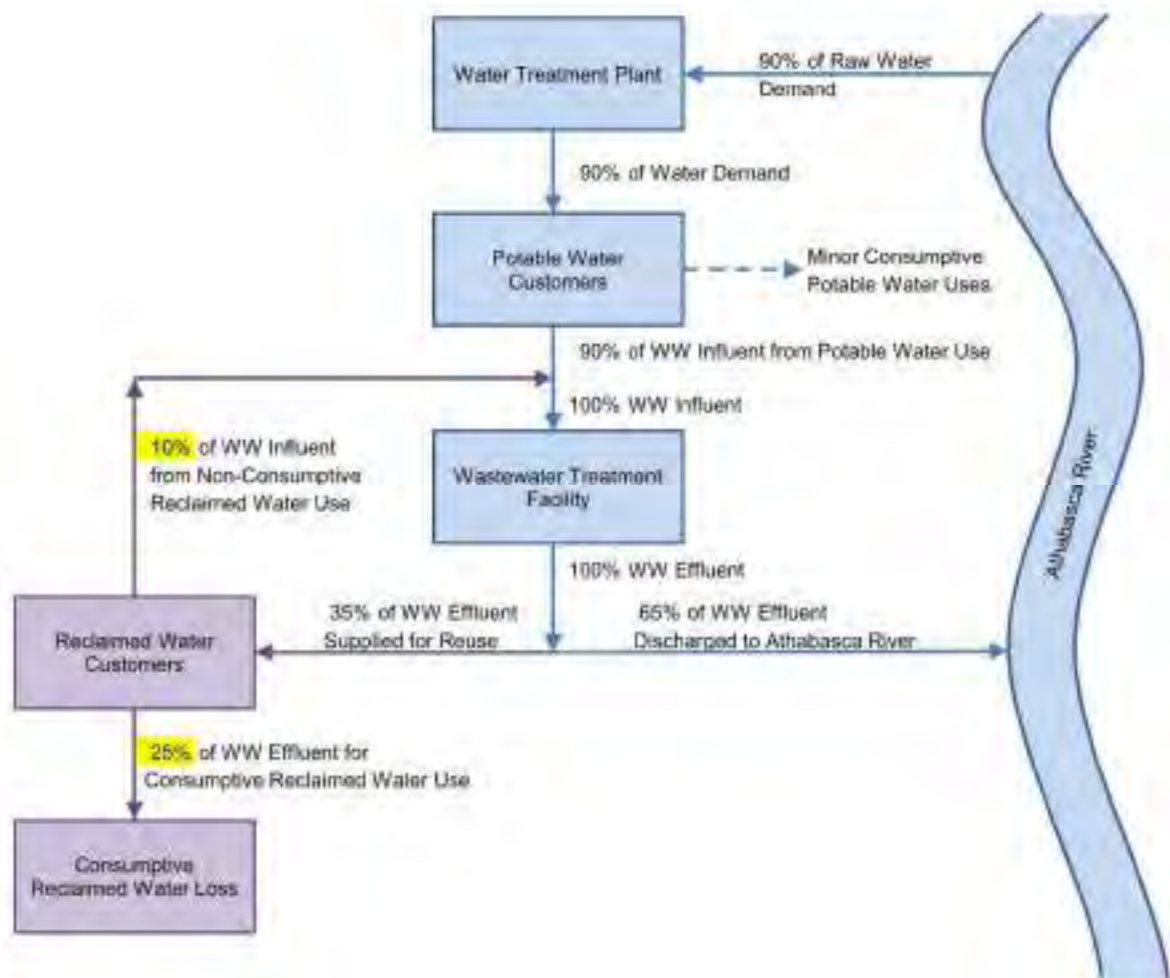
5.2.6 Reuse Water Infrastructure Requirements

Three main infrastructure components are required for a reuse water system: treatment; storage; and distribution.

As previously indicated, treatment at the Fort McMurray WWTF (as well as the future South Regional WWTF) is expected to meet stringent quality requirements for reuse water following filtration and chlorine disinfection. Reuse water storage will be required to help cover supply shortfalls (through equalization storage) and reduce peak treatment and distribution demands. Reuse water distribution to the end customers may include truck fills, pumping stations, and pipelines.

Depending upon the Municipality's preferred customers for reuse, the specific infrastructure requirements will vary.

**Figure 5-2
Water Balance Scenarios**



5.2.7 Implementing Reuse Water Infrastructure

There is a great deal of information to consider when planning a reuse water distribution network, including:

- Potential customers and demands;
- Regulatory requirements specific to the intended use;
- Potential customer locations;
- Future development for the Municipality;
- Existing infrastructure that could be utilized; and
- Local expectations.

Planning a reuse water distribution network for the Municipality must take into consideration existing, established developments, new developments planned for the community, as well as long distance commercial/industrial users.

For new development areas, the Municipality has two options to implement a reuse water system:

- Purple water pipe network
- Reservoir and truck/bucket fill

Depending upon the customer application and demands, the type of reuse system implemented in a new development may vary. Before determining what system is best suited the reuse water demands of the development area must be evaluated. For planning purposes, AE suggests that the Municipality considers constructing reuse reservoirs in major new development areas that would be fed by the FMWWTF or future South Regional WWTF. This allows the Municipality the flexibility to either implement full purple pipe networks or truck fills.

For existing developments, implementing a purple water pipe system is difficult as installation would require destruction of existing infrastructure. With this, the best suited reuse water system for an existing development area is a reservoir truck/bucket fill system for residents and commercial/industrial customers to use as desired.

The Municipality Long distance commercial/industrial developments are possible all around the UDSR. Implementing the reuse system for these systems seems to be more straight-forward as the customer demands requirements will likely be well defined prior to implementing the system. Due to the long distance, these systems may require dedicated pump stations and pipelines, if an existing reuse pipeline is not available.

To determine the location of reuse water infrastructure the Municipality must conduct a Reuse Water Master Plan to identify the needs and actions necessary for each catchment and development; as well as to assist the Municipality with identifying potential customers for reuse water.

5.2.8 Reuse Methodology Framework

This report provides a high level framework towards developing a strategy for reuse water supply. This preliminary framework will require significant, further development and refinement prior to implementing the reuse water strategy. The further work should include

- Review of the customer database and possibly a targeted market survey to evaluate the potential reuse water needs;
- Evaluation of water reuse potential for all practical uses;
- Confirmation of potential major industrial users and their locations; and
- Preparation of a Water Reuse Master Plan tying all of the information together.

A suggested review process for reuse water applications from residential developers and commercial/ industrial customers within the UDSR includes initial screening of applications (checklists); regulatory reviews; permit issuing; design, construction, and commissioning; and finally system operation. With respect to the application process for outside industrial customers, the process will be somewhat contingent on the specifics of each application.

The preliminary water reuse strategy should be further developed in a comprehensive Reuse Water Master Plan. The plan development should be led by the Municipality with input from key stakeholders (private developers - both, commercial and residential), commercial and residential water users, truckfill users, and external water users (remote industrial).

5.3 SOLIDS MANAGEMENT

Solids Management for the Municipality includes sources of solid waste (grit, screenings, waste sludge, biosolids, mud pit solids, compost, etc.) from the existing Fort McMurray WWTF and the future South Regional WWTF. A solids management plan for the solids generated by the wastewater treatment facilities in the urban Municipality is a key element of the treatment portion of the WWMP. The solids management plan looks at options from point of generation to disposal.

The Municipality's vision is to develop world class waste to energy facilities and an eco-industrial park to take the place of the landfill. Low temperature gasification/biodiesel facilities would convert waste to energy, producing electricity, heat, and biodiesel. As well, with the low temperature gasification process, recovery of materials from the residuals would be greatly facilitated. Electricity and heat would be supplied to greenhouses and CO₂ from the gasification process would be recovered and supplied to nearby greenhouses to increase plant productivity. One of the significant net environmental benefits would be a significant reduction in greenhouse gas emissions, achieved through leading waste management practices and reduced transportation requirements.

5.3.1 Solids Steams – Current Practices

The Fort McMurray WWTF currently handles the various sources of solids through different means. Below is a summary of the solids handling at the Fort McMurray WWTF:

- Grit removed by a grit vortex chamber is pumped to a grit classifier and dewatered prior to discharge into the collection bin prior to transport to the landfill.
- Screenings from two fine mechanical screens (6 mm openings) are macerated, washed and compacted (new system to be installed) prior to discharge into a collection bin for transport to the landfill.
- Primary sludge pumps withdraw settled raw sludge from three primary clarifiers and pump it to two fermenters. Scum from the primary clarifiers is collected in primary scum standpipes and is pumped to a primary rotary screen located in the Headworks Building for further dewatering.
- Thickened sludge from the fermenters is pumped to two centrifuges for dewatering. The fermenter sludge wastage pumping is linked to the thickened waste activated sludge pumping and to the operation of the centrifuge.
- Waste activated sludge (WAS) from the bioreactors is normally achieved by surface wasting of mixed liquor (WAS); the design also enables wasting of return activated sludge (RAS). The WAS is pumped to two dissolved air flotation (DAF) units for thickening.
- Each DAF unit has a skimmer that collects the float and pushes it over a beach into a float box that drains into a thickened WAS (TWAS) storage tank. TWAS is pumped from the storage tank to the centrifuges.
- Blended, fermented primary sludge and thickened secondary sludge are dewatered and discharged via gravity from two centrifuges into a horizontal sludge conveyor. An inclined conveyor transfers the dewatered sludge from the horizontal conveyor onto the mixing area floor in the compost building. New screw conveyors are currently being tendered to provide better system reliability and increased capacity.

In late 2012, the compost system became inoperable, as a result of a foul air (FOA) blower explosion. To cope with this emergency situation, the Municipality is hauling dewatered sludge directly to the landfill without composting. The FOA blower replacement is scheduled later in 2014 at which time composted biosolids will be hauled to the landfill for additional curing in windrows and eventual beneficial reuse.

Hydro-vac and other liquid wastes with high inert solids contents are hauled to the Municipality's mud pit located at the FMWWTF. The liquid portion of the wastes is drained to the mud-pit and the higher solids content portion is typically deposited in the adjacent area for natural drying. Solids from the mud pit are periodically excavated and deposited in the drying area. Some of the dried solids have been beneficially used as part of the berm construction for the new septage receiving facility. A long term plan for these wastes is required.

With respect to solids quantities, the Municipality indicated that the quantities of screenings and grit quantities are relatively minor compared to the dewatered sludge and biosolids. A mass balance provided a unit average dewatered sludge production estimate of 380 kg dry solids per ML wastewater treated; however, this will require future verification. At 25% dewatered solids concentration, the haulage of wet solids therefore equates with about 1,520 kg wet solids per ML wastewater treated.

5.3.2 Solids Streams – Projected Loads

Figure 5-3 illustrates the projected dry raw sludge solids production estimates for Fort McMurray. The projections show a rapid initial increase due to the planned direct handling of septage commencing in 2014 and then a steady increase at 4% per year (linearly) in line with the medium population growth rates. At 25% solids concentration, the wet solids production projections would be four times the indicated dry solids projections.

Currently the raw solids are transported for disposal in Fort McMurray's landfill. Prior to that, when composted solids were hauled to the landfill, the landfill records showed that the total weight of hauled compost was approximately 10% less but the number of loads were more than double (likely due to the less dense characteristics of the compost).

5.3.3 Review of South Regional WWTF Solids Management Technologies and Strategies

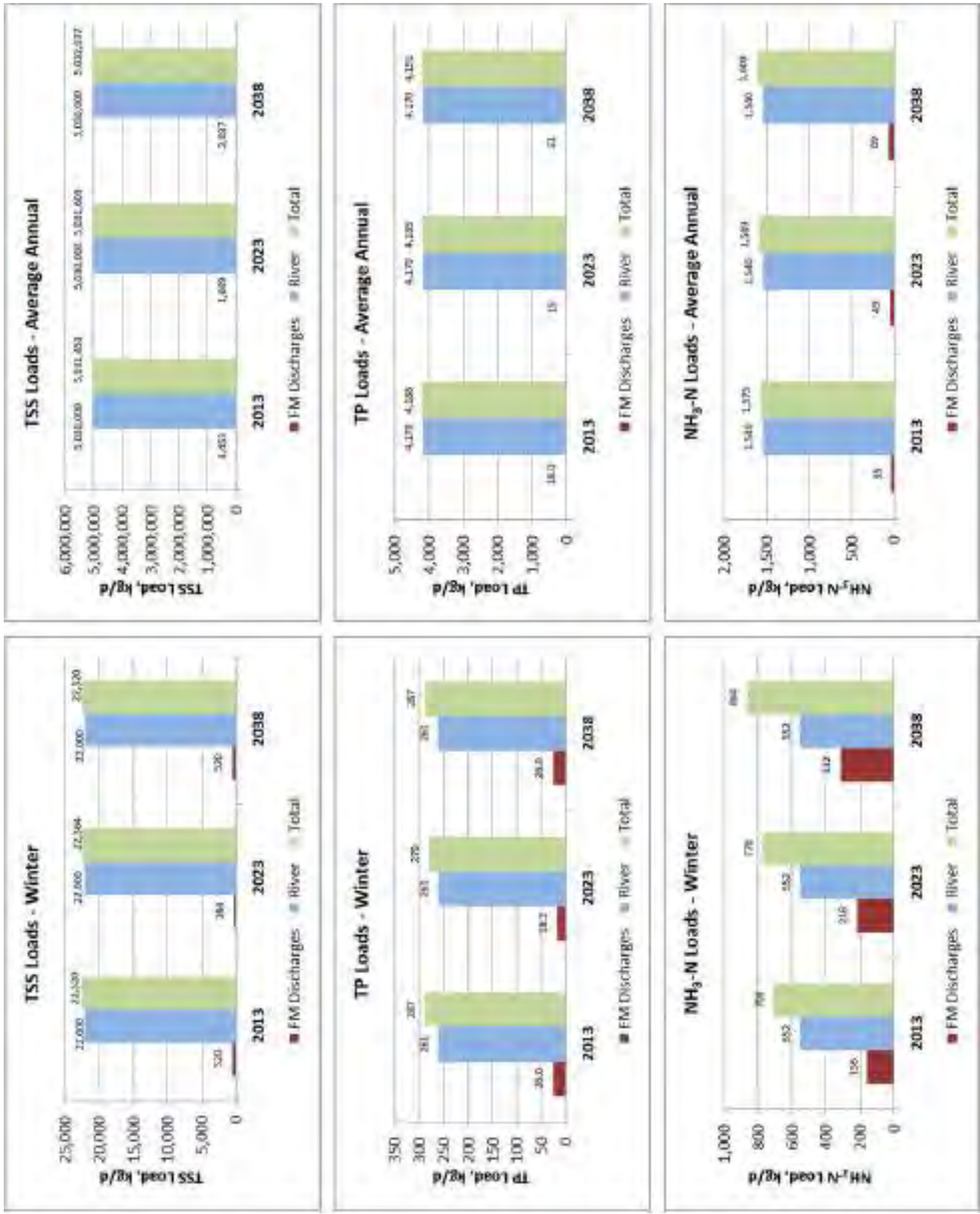
The recommended initial solids stream processes for the South Regional WWTF included:

- Fine screening, screenings washing/compaction, landfill disposal of screenings.
- Vortex grit removal, washing/dewatering, landfill disposal of grit.
- Source thickening of waste activated sludge with primary sludge in primary clarifiers.
- Alum for chemical phosphorus removal.
- Dewatering of the combined primary/secondary sludge tentatively with centrifuges. Other dewatering processes (e.g., screw press) may also have merit and should be considered further.
- Haulage of dewatered sludge to the Fort McMurray WWTF for inclusion in the composting process.

In the longer term, as the South Regional WWTF treats significantly more flow, the solids management processes may require modifications as follows:

- Screenings may be fed to a gasifier when it is available.
- Instead of WAS source thickening, utilize DAF to thicken WAS
- Instead of thickening the primary sludge in primary clarifiers, the primary sludge would be sent to fermenters to VFAs required for BNR treatment. The fermenters would also provide thickening of the primary sludge.
- Dewatering of the combined primary/secondary sludge tentatively with centrifuges:
- Feed dewatered sludge to gasifier when it is available. Consider a dryer using waste heat from the gasifier for further removal of moisture from the sludge prior to gasification.

Figure 5-3
Estimated Wastewater Effluent Load Impacts



- The layout of the sludge management facilities at the proposed South Regional WWTF should remain flexible to accommodate a range of sludge stabilization processes in the event that the Municipality changes direction and chooses not to proceed with a gasifier or other type of energy recovery facility.
- Consider backup sludge stabilization processes (e.g., alkaline stabilization) to provide reliable operation if the primary sludge stabilization process is temporarily out of service.

5.3.4 Solids Management Technologies

Solids management technologies include both solids pre-treatment and solids treatment technologies. Solids pre-treatment technologies are available to reduce WAS solids production and to improve WAS degradability. Cannibal is an example of a solids reduction process. Although the process typically reduces WAS mass in the order of 40% to 60%, this performance is not evident at plants with primary clarifiers. Since primary clarifiers are a key WWTF component in Fort McMurray, it appears that the potential benefits of the Cannibal process may not be significant enough to warrant further consideration at the facility.

With respect to WAS degradability improvement, technologies include:

- Thermal hydrolysis
- Chemical treatment
- Pulsed electric fields
- High intensity ultrasound

The benefits of WAS pre-treatment include improved digestion with additional gas production and recovery (with anaerobic digestion) for heating, fuel supply and/or electricity generation. Should the Municipality decide at a future date to digest sludge, then WAS degradability pre-treatment technologies should be considered at that time.

With respect to solids treatment technologies, raw sludge requires stabilization to render it much less putrescible (primarily reduced odour), to reduce vector attraction (e.g., insects, rodents), to improve appearance for end-user acceptance, to reduce health hazards (e.g., achieve low pathogen levels), and ultimately to enable beneficial use of the stabilized biosolids.

Common stabilization technologies are aerobic digestion, anaerobic digestion, composting, alkaline stabilization, and heat drying. With its composting process, the Fort McMurray WWTF is designed to produce Class A biosolids; however, the end use of the biosolids to date has only been landfill application and disposal.

Wastewater biosolids are recognized as a source of multiple recoverable assets: nutrients, organics, energy, and water. Resource recovery technologies include:

- Anaerobic digestion to produce biogas. The gas (primarily methane) can be used for digester heating, building heating, machinery drivers, power generation, pipeline injection, and vehicle fuel (with various gas cleaning requirements). Various combined heat and power (CHP) options are available. Established technologies include internal combustion engines, gas turbines, micro-turbines, and Stirling engines. Fuel cells are an emerging technology.
- Thermal conversion processes including fluidized bed incinerators with energy and heat recovery, off-site co-combustion (a secondary fuel source) in cement kilns, and gasification in which the biomass is thermally converted into syngas.
- Nutrient recovery processes such as Ostara's struvite (magnesium ammonium phosphate) crystallization process which is increasingly being used to recover nutrients from anaerobically digested sludge or centrate providing dry fertilizer pellets.

5.3.5 Biosolids Management Options

Review and short listing of the solids management technologies in the context of Fort McMurray's requirements resulted in recommendations for consideration at this time, specifically:

- Continued aerated static pile composting: Existing composting system is being restored to full operation. However, the future decommissioning of the composting system would be considered if other options are implemented in future.
- Gasification of dewatered sludge with municipal solid wastes: Subject to successful gasification trials.
- Anaerobic digestion with energy and nutrient recovery.
- Combinations of latter two options with heat drying.

With respect to hydro-vac type wastes, further study should be undertaken with the objective of developing a sustainable plan for managing mud pit wastes.

- Regarding septage wastes, septage characteristics should be confirmed and septage discharges should be restricted if necessary to enable proper WWTF operation. In addition the direct septage load impacts (no pre-treatment) should be evaluated relative to the indirect impacts (pre-treatment through aerated septage lagoon).

5.4 FOUL AIR MANAGEMENT

There are numerous sources of foul air (FOA) throughout any WWTF; therefore, FOA management is key to reducing the FOA levels. To develop a FOA Management Plan for the Municipality, the sources of gas waste (odorous gases and greenhouse gases) were reviewed from the existing Fort McMurray WWTF, as well as the future South Regional WWTF.

5.4.1 Background

Ammonia (NH₃), hydrogen sulphide (H₂S), organosulphur compounds, and volatile organic compounds (VOCs) are the main sources of odour in a treatment plant. Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) are the main sources of greenhouse gas emissions related to WWTF operations.

5.4.2 Existing Fort McMurray WWTF FOA Management

Foul air is collected from about a dozen locations around the WWTF for treatment. The largest FOA source is the operating compost tunnels. This FOA is pre-treated through a wet scrubber for ammonia gas removal and then combined with the remainder of the FOA sources for treatment through biofilters.

5.4.3 FOA Management Options/Evaluation

Nine FOA management options were identified and reviewed. Of those, four were recommended for consideration at this time:

- Wet scrubber: Continue use of wet scrubber at Fort McMurray WWTF. If the compost process is to be retained in the long term use (>5 years), install a second wet scrubber to provide redundant capacity. Depending on future South Regional WWTF processes, also consider wet scrubbers for application at that site.
- Diffusion of FOA into activated sludge: Consider for future South Regional WWTF.
- FOA supply to gasifiers: Consider if gasifier is to be constructed in close proximity to either WWTF.
- Biofilters: Continue biofilter use at Fort McMurray WWTF. Also, consider for future South Regional WWTF if gasifier option proves not to be feasible.

5.4.4 Greenhouse Gas Emissions

The historical focus of off-gas streams in WWTFs has been on odorous air; however, attention is now being given to off-gas streams containing GHGs. Table 5-4 lists the major GHGs and their Global Warming Potential (GWP) for a period of 100-year¹.

**Table 5-5
Greenhouse Gases and their Global Warming Potential**

GHG	GWP for 100-Year
Carbon Dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous Oxide (N ₂ O)	298
Chlorofluorocarbon	10,900

¹ Carbon Dioxide Information Analysis Centre: http://cdiac.ornl.gov/pns/current_ghg.html

Regional Municipality of Wood Buffalo Wastewater Master Plan

Some direct GHG emissions from the Fort McMurray WWTF originate from the aerobic biological treatment processes. Although CO₂ is recognized as a GHG, its release from the biological processes is not count against the facility's GHG emissions because it is considered biogenic. On the other hand, nitrous oxide (N₂O) is also likely released in small quantities and does count against the facility's GHG emissions; however, the equivalent GHG impact of N₂O is in the order of 300 times that of CO₂ so its impact may be significant. In addition, there may be some minor releases of methane (CH₄) where anaerobic conditions contribute to the conversion of organic acids to CH₄.

The existing septage receiving lagoons are another source of GHGs since anaerobically decaying sludge deposits in the lagoons release some methane which may escape into the atmosphere. The direct treatment of septage in the WWTF should help to greatly reduce this GHG source.

The current landfilling of the WWTF's raw sludge may be a relatively significant contributor to GHG releases. With the burial of the sludge, anaerobic conditions are maintained as the sludge slowly degrades. This source of GHG emissions will be eliminated when the aerobic composting process is re-activated at the WWTF.

USEPA² published estimates of annual GHG emissions in terms of equivalent CO₂ loads from various sources in the United States between 1990 and 2011. The estimates included wastewater systems. While US estimates may not necessarily reflect relative impacts of various activities in Canada in general, or more specifically in Fort McMurray, we expect that they should provide a general idea of the their relative GWP significance.

Table 5-6 provides a summary of some of the relative contributions. This shows that of the total emissions, wastewater systems account for an estimated 0.3% of the emissions. Landfills account for 1.5% of the total emissions, or about 5 times the wastewater emissions. Fossil fuel combustion is the primary source of GHG emissions at 78.7% of the total.

Table 5-6
Relative GHG Emissions (2011 Estimates for USA)

Source	% of Total Emissions	Comments
Fossil fuel combustion	78.7%	Main GWP contributor (CO ₂ release)
Wastewater systems	0.3%	Excludes biogenic CO ₂ . Relative impacts: CO ₂ : CH ₄ : N ₂ O : Other – 0 : 76 : 24 : 0
Landfills	1.5%	Approx. 5 times more contribution than from wastewater. Landfill emissions based solely on CH ₄ release.
Remainder	19.5%	
Total	100.0%	

² USEPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks

5.5 MAIN FINDINGS

5.5.1 Effluent Total Loadings

- **River water quality guideline parameters:** TSS, NH₃-N and TP.
- **Low flow condition:** the river water quality guidelines for the three parameters are maintained.
- **Average annual flow condition:** the water quality guidelines for TSS and NH₃-N are met; however, the water quality guideline for total phosphorus is exceeded because the upstream concentration (before Fort McMurray's discharges) already exceeds the guideline.
- **TSS Loading:** 25-year projected annual change in TSS concentration shows a marginal improvement due to the relatively lower TSS of the discharges.
- **TP Loading:** The total phosphorus concentration shows a 0.3% increase.
- **NH₃-N Loading:** The ammonia-N concentration shows a 4.3% increase.

5.5.2 Effluent Reuse

- **Consumptive or non-consumptive:**
 - Consumptive reuse applications (e.g., irrigation) do not return water back to the wastewater collection system.
 - Non-consumptive re-use applications (e.g., toilet flushing) return water back to the wastewater collection system for re-treatment.
- **Infrastructure components:** treatment; storage; and distribution. Depending upon the Municipality's preferred customers for reuse, the specific infrastructure requirements will vary.
- **Reuse Water Quality:** Fort McMurray WWTF is expected to meet stringent quality requirements for reuse water following filtration and chlorine disinfection.
- **Reuse System Planning:** Information to consider when planning a reuse water distribution network, includes:
 - Potential customers and demands;
 - Regulatory requirements specific to the intended use;
 - Potential customer locations;
 - Future development for the Municipality;
 - Existing infrastructure that could be utilized; and
 - Local expectations.

5.5.3 Solids Management

- **Sources of solid waste:** grit, screenings, waste sludge, biosolids, mud pit solids, compost, etc.
- **Dewatered sludge production:** estimate at 380 kg dry solids per ML wastewater treated which equates to ~1,520 kg wet solids per ML wastewater treated.
- **Projections:** A rapid initial increase is estimated due to the planned direct handling of septage commencing in 2014.
- **Currently Solids Management Plan:** raw solids are currently transported for disposal in Fort McMurray's landfill. Prior to that, composted solids were hauled to the landfill.

5.5.4 Foul Air Management

- **Main Sources of Foul Air:** Ammonia (NH₃), hydrogen sulphide (H₂S), organosulphur compounds, and volatile organic compounds (VOCs).
- **Main Source of Greenhouse Gases:** Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O)
- **Current Foul Air Management Plan:**
 - Foul air is collected from about a dozen locations around the Fort McMurray WWTF for treatment;
 - Pre-treated through a wet scrubber for ammonia gas removal; and
 - Remainder of the FOA sources are treated through biofilters.
- **Nine FOA management options** were identified and reviewed, four were recommended for consideration:
 - Wet scrubber;
 - Diffusion of FOA into activated sludge;
 - FOA supply to gasifiers; and
 - Biofilters.
- **Greenhouse gas emissions** from the Fort McMurray WWTF originate from:
 - Aerobic biological treatment processes;
 - Current landfilling; and
 - Existing septage receiving lagoons.

5.6 RECOMMENDATIONS

5.6.1 Effluent Total Loadings

- **Interim Total Loadings Plan:** The following is recommended:
 - Submit draft TLP and proposed stormwater monitoring plan to AESRD for review;
 - Review meeting with AESRD;
 - Monitor stormwater sites (2014 – 2015);
 - Update TLP with data from additional monitoring (May 2015); and
 - Submit updated plan to AESRD (June 2015).
- The potential for additional wastewater, stormwater, and snow dump system improvements to help protect the Athabasca River will have to be reviewed with AESRD following submission of this preliminary Total Loadings Plan, and again from time to time, as more data become available.

5.6.2 Effluent Reuse

- **Reuse Water Master Plan:** Further work to develop a Reuse Water Master Plan should be completed, including:
 - Review of the customer database and possibly a targeted market survey to evaluate the potential reuse water needs;
 - Evaluation of water reuse potential for all practical uses;

- Confirmation of potential major industrial users and their locations; and
- Preparation of a Water Reuse Master Plan tying all of the information together.

5.6.3 Solids Management

- **Near-term plan (up to 5 years):**
 - Review sludge production estimates to confirm the basis for the solids management plan.
 - Continue composting. Directly dispose dewatered sludge at the landfill only during emergency operations.
 - Investigate the beneficial uses of composted biosolids further to provide the Municipality with alternatives for their ultimate end use.
 - Confirm the characteristics of solids (Metals, TS, VS, etc.) for dewatered sludge, compost, hydro-vac type wastes, and septage solids to help confirm viable management options and appropriate beneficial uses.
 - Evaluate longer term options for biosolids management to facilitate transition to improved biosolids management in the longer term, should alternate management options prove more favourable than the current practices.
- **Long term plan (5-20 years):**
 - Consider the following alternate options as a possible replacement for the current composting system: (a) gasification of dewatered sludge in conjunction with municipal solid wastes, (b) anaerobic digestion with energy and nutrient recovery, and (c) combinations of gasification and anaerobic digestion options with sludge drying.
 - If a gasifier becomes part of the Municipality's future infrastructure, maximize the energy recovery potential by locating the gasifier in close proximity of to the sludge drying facility.
 - Depending on the Municipality's growth, operating experiences, and technology advances, update the long term plan periodically (as required).

5.6.4 Foul Air Management

- **Near-term plan (up to 5 years):**
 - The Fort McMurray WWTF's current odour management systems should be kept operational.
 - If the longer term solids management plan involves continued composting, then a second wet scrubber should be installed for backup.
- **Long term plan (5-20 years):**
 - If a gasifier is to be installed at the new landfill site in future, in close proximity to the proposed South Regional WWTF, the opportunity to use FOA to meet part of the gasifier's air supply requirements should be considered.
 - Haulage of dewatered sludge from the Fort McMurray WWTF to a future gasifier at the landfill site would simplify odour control at the Fort McMurray WWTF site. The large volume of FOA from the compost facility would be eliminated with the decommissioning of the compost process. The remaining FOA treatment could be effectively accommodated with the existing wet scrubber and/or biofilters.

- The possible future construction of a gasifier at the existing Fort McMurray WWTF site could afford the Municipality with the same benefits as for the South Regional WWTF site.
- If a future gasifier is not to be installed at the South Regional WWTF site, consider diffusion of the FOA sources into the activated sludge aeration basins at that site.
- Re-evaluate the recommended FOA management approach, as required, if a solids management approach, other than continued composting or gasification, is adopted in future.

SUMMARY REPORT

Closure

This report was prepared for the Regional Municipality of Wood Buffalo Wastewater Master Plan to summarize the findings in the Technical Memorandums that were prepared for the Wastewater Treatment tasks within the project.

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.



Jackie Mykytiuk, P.Eng.
Project Manager



Patrick Given, M.Sc., P.Eng.
Senior Wastewater Engineer

ASSOCIATED ENGINEERING	
QUALITY MANAGEMENT SIGN-OFF	
Signature:	<i>Eden Aszelen</i>
Date:	<i>Sept 26, 2014</i>
APEGA Permit to Practice P 3979	



**Associated
Engineering**

GLOBAL PERSPECTIVE.
LOCAL FOCUS.