REPORT

Town of Beaverlodge

Wastewater Lagoon Upgrade Options

JUNE 2022

TABLE OF CONTENTS

LIST OF TABLES

PAGE NO.

LIST OF FIGURES

1 INTRODUCTION

The Town of Beaverlodge (Town) owns and operates the Beaverlodge Wastewater Lagoon System, under the *Environmental Protection and Enhancement Act (EPEA)* registration 408-02-00, which requires the system to conform to the Code of Practice for Wastewater System Using Wastewater Lagoons.

The wastewater lagoon system consists of four (4) anaerobic cells, a facultative cell, a partial mix aerated cell (post-facultative aerated treatment cell), and two (2) aerated storage cells. Wastewater flows through four (4) anaerobic cells located within the facultative cell, then into the facultative cell. The wastewater is then pumped from the facultative cell to cell #1 via a lift station. Cell #1 is divided into 3 smaller cells (cells #1A, #1B, and #1C), each separated by an impermeable geomembrane flow diversion baffle. From cell #1, wastewater is transferred to storage cells #2 and #3 by gravity for aerated storage prior to discharge to the Beaverlodge River. The lagoon system was last upgraded in 2008 with the addition of an aeration system to cells #1, #2, and #3. Aeration is provided by four (4)-20 Hp blowers located within the blower building, which is situated at the center of the lagoon site. The existing lagoon site layout is shown in **Figure 1-1**.

1.1 Background Information

In October 2020, Associated Engineering (AE) completed a Wastewater Lagoon Assessment Technical Memorandum to determine if the existing lagoon system has enough storage and treatment capacity for the next 25 years and concluded the following:

- The current wastewater lagoon system does not have sufficient storage capacity for annual discharges.
- Based on current, historical effluent quality (2017–2020) and data collected during the 2020 flow year, and using historical river quality data, the Beaverlodge River Assessment Report (**Appendix A**: Wastewater Lagoon Assessment (2020) Technical Memorandum) concluded the following:
  - Un-ionized ammonia in the river downstream of the outfall during the fall discharges from the storage cells is not expected to cause adverse effects to the fish.
  - Un-ionized ammonia concentrations at the edge of the mixing zone in the river may exceed the applicable guidelines under typical spring river flows and there may be adverse effects.
  - Total phosphorus concentration in the river downstream of the outfall during the typical spring discharge conditions increases by 40%, where an approximately 30-fold increase was determined under typical fall discharges. During fall discharges, the increase is significant enough that it changes the trophic status of the river from eutrophic to hyper-eutrophic, which can potentially lead to increased growth of attached and floating algae, which in turn can lead to unfavourable pH and dissolved oxygen levels.
- The current wastewater lagoon system does not meet Alberta Environment and Parks' (AEP's) design standards and guidelines for anaerobic and facultative cell requirements, based on its current configuration, historical population, and release schedule of discharging twice per year, which is not in compliance.
- The existing "Enhanced Conventional Wastewater Lagoon" system, comprising anaerobic cell(s), facultative cell and partially mixed aerated cell(s), would meet the year-round effluent 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) of less than 25 mg/L for the next 25 years of projected wastewater flows and loads .
- The estimated capital cost of upgrading the system to meet the AEP's design standards and guidelines for annual discharges (a total of 12 months of storage) will be $4.5 M in 2020 dollars, excluding the cost of land acquisition (if needed).

- For temporary bi-annual discharges:
  - Town's lagoon system can meet a low level of $cBOD_5$ and ammonia-N (NH_4-N) during fall discharges, until 2035, assuming that the existing aeration system can meet necessary oxygen demand.
  - Spring discharges will, in general, result in higher effluent phosphorus concertation than that of the fall discharges, due to lower biological activities. The high-level capital cost for an Alum dosing skid to reduce effluent total phosphorus concentration, during fall discharges, to an acceptable level was estimated to be $50,000, with an annual operating cost (Alum) of $12,000.

Subsequent to the report, Alberta Transportation (AT) indicated that their planned twinning of Highway 43 will affect the lagoon footprint. The proposed highway twinning and associated CN rail realignment will intersect the north-east corner of the existing lagoon site. The planned twinning will also be constructed over the Town's trunk sewer which discharges to the lagoon. The originally proposed lagoon upgrades will now need to consider the planned highway twinning, associated minimum setback requirements, and potential impacts to the trunk sewer line.

AE reviewed the proposed lagoon upgrades with AEP though a virtual meeting. During the meeting it became clear that AEP did not have records of the aeration upgrades that the Town performed under court order in approximately 2008. AEP indicated that they expect the upgraded lagoon will fall within the Code of Practice. AE will be required to review at the time of application, and confirm prior to application.

1.2 Scope of Assignment

The scope of this assignment is to review the wastewater lagoon upgrade options necessary to meet the Provincial and Federal Regulations for Wastewater System Using Wastewater Lagoons while accounting for the planned Highway 43 upgrades. The following items were reviewed as part of this assignment:

- Confirmation of design criteria.
- Lagoon Upgrade Assessment including expansion of existing lagoons or construction of new lagoons while considering:
  - Lagoon hydraulic capacity;
  - Lagoon effluent quality;
  - Suitable location for chemical addition and aeration, if required, to meet future regulatory requirements;
  - Constraints mapping to identify and illustrate the available land to construct the lagoon upgrade. Constraints will include land purchase requirements, setback distances, topography, environmental sensitivities, etc.;
  - Preliminary earthwork modeling and quantity estimates;
  - Piping requirements;
  - Regulatory permits required for the upgrades; and
  - Opinion of probable cost and schedule durations.

- Trunk Sewer Assessment including existing conditions and impacts of Highway 43 and CN rail relocation while considering:
  - Survey inverts and CCTV of the trunk sewer;
  - Hydraulic assessment of the trunk sewer to confirm its capacity and ability to service the Town for the foreseeable future;
  - Review AT and CN requirements for utility crossings and identify any potential upgrades that may be required; and
  - Opinion of probable cost of any proposed upgrades.
- Funding Review including cost split between Alberta Transportation and the Town of Beaverlodge, funding opportunities, and support in funding applications.

IF NOT 25 mm ADJUST SCALES
25 mm
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

Associated Engineering

BEST MANAGED COMPANIES
Platinum member

Beaverlodge

AE PROJECT No.	2021-3219
SCALE	1:4,500
APPROVED	
DATE	2022FEB16
REV	
DESCRIPTION	ISSUED FOR DRAFT

FIGURE 1-1

TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

EXISTING LAGOON SITE LAYOUT

2 DESIGN CRITERIA

2.1 Population Projection

The historical Federal Census data (1986–2016) for the Town was analyzed to project the future sewered population (actual residential population). The Town's population has grown modestly at an average rate of 1.1% per annum from 1986 to 2016. This is consistent with the growth rate (1.0%) used for the design of the Town's Water Treatment Plant, by AE. An annual growth rate of 1.0% was, therefore, used to estimate the population for a design horizon of 25 years. **Table 2-1** summarizes the projected populations of the Town for the next 25 years.

Table 2-1
Projected Population

Year (Design Horizon)	Population
2020 (0)	2,565
2025 (5)	2,700
2030 (10)	2,830
2035 (15)	2,980
2040 (20)	3,130
2045 (25)	3,290

2.2 Wastewater Generation Projection

Alberta Environment and Parks' (AEP) design standards and guidelines for wastewater lagoons are a function of average annual wastewater generation rate (daily). **Table 2-2** summarizes the historical total annual wastewater release volumes provided by the Town for the period of 2014 to 2019. The volumes provided are total wastewater generation volumes for the entire year as estimated by the Town, therefore, are inclusive of:

- Domestic wastewater generation;
- Any septage or truck dump flows; and
- Inflow and infiltration (I/I).

Influent flow to the lagoon system is not metered; hence, historical wastewater release data for the Town and corresponding sewered population was used to estimate average annual per capita wastewater generation rate, as shown in **Table 2-2**. A wide range in the per capita generation rate was recorded. The estimated annual release rate for 2017 was significantly higher than the other estimated release rates, during 2014 to 2019, and there was no significant correlation between the per capital release rate and the recorded annual precipitation. Hence, the high release rate, in 2017, could be the result of inaccurate release volume measurements. Due to the limited scope, AE was unable to verify this premise during this assessment.

AEP defines the average daily design flow as the "greatest" annual average per capita daily flow, which is estimated to occur during the design life of the facility. Hence, a per capita generation rate of 625 L/d was used in this study to estimate future design flow. The original design flow was 380 L/c/d. It should be noted that the design flow used in this assessment is significantly higher than what is typically seen (approximately 500-550 L/c/d), in the Northern Alberta communities of similar size and characteristics, which may be attributed to various reasons:

- Inaccurate release volume calculation; and
- Significant I/I issue that could be addressed in the future to some degree to reduce the inflow value.

Table 2-2
Historical Wastewater Release

Year	Population	Spring Release (m^3)	Fall Release (m^3)	Total Release (m^3)	Total Annual Precipitation (mm)	Annual Release Rate (L/c/d)
2014	2,425	273,681	207,318	480,999	356	543
2015	2,445	282,374	222,614	504,988	435	566
2016	2,465	297,469	193,317	490,787	586	545
2017	2,485	318,367	248,241	566,608	488	625
2018	2,505	268,325	180,180	448,505	553	490
2019	2,526	234,299	173,555	407,854	447	442
2020	2,565	295,802	101,870	397,672	356	425

The average daily wastewater generation rate for the future assessment period was estimated by applying the per capita wastewater generation rate, 625 L/c/d, to the projected populations for the Town, as in **Section 2.1**. The estimated daily and annual wastewater generation volumes are summarized in **Table 2-3**.

Table 2-3
Estimated Annual Wastewater Generation

	2020	2025	2030	2035	2040	2045
Rate (m^3/d)	1,610	1,690	1,780	1,870	1,960	2,060
Rate (m^3/yr.)	579,600	608,400	640,800	673,200	705,600	741,600

Section 3.4.1.5.4 of AEP's design standards and guidelines require a total gravity collection system, i.e., no pumping station with a capacity <500 m^3/d, to have a portable or permanent flow measuring device provided at the inlet of the wastewater lagoons. Hence, AE recommends installation of a Parshall flume type flow meter at the inlet or an ultrasonic flow meter at the lift station that feeds cell 1A to measure the influent flow to the wastewater lagoon system and verify the design assumption used in this assessment before proceeding with the design to upgrade . In addition, AE recommends completing an inflow and infiltration (I&I) study to identify potential options to reduce the I&I contributions to the lagoon system, i.e., lining of pipes and manholes.

2.3 Wastewater Quality Estimation

AEP does not have any guidelines to estimate influent design loads for conventional wastewater lagoons, as the design guidelines are based on the hydraulic retention time of average daily flow. For aerated lagoons, AEP recommends using the influent wastewater characteristics of typical domestic wastewater (BOD - 200 mg/L, TSS - 200 mg/L), unless the characteristics are considerably different. The Town does not have to monitor and report influent concentrations, as part of the requirements of the Code of Practice; therefore, data were not available to estimate or verify influent wastewater characteristics.

AE recommends that the Town completes a minimum of four (4) grab samples (one per season) throughout the year to start building a baseline of influent quality data for critical parameters, including BOD_5, Total Kjeldahl Nitrogen (TKN), Ammonia, and Total Phosphorus. AE reviewed the influent characteristics (BOD_5 only) for the Town of Valleyview that is of a similar scale and characteristics, as the Town of Beaverlodge. The influent BOD concentration varies between 180–220 mg/L, for the Town of Valleyview, which is typical of domestic wastewater.

Table 2-4 shows influent concentration for typical domestic wastewater used as the design basis for the Town's lagoon system upgrades.

Table 2-4
Estimated Design Influent Concentration

Parameter	Concentration (mg/L)
BOD_5	200
Total Kjeldahl Nitrogen (TKN) as N	31
Ammonia as N	23
Total Phosphorus as P	5.2

3 LAGOON UPGRADE ASSESSMENT

3.1 Design Capacity Requirements

AEP established design criteria for wastewater lagoon cell configurations, based on the average daily design flow. Table 3-1 summarizes wastewater lagoon cell requirements in AEP's standards. The Town has an average daily design flow of more than 500 m^3/d; hence, the wastewater lagoon system should have four (4) anaerobic lagoons, each with two days of storage capacity, based on the average daily design flow. Facultative cells are required in all lagoon systems and shall retain influent wastewater for at least 60 days, based on average daily design flow. Storage cells shall retain a minimum of 12 months of storage, based on the average daily design flow. However, the current lagoon system could conveniently be categorized as "Enhanced Conventional Wastewater Lagoon" since the system includes a partial mix aerated cell downstream of anaerobic and facultative cells and the system also does not meet the design standard for aerated lagoons (a completely mixed cell with a retention of at least two (2) days). The following sections review and compare the design standards by AEP for wastewater lagoon and followed by the enhancement in the biological treatment efficiency of wastewater lagoon system through aeration.

Table 3-1
AESRD Wastewater Lagoon Design Criteria

Average Daily Design Flow (m^3/day)	Number of Anaerobic Cells	Requirements for Facultative Cell(s)	Requirements for 12 months Storage Cell(s)
< 250	0 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m
250 – 500	2 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m
>500	4 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m

3.2 Current System Hydraulic Capacity

The existing wastewater lagoon consists of eight (8) cells: four (4) anaerobic cells, one (1) facultative cell, once partially mixed aerated cell, and two (2) storage cells., The active volumes were calculated from the bottom of the cell to the high-water level, with a minimum of 0.5 m freeboard based on estimates from the existing record drawings. A summary of the existing wastewater system capacity (volume) is shown in Table 3-2. Note that the volume of the cells is estimated, based on record drawings only; a survey was not conducted to verify the values noted below.

Table 3-2
Summary of Hydraulic Capacity of Existing Wastewater System

Parameter	Value
Anaerobic Cell	
Number of Cells	4
Operating depth, m	3.65
Volume of each cell, m^3	1,360
Total volume, m^3	**5,440**
Facultative Cell	
Number of Cells	1
Operating depth, m	1.5
Total volume, m^3	**59,600**
Aerated Cell (Partially Mixed)	
Number of Cells	1
Operating depth, m	2.5
Volume (Cell#1A), m^3	27,500
Volume (Cell#1B), m^3	24,750
Volume (Cell#1C), m^3	62,350
Volume (Cell #1 total), m^3	**114,600**
Storage Cell (Aerated)	
Number of Cells	2
Operating depth, m	2.5
Volume (Cell #2), m^3	23,800
Volume (Cell #3), m^3	70,300
Total volume, m^3	**308,100**

The design capacity requirements for anaerobic, facultative, and storage cells are summarized in Table 3-3 for 2045, based on the Standard and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, Part 3 Wastewater Systems Standards for Performance and Design (ESRD, 2012).

Table 3-3
Recommended Design Capacities

Anaerobic Cell (s)[1], m³		Facultative Cell + Aerated Cell, m³		Storage Cell (s)[2], m³	
Existing	Required by 2045	Existing	Required by 2045	Existing (Cell #2 & Cell 3)	Required by 2045
5,440	16,450	174,200	123,360	308,100	741,600

Note:
[1] Requires 4 anaerobic cells in series, each with 2 days holding capacity, based on average daily design flow and an operating depth of 3.0 to 3.5 m.
[2] 12 months of storage.

3.3 Effluent Quality Objective

Table 3-4 summarizes the effluent quality objectives used for the proposed upgrades for the design horizon.

Table 3-4
Upgraded Lagoon Effluent Quality Objective

Parameter	Unit	Value
Flow	m^3/d	2,060
Effluent $cBOD_5$	mg/L	25

3.4 Land Restrictions

As per Standard and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, Part 3 Wastewater Systems Standards for Performance and Design (March 2013), setback distances are shown below in Table 3-5:

Table 3-5
Minimum Setback Distance (m) from the "Working Area"* of the Wastewater Lagoons

Minimum Setback Distance (m) from the "Working Area"* of the Wastewater Lagoon to:	Distance
The property line of the land where the lagoon is located	30
The designated right-of-way of a rural road or railway	30
The designated right-of-way of a primary or secondary highway	100
A "building site"** for school, hospital, food establishment or residential use	300

*"Working Area," means, those areas of a parcel of land that are currently being used or will be used for the processing of wastewater.
** "building site" means a portion of the land on which a building exists, or can or may be constructed

Notes:

- Minimum setback distance from the "working area" of the wastewater lagoon to a "building site" on the property of a "privately owned development" which the lagoon serves may be reduced to 100 m.
- Setback distances may be varied with the written consent of the "Director".

Figure 3-1 shows the existing land ownership around the project area including land already acquired by Alberta Transportation for the future relocation of Highway 43 and CN Rail. Preliminary drawings of the future Highway 43 corridor were provided by Alberta Transportation and are included in **Appendix B**. The future CN Rail ROW is included within the acquired land and is shown on the south side of the corridor.

Associated further inquired with Alberta Transportation who advised that only a 40 m setback (as compared to the 100 m listed in **Table 3-5**) is required for the future alignment of Highway 43. This 40 m setback was further clarified to be from the future Highway 43 ROW to the bottom of the revised lagoon berms.

Associated also contacted CN Rail to seek further clarification on a setback distance. CN Rail advised that they need to further evaluate internally and verify the proposed design before providing a setback. To mitigate the risk associated with this unknown, a setback of 100 m will be utilized for the analysis.

3.5 Proposed System Hydraulic Capacity

The direction for lagoon expansion is limited to the east as a result of the proposed alignment for Highway 43 and CN Rail to the north and the Beaverlodge River to the west and the south. As a result, the volumes of Aerated Cell (Partially Mixed) 1C and Storage Cell 2 are reduced. Subsequently, to meet storage requirements, a new storage cell #4 is proposed. Revised volumes are shown in **Table 3-6** and a preliminary configuration is shown in **Figure 4-2**.

Table 3-6
Summary of Hydraulic Capacity of Existing and Proposed Wastewater System

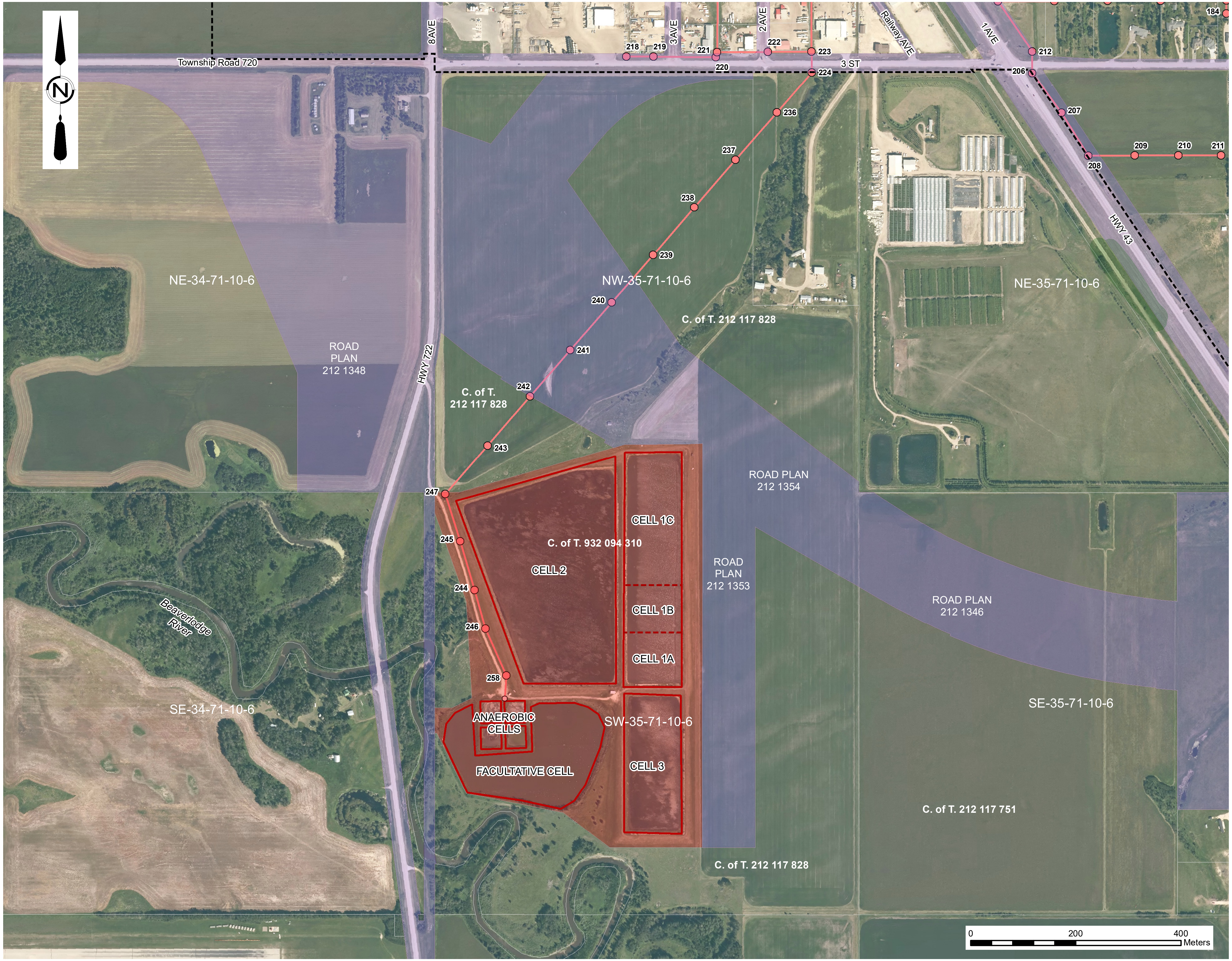
Parameter	Existing	Proposed
Anaerobic Cell		
Number of Cells	4	-
Operating depth, m	3.65	-
Volume of each cell, m^3	1,360	-
Total volume, m^3	5,440	-
Facultative Cell		
Number of Cells	1	-
Operating depth, m	1.5	-
Total volume, m^3	59,600	-
Aerated Cell (Partially Mixed)		
Number of Cells	1	1
Operating depth, m	2.5	2.5
Volume (Cell#1A), m^3	27,500	27,500
Volume (Cell#1B), m^3	24,750	24,750
Volume (Cell#1C), m^3	62,350	23,650
Volume (Cell #1 total), m^3	114,600	75,900
Facultative Cell + Aerated Cell (Partially Mixed)	169,400	135,500 >123,360
Storage Cell (Aerated)		
Number of Cells	2	3
Operating depth, m	2.5	2.5
Volume (Cell #2), m^3	238,800	200,000
Volume (Cell #3), m^3	70,300	70,300
Volume (Cell #4), m^3	-	375,000
Total volume, m^3	308,100	645,300 < 741,600*

* If I/I flows are addressed the difference between projected required storage for 2045 and available storage is not anticipated to be an issue.

The revised cells are modelled with the following design criteria:

- 4:1 interior side slopes and 4:1 exterior side slopes;
- 4.0 m top of berm width; and
- Minimum 0.6 m of freeboard.

The proposed hydraulic capacity of the treatment cells (anaerobic, facultative and partially mixed) is based on cell volumes remaining after taking into consideration the setback. Due to land availability constraints the design upgrade focussed on achieving effluent quality within the treatment cells through the upgrades of aeration, and then allowing the remaining land to be utilized for construction of storage cells. The aeration demand estimate for treatment was conservative in that it did account for minimal treatment achieved in the small anaerobic cells and the facultative cell, as explained below.



LEGEND:

- Government Road Allowance
- Existing Lagoon Parcel
- Sanitary Manhole
- Sanitary Gravity Main
- Sanitary Detention
- Town of Beaverlodge Boundary

Associated Engineering

BEST MANAGED COMPANIES Platinum member

Beaverlodge

FIGURE 3-1

TOWN OF BEAVERLODGE
LAGOON UPGRADE OPTION ASSESSMENT

EXISTING LAND OWNERSHIP

AE PROJECT No.	2021-3219
SCALE	1:7,000
APPROVED	
DATE	2022FEB16
REV	
DESCRIPTION	ISSUED FOR DRAFT

IF NOT 25 mm ADJUST SCALES
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

SAVE DATE: 2/16/2022 8:11:29 AM SAVED BY:
DRAWING PATH: C:\Users\richardsonk\Desktop\A_LOCAL_PROJECT_WORK\2021-3219_Beaverlodge_Carlie\3-1_Existing_Land_Ownership.mxd
DATA SOURCE: :

3.5.1 Anaerobic Cell Revisions

A minimum of 11,000 m^3 of additional storage capacity needs to be added to meet the anaerobic system's holding capacity requirements for 2045. The current wastewater lagoon system does not have enough hydraulic capacity to even meet the current system's anaerobic storage requirement. No sludge survey was conducted to estimate the actual depth (sludge depth) in the anaerobic cells.

To meet the AEP recommended guideline for anaerobic cell (s), either existing anaerobic cells have to be upgraded or additional cell(s) have to be constructed. In both cases, the cell surface area would be such that the resulting cell(s) would work as a facultative cell(s) instead of an anaerobic cell(s). Hence, AE proposes that the existing anaerobic lagoon remain the same while the aeration system in cell #1 is upgraded to improve the treatment performance so that the year-round effluent quality objective is met for annual releases.

3.5.2 Facultative Cell Revisions

The existing wastewater lagoon system's configuration requires additional facultative cell volume; however, a combination of the facultative cell and the aerated partially mixed (Cell #1) would meet the 2045 Hydraulic capacity requirements as shown in **Table 3-5**. Since Cell #1 is aerated, the working depth is not limited to the maximum allowable working depth for a facultative cell (1.5 m). Therefore, no additional facultative cell capacity is recommended.

3.5.3 Aerated Cell Revisions

AE proposes using a combination of the existing facultative cell and revised aerated cell#1 (Partially Mixed) to provide treatment requirements to meet year-round effluent quality objective. Separate removal mechanisms are involved in facultative cell and aerated cell treatment. Hence, the following assumptions were made to estimate $cBOD_5$ removal capacity of the wastewater lagoon system, for 2045:

- Assumptions for minimum (winter) cBOD removal capacity:
  - Average winter lagoon temperature of 2 °C.
  - $cBOD_5$ removal mechanism in the existing anaerobic and facultative cells is solely sedimentation of particulate cBOD and is assumed to be an average of 10%, each .
  - $cBOD_5$ removal efficiency in partial mix aerobic cells (cells #1A, #1B, and #1C) was estimated, using a plug flow kinetic model with an appropriate temperature correction factor.

The average winter effluent cBOD concentration for the Town's lagoon system for the design year of 2045 is estimated to be 18.0 mg/L based on the assumptions above. Hence, it can be projected that modified "Enhanced Conventional Wastewater Lagoon" system (anaerobic + facultative + aerated cell) would have enough hydraulic capacity to meet the year-round low effluent $cBOD_5$ concentration (less than 25 mg/L). **Table 3-4** summarizes the historic lagoon effluent quality for the existing system during the spring and fall discharges. The existing lagoon system was unable to meet the year-round low effluent $cBOD_5$ concentration (<25 mg/L) reliably especially during spring discharge (April – May). This lack of BOD treatment capacity could be attributed to inadequate aeration and/or mixing available to the aerated cell.

Table 3-7
Historic Lagoon Effluent Quality

Spring			Fall		
Date	BOD_5 (mg/L)	Ammonia-N (mg/L)	Date	BOD_5 (mg/L)	Ammonia-N (mg/L)*
29-Jun-16	33	1.3			
16-Mar-17	3	0.3	14-Sep-17	<2	<.02
24-Apr-18	7	4.7	4-Sep-18	<2	<.05
24-Apr-19	8	8.5	2-Oct-19	<2	Not Available
22-May-19	20	4.2	3-Sep-19	<2	<.05
			27-Oct-20	3.1	0.237
			02–Nov-21	<2	0.294

* Data available appears to be a mix of unionized and total Ammonia readings.

The partially mixed aerated cells are typically designed to satisfy the design organic loading while maintaining an adequate uniform dissolved oxygen level (greater than 2.0 mg/L) in the cell. The design intent is not to maintain a uniform solids concentration, hence allowing solids allowed to settle in the cell to undergo aerobic/anaerobic digestion. A high-level evaluation of the existing system identified that the aeration system, includes blower and diffusers, in cell #1 is not adequate to meet the design requirement for 2045. Therefore, AE reviewed, in consultation with Nexom, an upgraded aeration system design for cell #1 that meets the necessary mixing and oxygen requirements for an annual average effluent cBOD concentration of 15 mg/L. Nexom's proposed scope of supply to upgrade the aeration system to meet the desired cBOD concentration of 15 mg/L includes:

- Removal of existing linear aeration diffusers and feeder lines.
- Cells #1 and #4A HDPE shallow buried main header piping.
- H3-4 Diffuser assemblies complete with EPDM Membranes and accessories for Cell #1.
- H2-4 Diffuser assemblies complete with EPDM Membranes and accessories for Cells #2, #3 and #4A.
- Floating and submerged lateral, feeder piping, fittings, lateral valves and sandbag ballasts as required.
- Self-tensioning lateral assemblies and anchor posts.
- Three (3) 40 hp positive displacement blowers with VFDs and control panel.
- Blower header and connection pipe.

Nexom's proposal for the cell#1 aeration system upgrades is shown in **Appendix C**. Three (3) new 40 Hp blowers (Duty-Duty-Standby) will be installed in the existing blower building replacing two (2) old blowers while the remainder two (2) old blowers will be used to provide aeration to storage cells as described in **Section 3.4.4**. A preliminary desktop evaluation of the record drawing shows that there is sufficient space for the three (3) new blowers after removal of the existing two (2) old blowers. The space requirement for installation, operation and maintenance of the new blowers needs to be verified during the detailed design phase.

3.5.4 Storage Cell Revisions

There are lagoon systems in Alberta that discharge twice a year, but low flow conditions in fall and the total phosphorous (TP) issue, as identified in the Beaverlodge River Assessment Report, would require 12 month's of storage option to be considered. To meet 12 month's of storage (741,600 m^3) requirement for 2045, a minimum of 433,500 m^3 of additional storage capacity needs to be added. .

The addition of a new storage cell 4 is required to account for storage lost as a result of the future Highway 43 relocate and to meet the required 12 month storage for 2020 and 2045.

3.6 Nutrient Removal Capacity Assessment

The conventional wastewater lagoon and aerated lagoon systems are not typically designed for Ammonia and Phosphorus removal. Hence, a significant and reliable year-round reduction in effluent nitrogen and phosphorus concentration is not achievable, especially during Spring discharges. In addition, influent nutrient loads in the lagoon system are also not available due to a lack of monitoring and reporting requirements. There is also a lack of predictive kinetic lagoon nutrient removal models that can approximate lagoon effluent nutrient concentrations. Therefore, in this study, ammonia and total phosphorus removal capacities were evaluated based on the performance of the existing lagoon system by analyzing historical effluent concentration and lagoon nutrient removal performance in Northern Alberta.

3.6.1 Ammonia Removal Capacity Assessment

Ammonia removal in facultative wastewater treatment ponds occurs via three mechanisms: gaseous NH_3 stripping to the atmosphere, NH_3 assimilation in algal and heterotrophic biomass, and biological nitrification. Nitrification generally does not account for a significant portion of NH_3 removal, especially when the lagoon temperature falls below 5 °C (Mcnaughton, Stoll, Smith, MIddlebrooks, & Bowman, 2011). Ammonia assimilation in biomass depends on the biological activity in the system and is affected by temperature, organic load, detention time, and wastewater characteristics. The rate of gaseous NH_3 losses to the atmosphere depends mainly on the pH value, temperature, and the mixing conditions in the pond. Regardless of the specific removal mechanism involved, ammonia removal in facultative wastewater ponds may approach 99%, during the Summer months (Fall discharges), with the major removal occurring in the primary cell of a multi-cell pond system.

The ammonia removal rate in the aerated lagoon is a function of BOD loading rate and detention time. With a low residual BOD concentration, significant ammonia removal can be achievable in the final aerated cell, only if enough oxygen and mixing energy is provided and temperature is favourable for the hydraulic retention time.

As was shown in **Table 3-4**, effluent ammonia concentrations, during Spring discharges, are higher than that of Fall discharges, due to reduced biological activity during the winter months. The addition of storage cell (**Section 3.5.4**) to permit year-round storage and single annual discharge would allow effluent ammonia concentration to be diluted to a lower concertation than historic Spring discharge concentration.

The River Assessment Report, dated October 2020, identified that the un-ionized Ammonia concentration at the edge of mixing zone is not expected to cause adverse effects to fish during the Fall. On the contrary, the un-ionized ammonia concentration at the edge of the mixing zone may exceed the applicable guideline under typical Spring river flows and there may be adverse effects. The effluent ammonia concentration can not be reduced reliably in a wastewater lagoon system during the Winter, without the addition of a lagoon effluent treatment process. Ammonia toxicity to aquatic life is affected by pH. Ammonia-nitrogen (NH3-N) has a more toxic form at high pH and a less toxic form at low pH, un-ionized ammonia and ionized ammonia (NH4 +), respectively. The un-ionized form of ammonia is approximately 100 times more toxic than ionized form of ammonia and in general, less than 10 % of total NH3-N is in the un-ionized form when pH is less than 8.0. However, this proportion increases dramatically as pH increases (**Figure 3-2**). The effect of pH on the relative proportion of un-ionized form of ammonia is more significant in higher effluent temperature especially during fall discharge. Hence, AE recommends that the effluent pH level be adjusted below 8.0 by adding Alum year-round, that will also reduce total phosphorus concentration, as described in the following section in details, to reduce the likelihood of un-ionized ammonia related effluent lethality/toxicity.

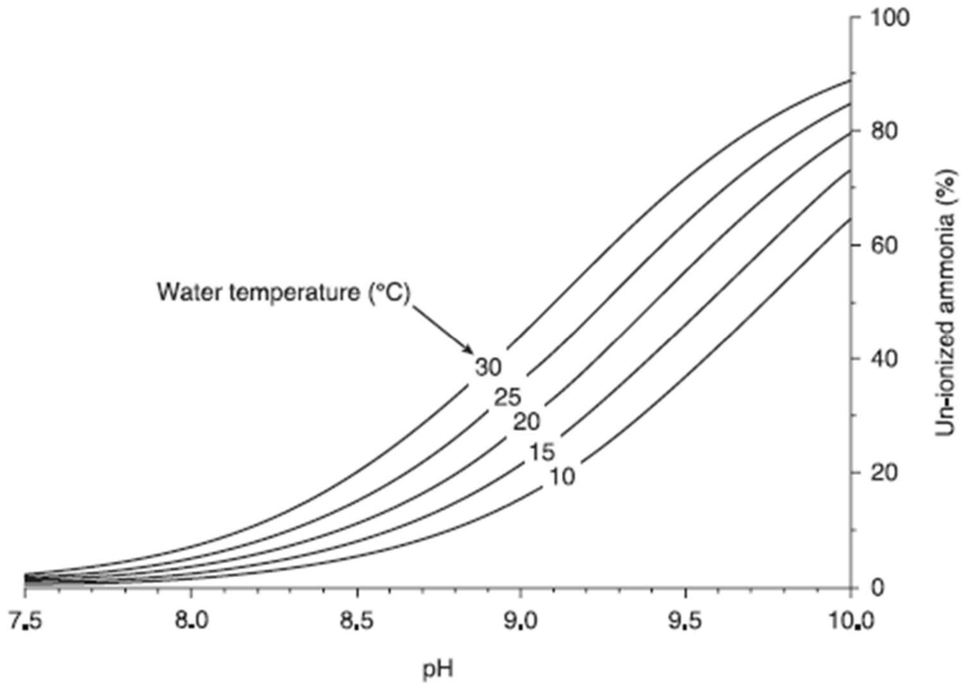


Figure 3-2
Proportion of more toxic un-ionized ammonia increase as a function of pH and temperature (Banrie, 2013)

3.6.2 Total Phosphorus Removal

Phosphorus removal in ponds may result from physical mechanisms, such as adsorption, coagulation, and precipitation. Without the addition of coagulant, phosphorus removal using the physicochemical mechanisms, will be insignificant. The uptake of phosphorus by organisms for cell metabolism, as well as storage, can also add to phosphorus removal. Phosphorus removal in wastewater ponds has been reported to range from 30% to 95% (USEPA, 1983). The removal efficiency varies seasonally with the growth of organisms in a lagoon system.

The Town does not have any historic effluent total phosphorus (TP) concentration data. The River Assessment Report measured an average TP concentration of 1.64 mg/L for Spring effluent for 2020. The TP concentration at the edge of the mixing zone for Spring discharges is calculated to be 0.33 mg/L. The TP concentration in the river, during typical Spring discharge conditions, increased by 40%, where an approximately 30-fold increase was determined under typical Fall discharges.

The Town applied a slug load of Alum to the lagoon Cell#1 on July 30, 2021 to mitigate impacts of effluent phosphorus during fall discharge (November 1, 2021 to November 22, 2021) on the river. The TP concentrations upon Alum addition on November 3, 2021 at the point of effluent discharge was 0.31 mg/L which was significantly below the historical average effluent concentrations without the addition of Alum (1.4 mg/L). Therefore, AE proposes year-round alum addition to the discharge header of the existing lift station between facultative cell and cell#1 to reduce the total phosphorus concentration to as low as 0.50 mg/L. For an alum (aluminum sulphate) dosage of 33 mg/L and an aluminum sulphate solution concentration of 48.5 w/w% (as $Al_2(SO_4)_3$), the expected average volume of alum required per day is 104 L. The appropriate alum dosage to achieve effluent TP objective will need to be confirmed utilizing jar tests performed on actual lagoon wastewater. However, the alum dosage utilized for the preliminary design represents a conservative dosage.

AE recommends using IBC totes as the primary storage method, as it provides enough storage volume while requiring minimal equipment for transportation (i.e. pallet jack). HDPE chemical containment pads should be utilized to store the totes. AE recommends using a 4.0 m x 4.0 m pre-engineered building to house a duplex alum dosing skid and IBC totes for year-round alum addition. The turbulence in the lift station discharge would provide the required initial mixing of alum and phosphorus, and the aeration system in cell #1 will provide the additional mixing energy to facilitate phosphorus precipitation. AE also recommends that a flowmeter be installed in the lift station to allow flow-pace Alum dosing. Flow-pace Alum dosing would allow better control, more efficient phosphorus removal, and hence would reduce the overall cost of Alum.

3.7 Lagoon Earth Balance

As a result of the Highway 43 relocation, modifications are required to cell 1 and cell 2. In order to obtain 12 months storage, a new cell 4 is proposed. Table 3-8 are preliminary estimates of earth balance quantities to complete the work.

Table 3-8
Cut and Fill Estimates

Description	Cut (m^3)	Fill (m^3)	Remainder
Cell 1 (Return to original contours)	(+) 0	(-) 60,000	(-) 60,000
Cell 2 (Return to original contours)	(+) 0	(-) 20,000	(-) 20,000
Cell 4 (New construction)	(+) 250,000	(-) 50,000	(+) 200,000
Total	**(+) 250,000**	**(-) 130,000**	**(+) 120,000**

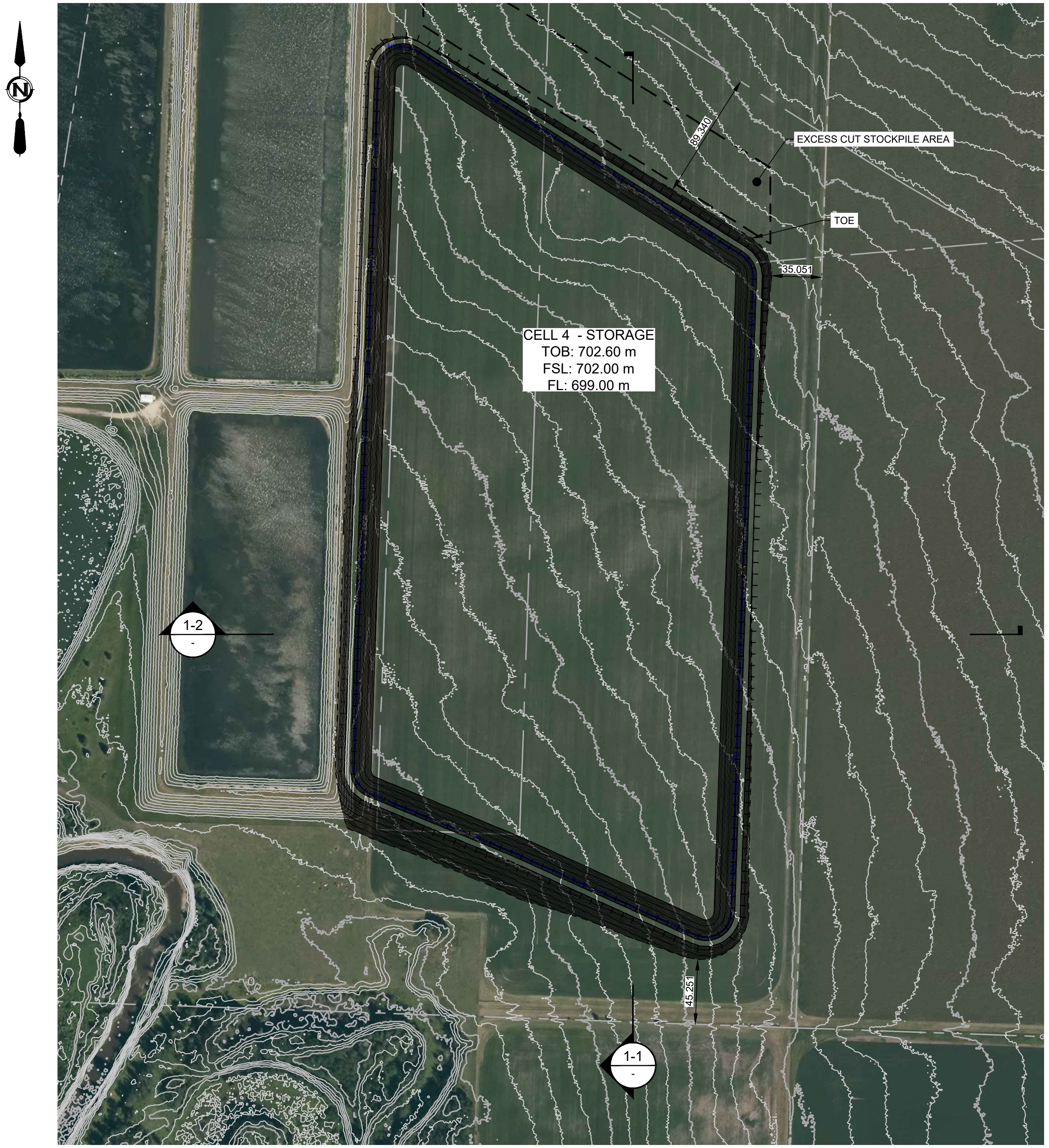
The modified cells are modelled with the following assumptions:

- 4:1 interior side slopes and 4:1 exterior side slopes.
- 4.0 m top of berm width.
- Existing topsoil depths are 0.3m.

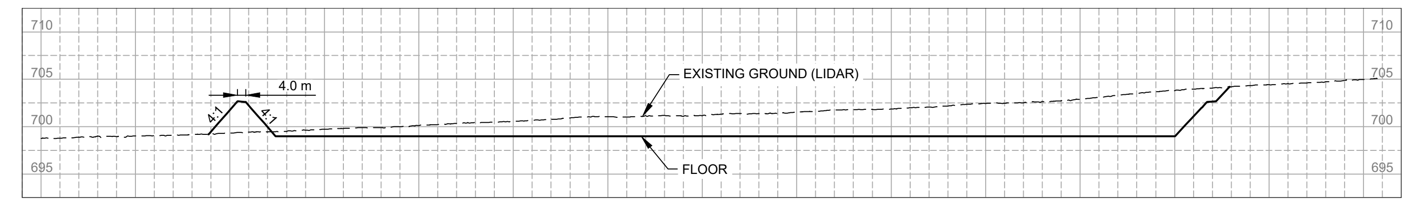
Figure 3-3 shows the proposed cell 4. Note that the scenario shown for cell 4 are for the least possible excess cut in order to maintain gravity operation with adjacent cells. In preliminary discussions of with Alberta Transportation, it is anticipated that fill material will be a commodity in construction. Based on this, excess cut material will be stockpiled within the 100 m setback from Highway ROW. Modifications to cells depth in order to obtain additional fill can also be considered in detailed design, working within the Alberta Standards and Guidelines for lagoon depths.

Considering the age of the lagoon system, there is likely some accumulation of sludge and/or silts in the cells proposed to be modified. As the materials within the lagoon have not been characterized at this stage and are not considered the anaerobic and facultative process cells, it is assumed the materials are not biological in nature and can be removed and incorporated into the stockpiled fills. AE recommends a sludge survey of the lagoons be conducted, which should include a sampling program to characterize the sludge. Characterization and quantification of the sludges within the lagoon system via a sludge survey will provide important information for the detailed design phase.

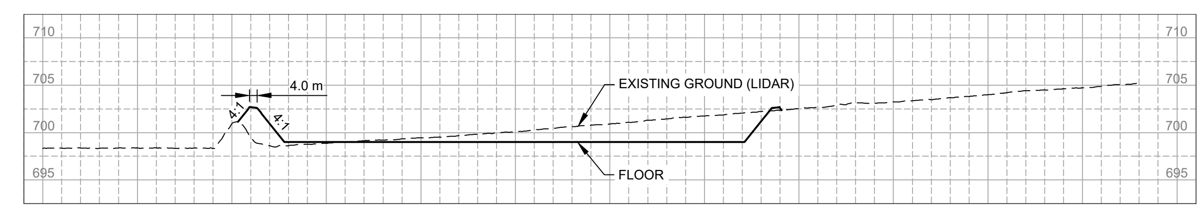
IF NOT 25 mm ADJUST SCALES
25 mm
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



1 PLAN 1:2000



1-1 SECTION H: 1:2000, V 1:400



1-2 SECTION H: 1:2000, V 1:400

CELL 4 VOLUMES TABLE

AREA	CUT [cu.m]	FILL [cu.m]	EXCESS / [DEFICIT] [cu.m]	TOPSOIL VOLUME [cu.m.]	FLOOR TO FSL [cu.m.]
1	219,380	58,105	[161,275]	46,475	375,640

NOTE:
TOPSOIL DEPTH ASSUMED TO BE 0.3 m.

PLOT DATE: 2022-05-09 4:31:52 PM
SAVE DATE: 2022-05-09 4:27:04 PM SAVED BY: FISHERK
DWG PATH: \\ae.ca\data\working\gp\2021-3219-00\civil\model\3219-00-c-7002.dwg

Associated Engineering
BEST MANAGED COMPANIES
Platinum member

Beaverlodge

AE PROJECT No.	2021-3219
SCALE	AS SHOWN
APPROVED	K. OGLETREE
DATE	2022MAY10
REV	C
DESCRIPTION	ISSUED FOR DRAFT

FIGURE 3-3

TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

CIVIL
CELL 4 CONFIGURATION OPTIONS

DRAFT

3.8 Geotechnical Considerations

A detailed geotechnical investigation for the proposed upgrades has not been completed at this stage of the project and will be required at the outset of the detailed design phase. A geotechnical investigation is required to confirm the viability of the preliminary design and to provide updated soil parameters for detailed design and specifications. The key considerations for the civil design from a geotechnical investigation include:

- Topsoil depth for consideration in earth balance calculations.
- Elevation of the ground water level and whether perched groundwater may be encountered during excavation.
- Evaluation of the use of the native clay as an in-situ compacted clay liner.
- New lagoon berm slope stability recommendations.

3.8.1 Liner Requirements

Municipal septage lagoons are expected to conform to the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. At this time, in-situ clay liners are projected for use in the altered and expanded lagoon cells. The feasibility of this approach will be evaluated upon completion of the geotechnical investigation, where the following will be evaluated:

- Suitability of in-situ materials as native or compacted clay liner.
- If suitable as compacted clay liner, depths of material conditioning required to achieve sufficient hydraulic conductivity, and meet regulatory requirements.

If the in-situ material is not suitable or the required depths of compacted clay liner are outside of typical requirements, alternatives will need to be evaluated. Alternatives such as geosynthetic liner systems may be required, which may add cost to the project. These considerations will be made during the detailed design phase in collaboration with the stakeholders.

4 TRUNK SEWER ASSESSMENT

4.1 Existing Trunk Sewer Conditions

The existing trunk sewer was installed in 2001. The total length from 3 Street to the Anaerobic Cell inlet manhole is 1515 m. Once the trunk sewer crosses crossing 3 Street, it continues southwest and diagonally across the quarter section north of the lagoons within a 9.14 m wide registered utility ROW. The first 1100 m from 3 Street up to the lagoon site is 375 mm SDR-35. Once in the lagoon site, the pipe transitions to 450 mm SDR-35 for the final 415 m up to the Anaerobic Cell inlet manhole. There are 15 manholes spaced at approx. 120 m or less with pipe cover ranging from approximately 2 m - 3.5 m.

4.1.1 Site Investigations

In December of 2021, the existing trunk sewer manholes were located, exposed and survey completed. **Figure 4-1**, **Figure 4-2** and **Figure 4-3** display updated plan profiles based on Lidar and survey data. Note that MH was not surveyed due to being buried too close to the property line fence.

In December of 2021, CCTV was completed without prior flushing and showed that the pipe was in generally good condition. The camera was able to CCTV the entire trunk sewer length without refusal. The reports showed minor and miscellaneous general observations including water level sag, staining and grease/debris on pipe walls, and encrustation.

4.1.2 Hydraulic Assessment

The existing gravity sewer main consists of 375 mm and 450 mm diameter PVC pipe installed at varying grades from 0.25% to 2.69%. Using Manning's formula for open channel flow, with a conservative coefficient of roughness of 0.012 and a maximum flow depth of 90% of pipe internal diameter, the lowest capacity would be experienced between MH224 and MH236 at 96 L/s. This is sufficient capacity for the Towns projected 2045 flows with a Peaking Factor of 4x as shown in **Table 4-1** below.

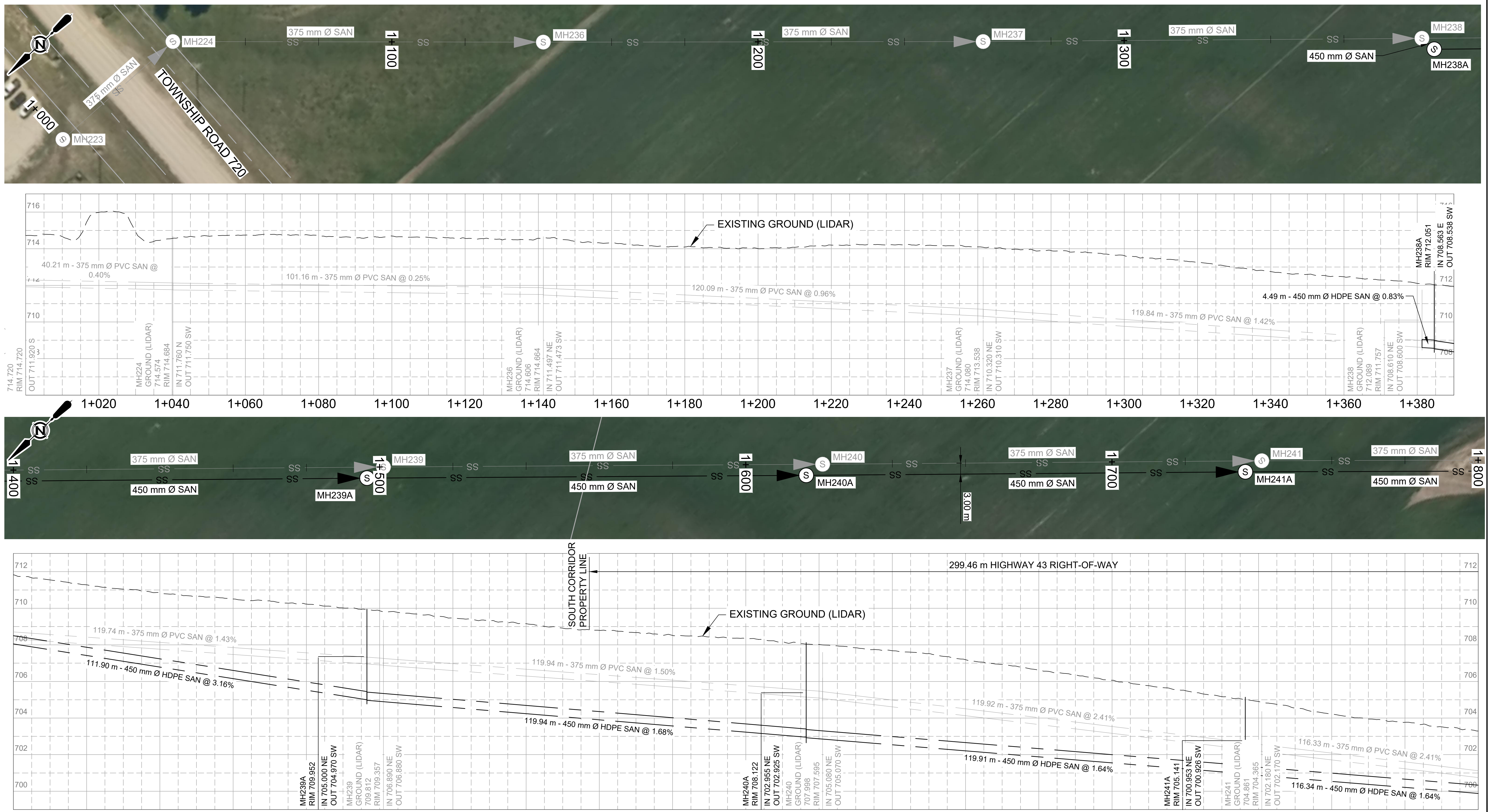
Table 4-1
Estimated Annual Wastewater Generation – Trunk Sewer Flows

	2020	2025	2030	2035	2040	2045
Rate (m^3/yr.)	579,600	608,400	640,800	673,200	705,600	741,600
Rate (L/s)	18	19	20	21	22	24
Rate (L/s) x4 Peaking Factor	74	77	81	85	89	94

The existing pipes contain sufficient capacity to provide for the projected 2045 requirements. Detailed design data is available in **Appendix D.**

\\ae.ca\data\working\gpr\2021-3219-00_doc_prod\pdf_assembly\Rpt_Pre_Design\rpt_WWLagoon_Upgrade_Options_rev2.docx

IF NOT 25 mm ADJUST SCALES
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



PLOT DATE: 2022-05-09 3:42:53 PM
SAVE DATE: 2022-05-09 3:40:04 PM SAVED BY: FISHERK
DWG PATH: \\ae.ca\data\working\gpi\2021-3219-00\civil\model\3219-00-c-7001.dwg

Associated Engineering

BEST MANAGED COMPANIES
Platinum member

Beaverlodge

AE PROJECT No.	2021-3219
SCALE	H 1:1000, V 1:200
APPROVED	K. OGLETREE
DATE	2022MAY10
REV	B
DESCRIPTION	ISSUED FOR DRAFT

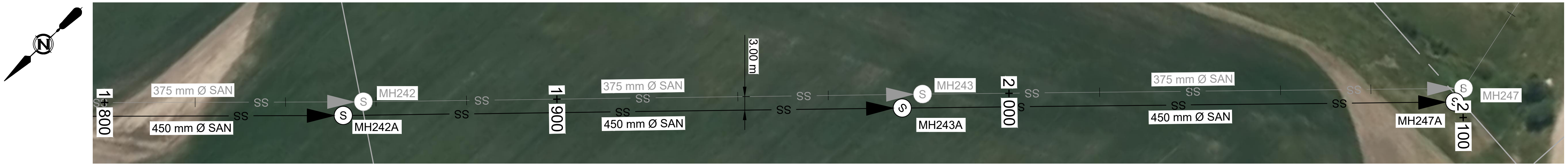
FIGURE 4-1

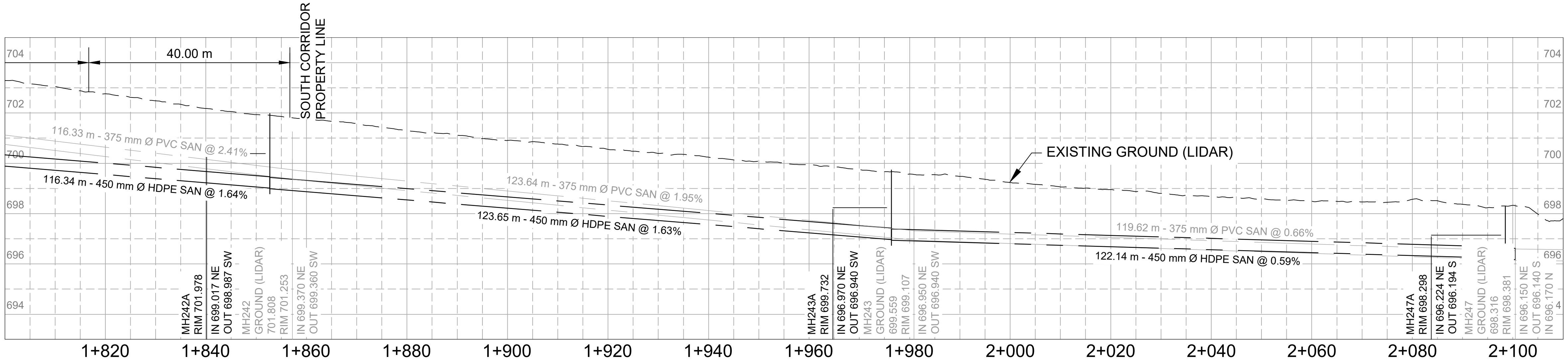
TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

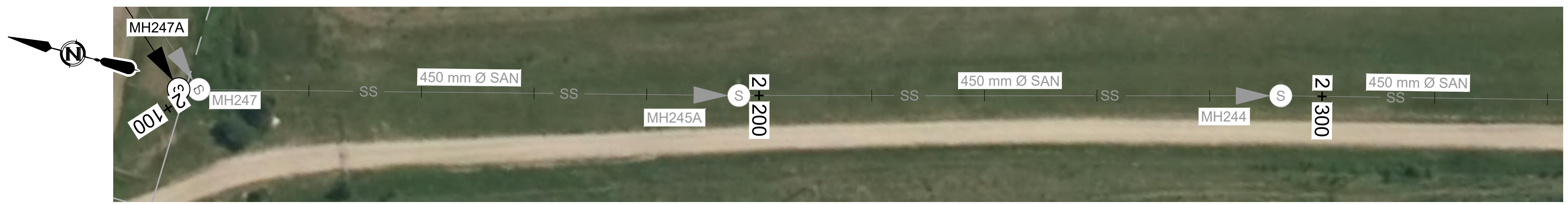
CIVIL
TRUNK SEWER
PLAN AND PROFILE

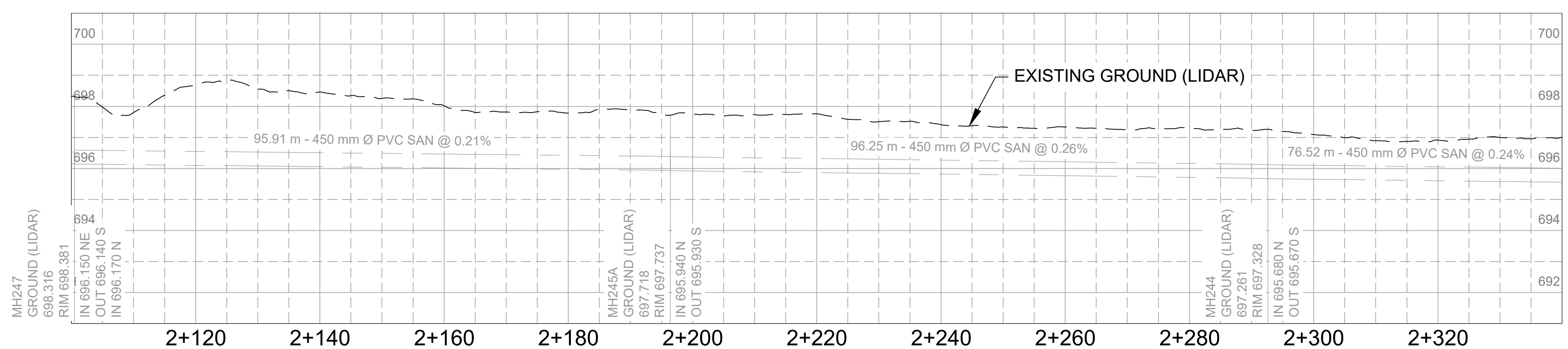
DRAFT

IF NOT 25 mm ADJUST SCALES
25 mm
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE









PLOT DATE: 2022-02-15 7:33:52 PM
SAVE DATE: 2022-02-15 7:11:37 PM SAVED BY: FISHERK
DWG PATH: q:\2021-3219-00\civil\model\3219-00-c-7001.dwg

Associated Engineering

BEST MANAGED COMPANIES Platinum member

Beaverlodge

AE PROJECT No.	2021-3219
SCALE	H 1:1000, V 1:200
APPROVED	C. PITTMAN
DATE	2022FEB16
REV	A
DESCRIPTION	ISSUED FOR DRAFT

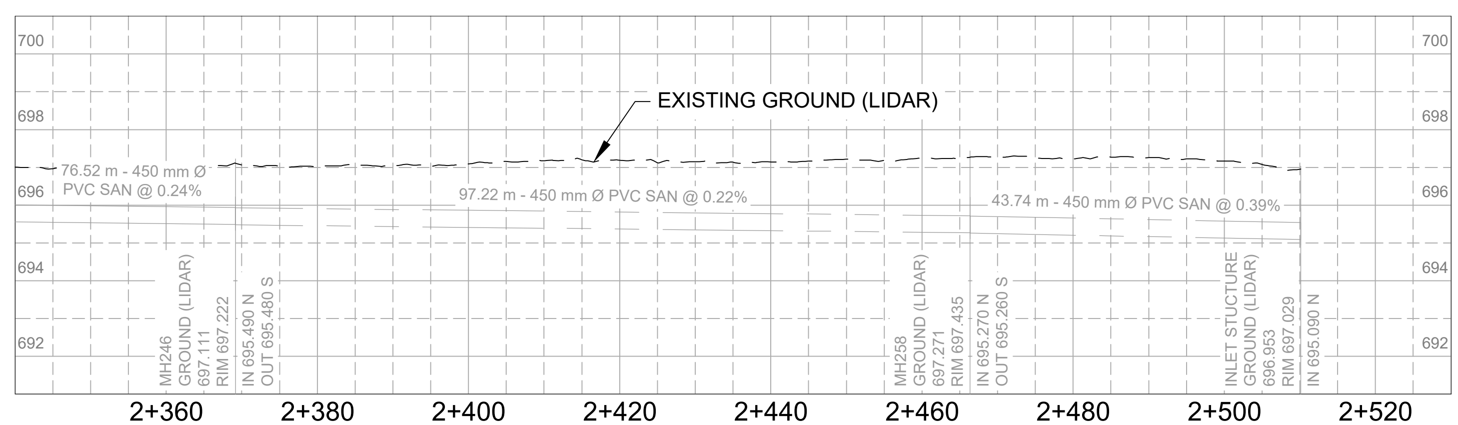
FIGURE 4-2

TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

CIVIL
TRUNK SEWER
PLAN AND PROFILE

DRAFT

IF NOT 25 mm ADJUST SCALES
25 mm
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



PLOT DATE: 2022-02-15 7:30:58 PM
SAVE DATE: 2022-02-15 7:11:37 PM SAVED BY: FISHERK
DWG PATH: q:\2021-3219-00\civil\model\3219-00-c-7001.dwg

Associated Engineering

BEST MANAGED COMPANIES
Platinum member

Beaverlodge

AE PROJECT No.	2021-3219
SCALE	H 1:1000, V 1:200
APPROVED	C. PITTMAN
DATE	2022FEB16
REV	A
DESCRIPTION	ISSUED FOR DRAFT

DRAFT

FIGURE 4-3

TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

CIVIL
TRUNK SEWER
PLAN AND PROFILE

4.2 Alberta Transportation and CN Relocate Requirements

4.2.1 Casing Requirements

Alberta Transportation requires welded steel casing or jointless pipe (HDPE) for Highway crossings. Considering the ROW at the crossing locations is upwards of 300 m in width, replacement of the existing PVC pipe with fused (jointless) HDPE pipe would be the preferred pipe material. Following design and construction of Highway 43, further discussion can occur with Alberta Transportation for the addition of manholes in allowable locations within the Highway ROW to better facilitate operation and maintenance of the trunk sewer.

CN Rail requires all utility crossings be protected by a steel casing for the full width of CN's right-of-way or 50 ft (15.24 m) whichever is greater. They further advise that all casing pipes shall be sloped not less than 0.3% and be designed for E80 Loading. Therefore, a steel casing lined with new HDPE or PVC pipe would need to be installed within the proposed 30 m CN ROW shown on the Alberta Transportation preliminary drawings.

The new HDPE sewer and HDPE sewer with steel casing would be installed within the existing 9.14 m width Sewer ROW but offset from the existing sewer. This is to allow the existing sewer to function during installation except during final connections on either side of the proposed Highway 43 and CN ROWs.

4.2.2 Pipe Cover

Alberta Transportation requires a minimum cover of 1.4 m below ditch bottom. The drawings provided by Alberta Transportation are preliminary and are limited to existing grades and centerline profile of Highway 43. Proposed ditch elevations are not shown on the drawings. The proposed Highway 43 centerline elevation at the trunk sewer crossing is approximately 0.6 m fill above existing grade at the Highway 43 centerline. Further information from Alberta Transportation would be required to confirm if the minimum 1.4 m cover in the ditch bottoms is met. However, and based the existing trunk sewer ranging between 2.2-2.6 m cover within the proposed Highway 43 ROW, there is a reasonable chance that an increase in pipe size, reduced slope and deepening of the trunk sewer within the Highway ROW will be required.

For a cased pipe, CN requires 6' (1.83 m) cover at base of rail, and 5' (1.52 m) cover at ditch bottom. The Alberta Transportation preliminary drawings show approximately 1.4 m cut from existing grade to proposed CN Rail ditch bottom at the sewer crossing location. Considering the existing trunk sewer has approximately 2.1 m cover at the proposed CN Rail crossing location an increase in pipe size, reduced slope and deepening of the trunk sewer within CN Rail ROW will be required.

5 REGULATORY REVIEW

5.1 Environmental Considerations

5.1.1 Land Use

Land use in the project area is largely rural residential with open fields used for agriculture. The alignment of the trunk sewer line replacement will be within previously disturbed area, within both the existing sewer line right-of-way (ROW), and Alberta Transportation ROW. The wastewater lagoon upgrade will require disturbance to the east of the existing lagoon cell alignment, within a portion of the Alberta Transportation ROW, and the remaining area within private lands; additional private land acquisition will be required for the lagoon. All project components will be located outside of public crown land.

5.1.2 Vegetation

The project is within the **Dry Mixedwood Natural Subregion**. The Dry Mixedwood Subregion is characterized by aspen forests, cultivated land, and fens that commonly occur in low lying area. This subregion is typically dominated by:

- Trembling Aspen (*Populus tremuloides*);
- Low Bush Cranberry (*Viburnum edule);*
- Prickly Rose (*Rosa acicularis);*
- Canada Buffaloberry (*Shepherdia canadensis);*
- Hairy Wild Rye (*Leymus innovates*); and
- Bunchberry (*Cornus canadensis*).

Dry sites on south and west-facing slopes can be dominated by grass species including:

- Porcupine Grass (*Hesperostipa spartea*);
- June Grass (*Koeleria macrantha*);
- Pasture Sage (*Artemisia frigida*);
- Northern Wheatgrass (*Elymus lanceolatus;*, and
- Slender Wheatgrass (*Elymus trachycaulus*).

Saskatoon (*Amelanchier alnifolia)* and buckbrush (*Symphoricarpos occidentalis)* shrublands occur in ravines or gullies and on lower slopes. Trembling aspen (*Populus tremuloides)*, white spruce (*Picea glauca)*, and jack pine (*Pinus banksiana)* can occur in pure or mixed stands (Natural Regions Committee 2006).

5.1.3 Soils

The soil types mapped by Agriculture Region of Alberta Soil Inventory Database (AGRASID) within the footprint of the proposed alignment are provided in **Table 5-1** (GOA 2018a). Generally, there are no environmental constraints for the projected related to soils.

Compliance considerations are focused on reclamation following the completion of construction. The *Environmental Protection and Enhancement Act*'s *Conservation and Reclamation Regulation* requires that soils are restored to their pre-disturbance capability (AB Reg 115/1993). While most of the project will occur in previously disturbed soils, soils removed in undisturbed natural areas should be replaced appropriately (e.g., topsoil and subsoil handled and stockpiled separately).

Table 5-1
Summary of Soil Type within Project Area

Location	Soil Correlation Area	Soil Landscape Model	Soil Type	Description
35-71-10 W6M	18	Luvisolic, Gleyed Dark Gray Luvisol on fine textured (C) water-laid sediments with till-like features, imperfectly drained.	ESH1/U1h - undulating – high relief.	Eco District: Beaverlodge Eco Region: Peace River Plain

5.1.4 Wildlife

The project area is not located within any provincially designated sensitive zones. The provincial database Fish and Wildlife Internet Mapping Tool indicates one mammal species, Grizzly bear (*Ursus arctos*), has previously been reported within 2 km of the alignment. Grizzly bear has a provincial listing of "At Risk" under the AB General Status, and are not listed federally under Schedule 1 of the *Species at Risk Act* (SARA).

Grizzly bears have large home ranges that are based on the occupancy by reproductive females, with females having smaller home ranges than males (females: 152 to 2932 km^2; males:501 to 4748 km^2; GOA 2008). Dens are typically in areas of deep snowfall, in natural caves, under roots of trees, or excavated on slopes (GOA 2016b). Grizzly bear dens are not expected to be present within the project area, however, there is the potential for Grizzly bears to be encountered during construction as shown in **Table 5-3**.

The project area is located in the Bird Conservation Region B5 with a general migratory bird nesting window of April 24 to August 29 of each year (Government of Canada 2017). Migratory birds, their nests, and eggs are protected federally under the *Migratory Birds Convention Act*. Construction activities, including vegetation clearing, have the potential to impact migratory birds and their nests, particularly during the breeding season as shown in **Table 5-3**.

5.1.5 Surface Water and Wetlands

The project footprint does not cross any mapped watercourses. The Alberta Merged Wetland Inventory database suggests low potential for the project site to contain wetland areas, though these areas are not well defined in preliminary desktop resources. The trunk sewer line replacement is not likely to encounter watercourse/wetland crossings as the new line will be installed within the existing and previously disturbed ROW. The wastewater lagoon will be relocated to a new area in agricultural lands and potential for wetland presence within the new site.

Wetland presence/absence should be confirmed in preliminary project planning. This can be completed through a detailed review of historical aerial imagery relative to wastewater lagoon upgrade site; depending on the available imagery and the type of wetlands encountered, a field assessment may also be recommended. If the wetlands are present and cannot be avoided, further permitting may be required (e.g., Water Act Approval and Wetland Assessment Impact Report).

5.1.6 Historical Resources

The project footprint is located within historical resources value lands (HRV) listing of 4 and 5. Approval under the *Historical Resources Act* will be required prior to construction as shown in **Table 5-2**. During the initial application review, additional assessments may be required by Alberta Culture such as Historic Resources Impact Assessment.

5.2 Operational Environmental Considerations

The Beaverlodge Wastewater Lagoon System operates under the *Environmental Protection and Enhancement Act (EPEA)* Registration No. 408-02-00, which requires the system to conform to the Code of Practice for Wastewater System Using Wastewater Lagoons. A re-registration application is to be submitted to Alberta Environment and Parks (AEP) to update records with the upgraded lagoon design drawings as shown in **Table 5-2**.

A notification letter submitted to AEP under the Act and *Wastewater and Storm Drainage (Ministerial)* Regulation will be required for the trunk sewer line replacement, a portion of an existing wastewater system as shown in **Table 5-2**.

5.3 Environmental Regulatory Considerations

The environmental permitting and compliance considerations are summarized below in **Table 5-2** and **Table 5-3**. Regulatory requirements for the wastewater lagoon upgrade and associated trunk sewer line replacement should be revisited as designs progress or change.

Table 5-2
Regulatory Requirements Applicable to Upgrade

Regulatory Agency	Act and Description	General Practices for Complying with the Act	Project Specific Requirements
Alberta Environment and Parks (AEP)	***Environmental Protection and Enhancement Act*** (EPEA) *Wastewater and Storm Water (Ministerial Regulation)*	Actions to comply with the EPEA range from a notification of proposed work relating to an existing EPEA approval, to amendment of an existing approval, to submission of a new EPEA approval application. Additionally, C&R Plan requirements are also dictated by the *Activities Designation Regulation*.	Project components regulated under this act include considerations for construction, and operation of the trunk sewer line replacement and wastewater lagoon upgrades **Submission:** A re-registration application for the wastewater lagoon upgrades will be required prior to construction. As well, a notification letter for the trunk sewer line replacement. Final approvals will require stamped and signed design drawings by the Professional Engineer. This project does not require a Conservation and Reclamation Approval as defined in the *Activities Designation Regulation*; the pipeline replacement will be < 2 km in length and 450 mm pipeline diameter resulting in a pipeline index of < 2690.
Alberta Culture and Status of Women (ACSW)	***Historical Resources Act***	Consultation with Alberta Culture is required prior to the onset of development activities for projects within a designated historical resource listing and for major pipeline projects regardless of listing.	**Submission:** The project footprint is located within historical resources value lands (HRV) listing of 4 and 5. Approval under this Act is required prior to construction. Additional assessments may be required such as Historic Resources Impact Assessment if requested by ACSW.

Table 5-3
Regulatory compliance considerations for the project

Act and Description	General practices for Complying with the Act
Migratory Birds Convention Act	This Act protects migratory birds, their eggs, and their active nests. Consider whether activities have the potential to disturb migratory birds (e.g., project clearing), particularly during their breeding season. Vegetation clearing and work with equipment near forested areas has the potential to impact migratory birds. Clearing work should be scheduled outside of the migratory bird nesting window. If the nesting window cannot be avoided, a qualified environmental professional should evaluate the site and determine whether there are active nests that could be impacted by the proposed activities. **Project Specific:** The project area falls within Bird Conservation Region B5 with a general nesting period from April 19 to August 29 for open, forested, and wetland habitats.
Species at Risk Act	Consider whether any species listed under SARA, Schedule 1, are known to occur in the project area. **Project Specific:** No SARA listed species have been previously documented in the project area.
Wildlife Act	Wilful molestation, disruption, or destruction of wildlife, or a house, nest, or den of wildlife, is prohibited under this Act. Consider whether any wildlife will be disturbed as part of project activities. Specific considerations may apply to provincially-sensitive species such as owls or raptors that may nest as early as March 1 in some parts of the province. **Project Specific:** Vegetation clearing after March 1 should consider potential impacts to nesting owls and other raptor species if trees proposed to be cleared are preferable habitat. Similar mitigations should be considered as noted under the *Migratory Birds Convention Act* above. Grizzly bears have also been documented within 2 km of the project area and human-wildlife encounters are possible. Mitigations should be implemented to avoid human-wildlife conflicts during construction.
Public Lands Act	Some existing occupation of Crown land may have existing permissions, such as municipal road right-of-ways, Range Road right-of-ways, and existing dispositions. Approval is required for any new occupation of Crown land, including the bed and shore of all waterbodies (i.e., dispositions (licence of occupation). Temporary Field Authorization may be required for laydowns/ short-term use. **Project Specific:** Project work will be located on private land or within existing surveyed road allowances and are not anticipated to require approvals under this Act. Submissions under this Act are not anticipated to be required.
Weed Control Act	Project activities must destroy weeds listed in Schedule 1 of the Act, and control/prevent the spread of weed species listed in Schedule 2. **Project Specific:** A comprehensive list of weed species in the project area is not available. Therefore, a weed survey is recommended prior to start of construction. During construction, if prohibited noxious weeds are encountered, they must be destroyed. If noxious weeds are encountered, they must be controlled. Mitigation measures typically involve routine and specific cleaning of equipment prior to entering the project site, and prior to operation at subsequent sites.

Act and Description	General practices for Complying with the Act
Agricultural Pests Act	Appropriate measures to mitigate the spread of agricultural pests should be employed. Clubroot (*Plasmodiophora brassicae*), *Fusarium graminearum*, and Virulent Blackleg of canola have been identified in some parts of Alberta. **Project Specific:** The project does not fall within an area of known clubroot presence and is not anticipated to be a concern for construction planning.

5.4 Construction Environmental Considerations

There are no environmental constraints identified that would prevent the project from proceeding as planned. Planning recommendations are focused on considerations to minimize disturbance to sensitive features in the trunk sewer line replacement and wastewater lagoon upgrade alignment including avoidance of potential wetlands identified and wildlife (e.g., timing for vegetation clearing).

It is expected that construction-related impacts for this project can be mitigated through early project planning and implementation of standard best management practices.

The following environmental mitigation measures are recommended to be incorporated into project planning:

- **Pre-Construction Contractor Submissions –** An Environmental Construction Operations Plan should be developed by the contractor prior to the start of work, including a project-specific Erosion and Sediment Control Plan. The ECO Plan should contain copies of all environmental regulatory permits secured for the project and kept on site through the duration of construction.
- **Project Scheduling –** there are no instream restricted activity periods for this project, however, construction timing should avoid working in wet conditions or periods of heavy precipitation or snowmelt. Wet weather procedures should be prepared by the contractor prior to the start of construction. Schedule tree clearing to be completed in winter, prior to the migratory bird and sensitive owl nesting window (Early March to Late August). If any additional tree clearing is required it should be scheduled outside of the nesting window, or should be preceded by a nest survey, completed by an environmental professional.
- **Wildlife Mitigation –** measures should be implemented as a safety precaution to reduce the likelihood of human-wildlife interactions, specifically for grizzly bears. This can include use of bear-resistant garbage receptacles and removing waste regularly from the work site (e.g., Government of Alberta BearSmart Program; GOA 2011).
- **Soils –** where excavation is required for the pipeline replacement and lagoon relocation, top soil and sub-soil must be stored separately; replacement should occur in the same order. Stockpiles should be stored in a way that prevents the erosion and degradation of soil, specifically where they are required for extended periods of time over multiple seasons.
- **Weed Control –** Equipment should arrive on site clean and free of dirt, debris, and grease/fluid leaks and utilize existing access points wherever possible. In addition, prohibited noxious weeds must be destroyed, and noxious weeds must be controlled; consult the Alberta Invasive Plant Identification Guide to assist in identification of weed species on site (Wheatland County 2013).
- **Wetlands –** a review of potential wetlands in the project area should be completed to determine if there are additional regulatory submissions required. Additional assessments and permits under the *Water Act* may be required if wetlands are identified and impacts are unavoidable.

- **Use of Equipment –** during construction, machinery should be washed, refuelled, and serviced a minimum of 30 m back from the channel banks of any watercourses and wetlands. Drip trays or secondary containment measures should be in place below fuel tanks.
- **Reclamation –** the site should be restored to its pre-disturbance condition, revegetating with an appropriate native seed mix that is free of weeds. It is important that the project lands must be restored to equivalent land-use capabilities following construction.

6 OPINION OF PROBABLE COST AND FUNDING ALLOCATION

This section presents an opinion of probable costs (± 30%) associated with the upgrade items described in **Section 3** and **Section 4**. **Table 6-1** provides a summary of probable cost and the detailed cost estimation table is provided in **Appendix E**. This opinion of probable cost of construction is made on the basis of experience and best judgment based on the scope of work proposed in the report. AE cannot and does not guarantee that proposals, bids or actual construction costs will not vary from this or subsequent cost estimates. The requested quotation from qualified equipment suppliers (Nexom) was used to estimate the process mechanical costs. The general, civil, structural, building mechanical, electrical and controls costs were estimated based on typical values and our experience with similar facilities.

Table 6-1
Opinion of Probable Total Capital Cost

Item No.	Description	Unit
1.0	General Requirements	$440,000
2.0	Trunk Sewer	$490,000
3.0	Lagoon Earthworks	$3,100,000
4.0	Lagoon Treatment	$1,300,000
5.0	Land Acquisition	$100,000
	Construction Subtotal	**$5,430,000**
6.0	Engineering Including Geotechnical Investigations (15%)	$810,000
7.0	Contingency (30%)	$1,630,000
	Total	**$ 7,870,000**

6.1 Funding Allocation

It is anticipated that AT will provide funding to assist with the relocation of the lagoon. Typically, only costs that are incurred as a result of the highway relocation will be eligible for funding. The below **Table 6-2** shows the anticipated allocation of funding. **Appendix E** shows a detailed percentage breakdown of the allocations.

Table 6-2
Opinion of Probable Cost Funding Allocations

Item No.	Description	Town Allocation	AT Allocation
1.0	General Requirements	$210,000	$230,000
2.0	Trunk Sewer	$ 0	$490,000
3.0	Lagoon Earthworks	$1,150,000	$1,950,000
4.0	Lagoon Treatment	$250,000	$1,000,000
5.0	Land Acquisition	$ 0	$100,000
	Construction Subtotal	**$1,610,000**	**$3,770,000**
6.0	Engineering Including Geotechnical Investigations (15% of allocation)	$240,000	$570,000
7.0	Contingency (30% of allocation)	$480,000	$1,130,000
	Total	**$2,330,000**	**$5,470,000**

Allocations shown have been based off of the following, rounded to the nearest $10,000 per cell:

General Requirements

- Temporary Facilities and Controls as well as ECO plan and Env. Controls are shared, as it is a component of the construction and upgrades.

Trunk Sewers

- As current capacity is fully sufficient for design timeline, alterations are required only due to highway relocation.

Lagoon Earthwork

- Costs for earthworks are shared with the exception of;
- Costs for existing cell alterations required due to conflict with the new ROW as shown in Figure 4-2 are allocated to AT exclusively.

Lagoon Treatment

- Upgrades to the aeration are required to restore proper treatment to the system and are allocated to AT, with the exception of the Cell 2, 3 equipment which is seen as a partial upgrade, and is thus shared.
- Alum delivery system is an upgrade to the treatment system effectiveness and is allocated to the Town.

Land Acquisition

- This item is required due to highway re-route, and has been allocated to AT.

6.2 Grant Funding

The work to alter, expand and upgrade the Town of Beaverlodge lagoon system may be eligible for funding from the Alberta Municipal Water/Wastewater Partnership (AMWWP). AE recommends that initial inquiries be made to determine the potential eligibility of this work for funding.

Based on the 2020 population of 2,567 residents, the potential grant funding for the project is 59.75% of project costs for the Town, as per the AMWWP funding formula (https://www.alberta.ca/amwwp-apply.aspx#jumplinks-2). This projects to a total of **$ 1,400,000** of funding based on the Estimate of Probable Costs.

7 CONCLUSIONS

The construction of the new Highway 43 alignment will impact the Beaverlodge lagoon system, requiring alterations to the layout and treatment strategy in order to accommodate the new highway alignment. As a result, an alteration to the current lagoon layout is required, complete with altered aeration to meet effluent requirements. The construction of a new storage cell is also proposed to meet the projected 2045 storage requirements.

The existing trunk sewer forcemain feeding the lagoon system has sufficient capacity for the projected 2045 peak flows. However, in order to meet the AT and CN requirements the following alterations are required:

- Change in pipe material to a jointless HDPE pipe to meet AT requirements for crossings.
- An increase in pipe size, reduced slope and deepening within the AT ROW.
- Steel casing across the CN ROW.

Funding for this work will be allocated between the Town of Beaverlodge and AT to reflect the costs of required upgrades from the highway relocation, and required upgrades for future growth.

8 RECOMMENDATIONS

Moving forward, Associated recommends the following next steps:

- Meet with AT/CN representatives to review the findings of this report and discuss next steps including progressing into detailed design, funding allocations, material stockpiling and setback distances/pipe covers.
- Proceed with the geotechnical investigations required to continue design for the lagoon expansion and new pipe installations.
- Begin discussions with AEP regarding application for the alterations and upgrades to the lagoon system under Code of Practice.
- Perform a sludge survey of the current lagoon system, complete with sludge characterization testing. This will inform on whether full or partial desludging may be required within the scope of this work.
- Install a flow meter or Parshall flume at the lagoon lift station to verify design inflows and complete an Inflow & Outflows (I/I) study of the existing sewer system to determine any potential sources of high inflows to the lagoon system. Reductions in flow values, or rectifications of any discovered infiltrations may reduce the required storage capacity.
- Begin a wastewater sampling program at the lagoon, collecting four (4) samples per year for comparison to the typical domestic wastewater, as discussed in **Section 2.4**.
- Initiate discussions with responsible AT staff for potential funding for the Town portion of the project under AMWWP for the upgrade components of the proposed lagoon alterations.

CLOSURE

This report was prepared for the Town of Beaverlodge to support the Town of Beaverlodge in the required lagoon alterations and upgrades resulting from the new Highway 43 alignment.

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.

29 Jun. 2022

PROFESSIONAL ENGINEER ALBERTA
KEITH OGLETREE
APEGA ID - 118392
2022-06-29

Chad Maki, P.Eng.
Project Manager

Keith Ogletree, P.Eng.
Project Engineer

2022-06-29
PERMIT TO PRACTICE
ASSOCIATED ENGINEERING ALBERTA LTD.

Signature ______________

PERMIT NUMBER: P 03979
The Association of Professional Engineers and Geoscientists of Alberta
180791

REFERENCES

Banrie. (2013, September 30). *The Fish Site*. Retrieved April 13, 2022, from https://thefishsite.com/articles/managing-ammonia-in-fish-ponds#:~:text=Un%2Dionised%20ammonia%20is%20the,pH%20is%20less%20than%208.0.

ESRD. (2012). *Standards and guidelines for municipal waterworks, wastewater and storm drainage systems.* Edmonton: Environment and Sustainable Resource Development.

Mcnaughton, E., Stoll, S., Smith, J. E., MIddlebrooks, E. J., & Bowman, R. (2011). *Principles of Design And Operations Of Wastewater Treatment Pond Systems For Plant Operators, Engineers, And Managers.* U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-11/088.

USEPA. (1983). *Municipal Wastewater Stabilization Ponds.* Cincinnati, Ohio: US Environmental Protection Agency.

APPENDIX A - WASTEWATER LAGOON ASSESSMENT TECHNICAL MEMORANDUM (2020)

TECHNICAL MEMORANDUM

Town of Beaverlodge

Wastewater Lagoon Assessment

OCTOBER 2020

A Carbon Neutral Company

CANADA BEST MANAGED COMPANIES Platinum member

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Town of Beaverlodge (Town) owns and operates the Beaverlodge Wastewater Lagoon System, under the *Environmental Protection and Enhancement Act* (EPEA) registration 408-02-00, which requires the system to conform to the *Code of Practice for Wastewater System Using Wastewater Lagoons*.

The wastewater lagoon system consists of four (4) anaerobic cells, a non-aerated facultative cell, a partial mix aerated cell (post-facultative aerated treatment cell), and two (2) cells for aerated storage. Wastewater flows through four (4) anaerobic cells located within the facultative cell, then into the facultative cell. The wastewater is then pumped from the facultative cell to Cell #1 (partial mix) via a lift station. Cell #1 is divided into 3 smaller cells (Cells #1A, #1B, and #1C), each separated by an impermeable geomembrane flow diversion baffle. From Cell #1, wastewater is transferred to Storage Cells #2 and #3 by gravity for aerated storage prior to discharge to the Beaverlodge River. The lagoon system was last upgraded in 2008 with the addition of an aeration system to Cells #1, #2, and #3. Aeration is provided by four (4) blowers located within the blower building, which is situated at the center of the lagoon site. A site schematic of the wastewater lagoon system is shown in **Figure 1-1**.

The lagoon was designed for controlled discharges once per year. However, it currently discharges twice per year, as the storage cells reach capacity in less than a year. Associated Engineering (AE) completed a *River Assessment Study* to evaluate the "adverse effects" of twice-annual discharges on the water quality and fish, in the Beaverlodge River. The detailed report is affixed as **Appendix A**. Based on the current achieved effluent quality (2017–2020), data collected during the 2020 flow year, and using the historical river quality data, the report concluded the following:

- Un-ionized ammonia in the river, during the Fall discharges from the storage cells, is not expected to cause adverse effects to the fish.
- Un-ionized ammonia concentrations at the edge of the mixing zone in the river may exceed the applicable guidelines under typical Spring river flows and there may be adverse effects.
- Total phosphorus concentrations, during the typical Spring discharge conditions, increases by 40%, where an approximately 30-fold increase was determined under typical Fall discharges. During Fall discharges, the increase is significant enough that it changes the trophic status of the river from eutrophic to hyper-eutrophic, which can potentially lead to increased growth of attached and floating algae, which in turn can lead to unfavourable pH and dissolved oxygen levels.

The scope of this assignment is to determine if the existing lagoon system has enough storage and treatment capacity for the next 25 years. The following items were reviewed as part of this assignment:

- *Hydraulic Capacity Review*: Desktop review of lagoon sizing, considering the existing population and sewage flows, and future population projections. The review included the ability of the lagoon to meet hydraulic detention times for annual and bi-annual discharges:
    - *Organic Removal Capacity Review*: Desktop review to establish the 5-day Biochemical Oxygen Demand (BOD_5) removal capacity of the lagoon system.
    - *Nutrient Removal Capacity Review*: Desktop review to establish the Ammonia and Phosphorus (P) removal capacity of the lagoon system.

Figure 1-1
Town of Beaverlodge Wastewater Lagoon System Site Schematic

2 POPULATION, FLOW AND WASTEWATER CONCENTRATION PROJECTION

2.1 Population Projection

The historical Federal Census data (1986–2016) for the Town was analyzed to project the future sewered population (actual residential population). The Town's population has grown modestly at an average rate of 1.1% per annum from 1986 to 2016. This is consistent with the growth rate (1.0%) used for the design of the Town's Water Treatment Plant, by AE. An annual growth rate of 1.0% was, therefore, used to estimate the population for a design horizon of 25 years. Table 2-1 summarizes the projected populations of the Town for the next 25 years.

Table 2-1
Projected Population

Year (Design Horizon)	Population
2020 (Current)	2,555
2025 (5)	2,673
2030 (10)	2,797
2035 (15)	2,927
2040 (20)	3,064
2045 (25)	3,208

2.2 Wastewater Generation Projection

Alberta Environment and Parks' (AEP) design standards and guidelines for wastewater lagoons are a function of the average wastewater generation rate (daily). The Town provided historical annual wastewater release data. Table 2-2 summarizes the historical total annual wastewater volumes for the period of 2014 to 2019. The volumes provided are total wastewater generation volumes for the entire year as estimated by the Town, therefore, are inclusive of:

- Domestic wastewater generation;
- Any septage or truck dump flows; and
- Inflow and infiltration (I/I).

Influent flow to the lagoon system is not metered; hence, historical wastewater release data for the Town and corresponding sewered population was used to calculate average annual per capita wastewater generation rate, as shown in Table 2-2. A wide range per capita generation rate was recorded. The estimated annual release rate for 2017 was significantly higher than the other estimated release rates, during 2014 to 2019, and there was no significant correlation between the per capital release rate and the recorded annual precipitation to the Town. Hence, the high release rate, in 2017, may be the result of inaccurate release volume measurements. Due to the limited scope, AE was unable to verify this premise, during this assessment.

AEP defines the average daily design flow as the greatest annual average per capita daily flow, which is estimated to occur during the design life of the facility. Hence, a per capita generation rate of 625 L/d was used in this study to estimate future design flow. The original design flow was 380 L/c/d. It should be underscored that the design flow used in this assessment is significantly higher than what is typically seen (approximately 500-550 L/c/d), in the Northern Alberta communities of similar size and characteristics, which may be attributed to various reasons:

- Inaccurate release volume calculation;
- Significant I/I issues that can be addressed to a degree to reduce the inflow value; and/or
- Significant truck dump flows from outside of the population numbers, so there might be a population equivalent attached to the truck dump flows.

Table 2-2
Historical Wastewater Release

Item	2014	2015	2016	2017	2018	2019
Population	2,425	2,445	2,465	2,485	2,505	2,526
Spring Release (m^3)	273,681	282,374	297,469	318,367	268,325	234,299
Fall Release (m^3)	207,318	222,614	193,317	248,241	180,180	173,555
Total Release (m^3)	480,999	504,988	490,787	566,608	448,505	407,854
Total Annual Precipitation (mm)	356	435	586	488	553	447
Release Rate (L/c/d)	543	566	545	625	490	442

The average daily wastewater generation rate for the future assessment period was estimated by applying the per capita wastewater generation rate, 625 L/c/d, to the projected populations for the Town, as in Section 2.1. The estimated daily and annual wastewater generation volumes are summarized in Table 2-3.

Table 2-3
Estimated Annual Wastewater Generation

Rate	2020	2025	2030	2035	2040	2045
Rate (m^3/d)	1,600	1,670	1,750	1,830	1,915	2,005
Rate (m^3/yr.)	576,000	601,200	630,000	658,800	689,400	721,800

Section 3.4.1.5.4 of AEP's design standards and guidelines requires a total gravity collection system, i.e., no pumping station with a capacity <500 m^3/d, to have a portable or permanent flow measuring device provided at the inlet of the wastewater lagoons. Hence, AE recommends that a Parshall flume type flow meter be installed at the inlet to measure the influent flow to the wastewater lagoon system and verify the design assumption used in this assessment. In addition, AE recommends completing an inflow and infiltration (I&I) study to identify potential options to reduce the I&I contributions to the lagoon system, i.e., lining of pipes and manholes.

2.3 Wastewater Quality Estimation

The AEP does not have any guidelines to estimate design loads for conventional wastewater lagoons, as the design guidelines are based on the hydraulic retention time of average daily flow. For aerated lagoons, AEP recommends using the influent wastewater characteristics of typical domestic wastewater (BOD - 200 mg/L, TSS - 200 mg/L), unless the characteristics are considerably different. The Town does not have to monitor and report influent concentrations, as part of the requirements of the Code of Practice; therefore, data was not available to estimate or verify influent wastewater characteristics.

AE recommends that the Town complete at least a few samples throughout a year in order to start building a baseline of influent quality data. AE reviewed the influent characteristics (BOD_5 only) for the Town of Valleyview that is of a similar scale and characteristics, as the Town of Beaverlodge. The influent BOD concentration varies between 180–220 mg/L, for the Town of Valleyview, which is typical of domestic wastewater. The AEP does not have any guidelines to estimate influent concentrations for Ammonia and Total Phosphorus.

Table 2-4 shows estimated influent concentration for typical domestic wastewater used/can be used for preliminary assessment of removal capacity of Town's lagoon system.

Table 2-4
Estimated Design Influent Concentration

Parameter	Concentration (mg/L)
BOD_5	200
Total Kjeldahl Nitrogen (TKN) as N	31
Ammonia as N	23
Total Phosphorus as P	5.2

The conventional wastewater lagoon and aerated lagoon are not typically designed for ammonia and total phosphorus removal. Therefore, in this study, ammonia and total phosphorus removal capacities were evaluated based on the performance of the existing lagoon system by analyzing historical effluent concentration and lagoon nutrient removal performance in Northern Alberta. AE recommends that the Town collects and analyzes a minimum of three (3) grab samples a year, during the dry period to develop a baseline influent quality for critical parameters, including BOD_5, Total Kjeldahl Nitrogen (TKN), Ammonia, and Total Phosphorus.

3 SYSTEM CAPACITY ASSESSMENT

3.1 Design Capacity Requirements

AEP established design criteria for wastewater lagoon cell configurations, based on the average daily design flow. Table 3-1 summarizes lagoon cell requirements in AEP's standards and guidelines. The Town has an average daily design flow of more than 500 m^3/d; hence, the wastewater lagoon system should have four (4) anaerobic lagoons, each with two days of storage capacity, based on the average daily design flow. Facultative cells are required in all lagoon systems and shall retain influent wastewater for at least 60 days, based on average daily design flow. Storage cells shall retain a minimum of 12 months of storage, based on the average daily design flow.

Table 3-1
AEP Lagoon Design Criteria

Average Daily Design Flow (m^3/day)	Number of Anaerobic Cells	Requirements for Facultative Cell(s)	Requirements for 12 months Storage Cell(s)
< 250	0 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m
250 – 500	2 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m
>500	4 Minimum Depth = 3.0 m	Yes Maximum Depth = 1.5 m	Yes Maximum Depth = 3.0 m

3.2 Current System Hydraulic Capacity

The existing wastewater lagoon consists of eight (8) cells: four (4) anaerobic cells, one (1) facultative cell, and three (3) storage cells. The cumulative volume of the four anaerobic cells, facultative cell, aerated (partially mixed) cell and two storage cells is 6,400 m^3, 54,800 m^3, 114,600 m^3 and 309,100 m^3, respectively, based on estimates from the existing record drawings. The volumes were calculated from the bottom of the cell to the high water level, with a minimum 0.5 m of freeboard. A summary of the existing wastewater system capacity (volume) is shown in Table 3-2. It should be noted that the volume of the cells is estimated, based on record drawings only; a survey was not conducted to verify the values noted below.

Table 3-2
Hydraulic Capacity Summary of Existing Wastewater System

Parameter	Value
Anaerobic Cell	
Number of Cells	4
Operating depth, m	3.65
Volume of each cell, m^3	1,600
Total volume, m^3	6,400
Facultative Cell	
Number of Cells	1
Operating depth, m	1.5
Total volume, m^3	54,800

Parameter	Value
Aerated Cell (Partially Mixed)	
Number of Cells	1
Operating depth, m	2.5
Volume (Cell#1A), m^3	27,500
Volume (Cell#1B), m^3	24,750
Volume (Cell #1 total), m^3	114,600
Storage Cell (Aerated)	
Number of Cells	2
Operating depth, m	2.5
Volume (Cell #2), m^3	238,800
Volume (Cell #3), m^3	70,300
Total volume, m^3	309,100

The design capacity requirements for anaerobic, facultative, and storage cells are summarized in Table 3-3 for 2045, based on AEP standards and guidelines for wastewater lagoons. The following subsection discusses the capacity of the individual cells.

Table 3-3
Recommended Design Capacities

Anaerobic Cell (s), m^3		Facultative Cell, m^3		Storage Cell (s), m^3		
Existing	Required by 2045	Existing	Required by 2045	Existing (Cell #2 & Cell 3)	Required by 2045 (6 mths)	Required by 2045 (12 mths)
6,400	16,050	54,850	120,300	309,100	360,900	721,850

3.2.1 Anaerobic Cell Capacity Assessment

Figure 3-1 compares the projected anaerobic cell capacity requirements and the existing storage cell capacity from 2020 to 2045. Figure 3-1 and Table 3-3 show that the current wastewater lagoon system does not have enough hydraulic capacity for anaerobic storage or to even meet the current system's requirement. It should be mentioned that no sludge survey was conducted to estimate actual depth (sludge depth) in the anaerobic cells. A minimum of 10,000 m^3 additional storage capacity needs to be added to meet the anaerobic system's holding capacity requirements for 2045.

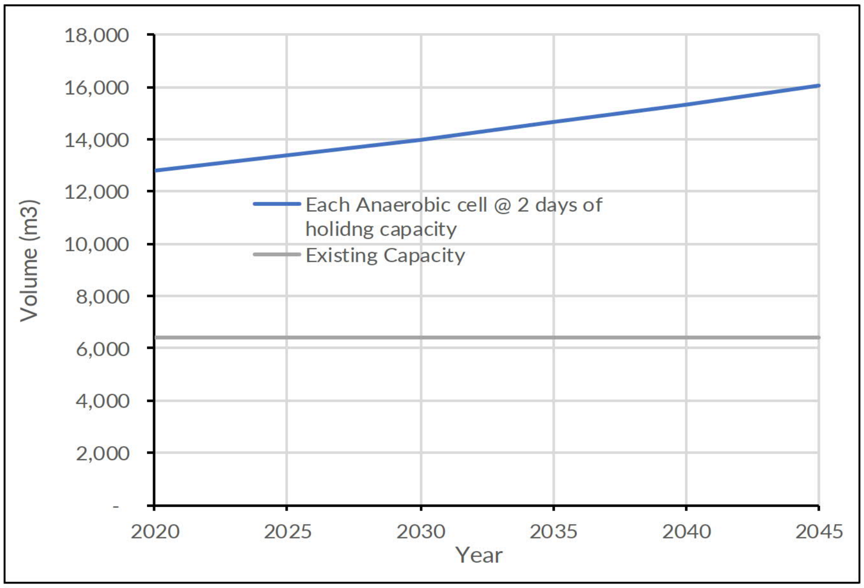


Figure 3-1
Anaerobic Cells Capacity Assessment

3.2.2 Facultative Cell Capacity Assessment

Figure 3-2 shows that the existing wastewater lagoon system's configuration requires additional facultative cell volume; however, a combination of the facultative cell and the aerated partially mixed (Cell #1) storage cells will meet the hydraulic capacity requirement for the next 25 years of projected wastewater flows. A combination of the facultative cell, Cell #1A and Cell #1B will also meet the facultative holding requirements for the next 15 to 17 years. Since Cell #1 is aerated, the working depth is not limited to the maximum allowable working depth for a facultative cell (1.5 m).

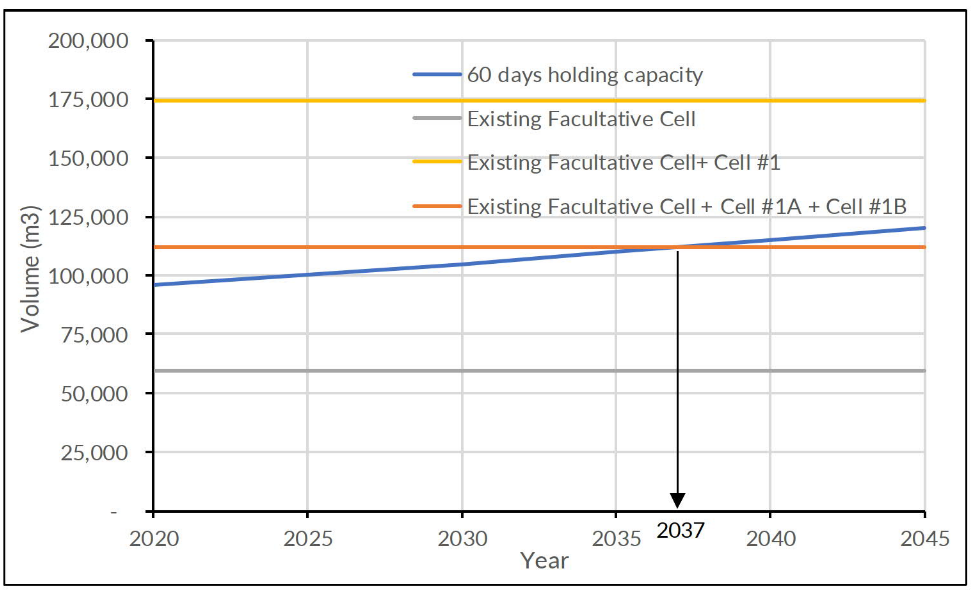


Figure 3-2
Facultative Cell Capacity Assessment

3.2.3 Storage Cell Capacity Assessment

The projected storage cell capacity requirements and the existing storage cell capacity is shown in **Figure 3-3**. The Town's current lagoon system does not have enough storage capacity to provide 12 months of storage for 2020.

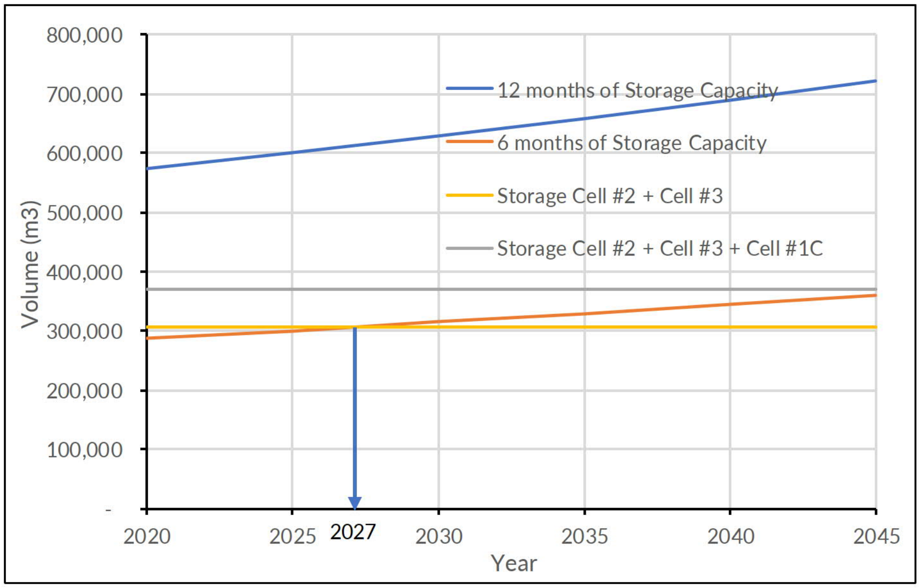


Figure 3-3
Storage Cell (s) Capacity Assessment

3.2.3.1 Annual Discharges

There are lagoon systems in Alberta that discharge twice a year, but the low flow conditions in the Fall and the total phosphorus issue, as identified in the Beaverlodge River Assessment Report, will require the 12 months of storage option to be considered. To meet the 12 months of storage (721,900 m^3) requirement for 2045, a minimum of 413,800 m^3 of storage capacity needs to be added. For the proposed upgrades, the wastewater lagoon system will have enough design capacity for controlled, annual discharges, under the most favourable receiving water conditions.

3.2.3.2 Bi-annual Discharges Options

The Town can consider following options for bi-annual discharges:

- The total volume of Storage Cell #2 and Cell #3 (Cell #1A and Cell 1#B being dedicated for equivalent holding capacity of facultative cell, as described in **Section 3.2.2**) will provide enough storage capacity for 6 months of storage for the next 8 years (until 2028).
- A combination of Cell #1C, Storage Cell #2, and Cell #3) will provide enough storage capacity for 6 months of storage for the entire assessment period (until 2045). In this scenario, a berm will need to be constructed to separate the proposed storage Cell #1C from Cell #1A and Cell #B (treatment).
- The Town can evaluate the feasibility of continuous discharges from the storage cells in the Summer (open water season) and blending it with the winter storage, while discharging Summer flows. Under this scenario, only 6 months of storage will be required.

3.3 BOD_5 Removal Capacity Assessment

AE proposes using a combination of the existing facultative cell and Cell#1A and Cell #1B to provide storage and treatment requirements for the facultative cell. Separate removal mechanisms are involved in facultative cell and aerated cell (Cell#1) treatment. Hence, the following assumptions were made to estimate the 5-day Carbonaceous Biochemical Oxygen Demand ($cBOD_5$) removal capacity of the wastewater lagoon system, for 2045:

- Assumptions for minimum cBOD removal efficiency, during Spring discharges:
  - Average lagoon temperature is 2°C.
  - $cBOD_5$ removal mechanism in the existing anaerobic and facultative cells is solely sedimentation of particulate cBOD and is assumed to be an average of 10% and 20%, respectively.
  - $cBOD_5$ removal efficiency in partially mixed aerobic cells (Cell#1A and Cell #1B) was estimated, using a plug flow kinetic model with an appropriate temperature correction factor.
- Assumptions for minimum cBOD removal efficiency during Fall:
  - Average lagoon temperature is 20°C.
  - $cBOD_5$ removal mechanism in the anaerobic cell is assumed to be an average of 10%.
  - $cBOD_5$ removal efficiency in the facultative cell was estimated, using a plug flow kinetic model with appropriate temperature correction factors. The estimated removal efficiency was 86%.
  - $cBOD_5$ removal efficiency in the aerobic cell (Cell #1A and Cell #1B) was estimated, using a partially mixed lagoon model with appropriate temperature correction factors.

The minimum effluent cBOD concentration for the Town's lagoon system for Spring and Fall discharges for 2045 is estimated to be 11.0 mg/L and 1.0 mg/L, respectively. The detailed calculations and related assumptions are presented in **Appendix B**. **Table 3-4** summarizes the historic lagoon effluent quality during the Spring and Fall discharges.

There is a discrepancy between the historic effluent BOD concentrations and the predicted value for the Spring discharges. This may be attributed to low settleable BOD (no influent wastewater characterization is available to date to verify this assumption), low temperatures that hinder biological activity, and short circuiting due to density stratification. The cBOD measured concentrations for the Fall discharges are in the same order of magnitude as was estimated for 2045. The reason is that the removal efficiency for the aerated lagoon system is a function of the hydraulic retention time and adequate aerated hydraulic retention will result in a significant reduction in effluent cBOD levels. Hence, it can be projected that the wastewater lagoon system has enough treatment capacity to meet the low effluent BOD concentration (less than 25 mg/L of $cBOD_5$) for both the Spring and Fall discharges. It was assumed that the wastewater system is not oxygen-limited, i.e., existing aeration system can meet high oxygen demand in the partially mixed aerobic cells, during the Summer months exerted by nitrification and algae.

Table 3-4
Historic Lagoon Effluent Quality

Spring			Fall		
Date	BOD_5 (mg/L)	Ammonia-N (mg/L)	Date	BOD_5 (mg/L)	Ammonia-N (mg/L)
29-Jun-16	33	1.3			
16-Mar-17	3	0.3	14-Sep-17	<2	<.02
24-Apr-18	7	4.7	4-Sep-18	<2	<.05

Spring			Fall		
24-Apr-19	8	8.5	2-Oct-19	<2	Not Available
22-May-19	20	4.2	3-Sep-19	<2	<.05

3.4 Nutrient Removal Capacity Assessment

Wastewater lagoon systems are not typically designed for Ammonia and Phosphorus removal. Hence, a significant year-round reduction in effluent nitrogen and phosphorus concentration is not achievable, especially during Spring discharges. In addition, influent nutrient loads in the lagoon system are also not available due to a lack of monitoring and reporting requirements. There is also a lack of predictive kinetic lagoon nutrient removal models that can approximate lagoon effluent nutrient concentrations. This section assesses the nutrient removal capacity, based on historic effluent concentrations.

3.4.1 Ammonia Removal Capacity Assessment

Ammonia removal in facultative wastewater treatment ponds occurs via three mechanisms: gaseous NH_3 stripping to the atmosphere, NH_3 assimilation in algal biomass, and biological nitrification. Nitrification generally does not account for a significant portion of NH_3 removal, especially when the lagoon temperature falls below 6°C. Ammonia assimilation in algal biomass depends on the biological activity in the system and is affected by temperature, organic load, detention time, and wastewater characteristics. The rate of gaseous NH_3 losses to the atmosphere depends mainly on the pH value, temperature, and the mixing conditions in the pond. Regardless of the specific removal mechanism involved, ammonia removal in facultative wastewater ponds may approach 99%, during the Summer months (Fall discharges), with the major removal occurring in the primary cell of a multi-cell pond system.

The ammonia removal rate in the aerated lagoon is a function of BOD loading rate and detention time. With a low BOD concentration, significant ammonia removal can be achievable in the aerated cell, only if enough oxygen is provided.

As shown in **Table 3-4**, effluent ammonia concentrations, during Spring discharges, are higher than that of Fall discharges, due to a lack of or reduced biological activities during the winter months. The lagoon system will achieve similar historic ammonia removal performance, in the future, with the assumption that the aeration system can provide adequate mixing and meet oxygen demands.

The River Assessment Report (**Appendix A**) identified that instead of low flow during typical Fall discharges, the un-ionized Ammonia concentration at the edge of mixing is not expected to cause adverse effects to fish, during the Fall. On the contrary, the un-ionized ammonia concentration at the edge of the mixing zone may exceed the applicable guideline under typical Spring river flows and there may be adverse effects. The effluent ammonia concentration can not be reduced reliably in a wastewater lagoon system, in the Winter, without the addition of an effluent treatment unit. But, the fraction of un-ionized ammonia levels can be reduced by lowering the pH level. Hence, AE recommends lowering the effluent pH level by adding Alum, during Spring discharges that will also reduce total phosphorus concentration, as described in the following section.

3.4.2 Total Phosphorus Removal

Phosphorus removal in ponds may result from physical mechanisms, such as adsorption, coagulation, and precipitation. Without the addition of coagulant, phosphorus removal, using the physicochemical mechanisms, will be insignificant. The uptake of phosphorus by organisms for cell metabolism, as well as storage, can also add to phosphorus removal. Phosphorus removal in wastewater ponds has been reported to range from 30% to 95% (USEPA, 1983). The removal efficiency varies seasonally with the growth of organisms in a lagoon system. Spring discharges will, in general, result in higher effluent phosphorus concertation than that of Fall discharges, due to lower biological activity.

The Town does not have any historic effluent total phosphorus concentration data. The River Assessment Report measured average total phosphorus concentration of 1.64 mg/L for Spring effluent for 2020 but measured Fall effluent concentrations is not available. Total phosphorus concentration at the edge of the mixing zone for Spring discharges is calculated to be 0.33 mg/L. Total phosphorus concentration in the river, during typical Spring discharge conditions, increased by 40%, where an approximately 30-fold increase was determined under typical Fall discharges. AE recommends the addition of alum to reduce the total phosphorus concentration to as low as 0.33 mg/L (at the edge of the mixing zone), during Fall discharges. For total phosphorus removal, the addition of Alum, in excess of 25 mg/L, will be required to lower the pH level. Reducing the pH level will also reduce the un-ionized ammonia fraction in the effluent.

Data collected by AE, during projects for the Town of Slave Lake's lagoon system and the Hamlet Grande Cache's Wastewater Treatment Plant showed that a significant reduction of effluent phosphorus concentration can be achieved if the reject water sludge (high in Alum) from the Water Treatment Plant is diverted to the Wastewater Treatment's system. AE recommends evaluating the feasibility of diverting the reject water (sludge) from the Town's Water Treatment Plant to the wastewater lagoon system, as a long-term solution to reducing operation costs of the lagoon's effluent phosphorus concentration reduction.

3.4.3 Conceptual Level Cost Estimates for Alum Addition

The conceptual cost estimate for the addition of 413,800 m^3 of storage capacity to the Town's existing wastewater lagoon system to meet AEP's design standards and guidelines is in the order of CAD $4.5 M. It is assumed that the site is suitable for clay liner construction and the cost for land acquisition (if required) is not included.

AE recommends using a temporary trailer to house an alum dosing skid with two pumps to add Alum for the Fall discharges. From the trailer, a flexible hose will be used to add alum to the inlet of Cell#1. The aeration system in Cell #1 will provide the necessary mixing energy to facilitate phosphorus precipitation. The high-level cost of the alum addition skid will be $20,000. It is assumed that the Town will provide the trailer to house the skid; hence, there are no capital costs assumed for the trailer.

The high-level cost of alum (operational costs) to lower the effluent total phosphorus concertation to the level of 0.33 mg/L (in river concentration), during the Fall discharges will be $5,000 per annum. It should be mentioned the estimated operating cost is based on theoretical values only. No consideration is given to account for the total phosphorus influent load increase due to changes in sewered population and the effects of wastewater matrix on the alum dose. Hence, AE recommends completing jar tests to determine the alum requirement each year before the onset of alum addition.

4 SUMMARY AND RECOMMENDATIONS

4.1 Summary

- The current wastewater lagoon system does not meet the release criteria for annual discharges.
- Based on current, achieved effluent quality (2017–2020) and data collected, during the 2020 flow year, and using historical river quality data, the Beaverlodge River Assessment Report concluded the following:
  - Un-ionized ammonia in the river, during the Fall discharges from the storage cells, is not expected to cause adverse effects to the fish.
  - Un-ionized ammonia concentrations at the edge of the mixing zone in the river may exceed the applicable guidelines under typical Spring river flows and there may be adverse effects.
  - Total phosphorus concentrations, during the typical Spring discharge conditions increases by 40%, where an approximately 30-fold increase was determined under typical Fall discharges. During Fall discharges, the increase is significant enough that it changes the trophic status of the river from eutrophic to hyper-eutrophic, which can potentially lead to increased growth of attached and floating algae, which in turn can lead to unfavourable pH and dissolved oxygen levels.
- The current wastewater lagoon system does not meet AEP's design standards and guidelines for Anaerobic and facultative cell requirements, based on its current configuration, historical population, and release flow.
- A combination of facultative cell and Cells #1A and #1B (aerated partially mixed) will meet the hydraulic capacity requirements for the next 25 years of projected wastewater flows for the facultative requirement only.
- The estimated capital cost of upgrading the system to meet the AEP's design standards and guidelines for annual discharges (a total of 12 months of discharges) will be $4.5 M, excluding the cost of land acquisition (if needed).
- For temporary bi-annual discharges:
  - Town's lagoon system can meet a low level of cBOD and ammonia during Fall discharges, until 2035, assuming that the existing aeration system can meet necessary oxygen demand.
  - Spring discharges will, in general, result in higher effluent phosphorus concertation than that of the Fall discharges, due to lower biological activities. The high-level capital cost (Alum dosing skid) for reducing effluent total phosphorus concentration, during Fall discharges, to an acceptable level will be $20,000, with an operating cost (Alum) of $5,000.

4.2 Recommendations

- Associated Engineering recommends completing a study to quantify inflow and infiltration (I&I) and identify potential options to reduce high I&I contribution.
- A Parshall flume type flow meter should be installed at the inlet to measure influent flow to the wastewater lagoon system.
- A wastewater characterization program (a minimum of three grab samples a year during dry periods) should be undertaken to establish a baseline influent quality for critical parameters (BOD_5, Total Kjeldahl Nitrogen (TKN), Ammonia and Total Phosphorus).
- Effluent total phosphorus concentration should be measured as part of the wastewater lagoon system's regular monitoring requirements. A minimum of four grab samples (one in each season)

- Jar tests should be performed to determine the Alum dose to reduce total phosphorus concentration for Fall discharges.
- Viability of diverting reject water (sludge) from the water treatment plant to the wastewater lagoon system should be evaluated to reduce the operation costs of effluent total phosphorus reduction.

CLOSURE

This report was prepared for the Town of Beaverlodge to assist in making decisions for the short-term and long-term solutions for the Town's Wastewater Lagoon System's effluent quality and discharge problem.

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.

2020-10-05

Sean Nicoll, P.Eng.
Project Manager

2020-10-05

Nicholai Kristel, P.Eng.
Process Engineer

Rony Das, E.I.T., M.A.Sc.
Process Engineer-In-Training

PERMIT TO PRACTICE
ASSOCIATED ENGINEERING ALBERTA LTD.

Signature ______________________
Jeff Fetter 2020-10-06

PERMIT NUMBER: P 03979
The Association of Professional Engineers and Geoscientists of Alberta

REFERENCES

United States Environmental Protection Agency (USEPA), 1983, *Design Manual – Municipal Wastewater Stabilization Ponds*, Cincinnati, OH.

APPENDIX A – BEAVERLODGE RIVER ASSESSMENT

Associated Engineering
GLOBAL PERSPECTIVE.
LOCAL FOCUS.

TECHNICAL MEMORANDUM

Town of Beaverlodge

Beaverlodge River Assessment

JULY 2020

A Carbon Neutral Company

CANADA BEST MANAGED COMPANIES Platinum member

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Town of Beaverlodge (the Town) operates a lagoon wastewater treatment system under an *Environmental Protection and Enhancement Act* (R.S.A. 2000, c. E-12) (EPEA) Code of Practice for Wastewater Lagoons, Registration (No. 408-02-00). The Code of Practice allows twice-annual discharge for lagoons, with written authorization by the Director. The lagoon was historically associated with poor effluent quality, but aeration was recently installed, improving effluent quality. Lagoon upgrades were intended to involve twice-annual effluent discharge events, however formal authorization to discharge twice per year was not obtained from Alberta Environment and Parks (AEP). Current lagoon capacity requires twice-annual discharge to maintain infrastructure integrity.

Spring 2020 effluent release was associated with elevated un-ionized ammonia[1] in lagoon cells during discharge to the Beaverlodge River, but still within federal effluent quality limits. Though the Code of Practice does not have specific effluent threshold requirements, AEP is concerned that effluent may be causing "significant adverse effects" on fisheries, per EPEA Section 108/109. "Significant adverse effects" could result if the provincial Surface Water Quality Guidelines for the Protection of Aquatic Life (AEP 2018) were exceeded to a significant degree, spatial extent and sufficient time in receiving waters to affect aquatic life.

The purpose of this report is to address the following two questions:

1. Did the spring 2020 discharge likely have "adverse effects" on the water quality and fish in Beaverlodge River?
2. Would twice-annual discharges be associated with "adverse effects" on the water quality and fish in Beaverlodge River?

The Town and Associated completed sampling of the river upstream of the outfall, downstream of the outfall, in and beyond the mixing zone during the first 2020 release in the spring. This study demonstrated minimal impacts on water quality during this high flow period (Associated Engineering 2020).

The second yearly release of effluent in fall typically coincides with low river flows, when the dilution capacity of the river is lower and the potential for impacts on water quality are higher. To understand the potential effects of the lagoon discharge on the river ecosystem during both spring and fall discharge periods this study simulated a range of river conditions, including fall conditions, using existing data.

The two major parameters of concern for "adverse effects" are:

- un-ionized ammonia (due to its potential toxicity to aquatic life); and
- total phosphorus (because the Beaverlodge River is already nutrient (phosphorus)-enriched, resulting in algae growth in summer).

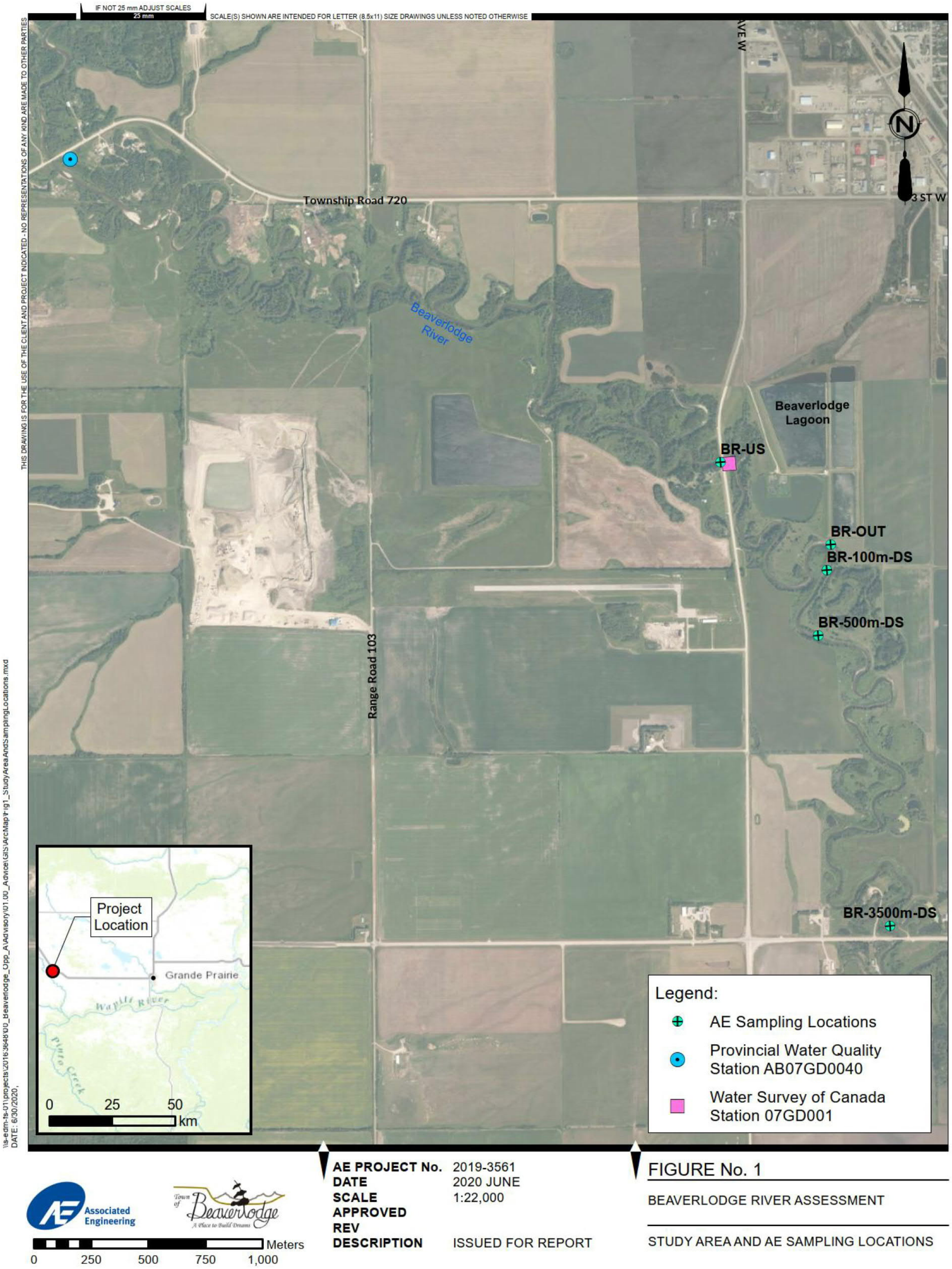
No other parameters of concern have been noted as elevated. Consequently, this assessment focused on ammonia and total phosphorus.

[1] Elevated, but not exceeding guidelines.

2 SITE DESCRIPTION

The Town of Beaverlodge is approximately 40 km west of the City of Grande Prairie and 40 km east of the British Columbia (BC) border. Beaverlodge River is over 150 km long and is part of the Peace River Watershed (AECOM 2009), with a watershed area of 1,610 km^2. The headwaters of the Beaverlodge River originate in the upland areas on both sides of the BC-Alberta border (AECOM 2009). It flows from northwest to southeast through farmland and then through a steep-sided valley to the confluence with the Redwillow River and eventually the Wapiti River (AECOM 2009). The Town's lagoon is south of the town and releases effluent to the Beaverlodge River from an outfall on the northern riverbank twice a year (i.e. once in the spring and once in the fall) (Figure 2-1).

Figure 2-1
Study Area and Sampling Locations



3 METHODOLOGY

The assessment consisted of a hydrology analysis, water quality assessment, and review of fish populations and habitat. Seasonal river flows were analyzed to understand the dilution capacity of the river for the lagoon effluent in spring and fall. The mass balance approach described in the Water Quality Based Effluent Limit (WQBEL) Procedures Manual (Alberta Environmental Protection 1995) was used and adapted to assess the impacts of lagoon discharge on the river water quality in spring and fall. Available reports and data on fish populations and their ecology in Beaverlodge River were reviewed to understand what local species are present and when these would be most vulnerable to water quality impacts.

The data analysis and reporting included:

- Calculating summary statistics of historical water quality data from the Beaverlodge River upstream of the discharge, for input to the mass balance;
- Calculating spring and fall flow rates based on Beaverlodge River historical flow data, to assess dilution and for input to the mass balance;
- Estimating reasonable potential to exceed chronic surface water quality guidelines in the river using mass balance modelling for total ammonia and total phosphorus; and
- Discussing populations and ecology of local fish species and their seasonal sensitivities to water quality impacts.

The following four scenarios were studied:

- Typical spring discharge;
- Typical fall discharge;
- Actual conditions on June 3, 2020; and
- Potential low flow fall release.

The methodologies for hydrology analysis, water quality data analysis, un-ionized ammonia calculations, and review of fish populations and habitat are detailed in the following sections.

3.1 Hydrology Analysis

Flow data were obtained from the Water Survey of Canada (WSC) hydrometric station on the Beaverlodge River near Beaverlodge (Station 07GD001, WSC 2020). The watershed area of the river system at the WSC station is 1,610 km^2. River flows have been monitored by WSC since 1968. This station records flows mainly from March to October, but has some winter data as well. No data were available for 2016, 2017 and 2019. Therefore, 1987-2018 was used for obtaining the last 30 years of hydrological analysis.

Data summary statistics of flow data from the most recent available 30 years (1987-2018) were used to develop a hydrograph of typical seasonal flow patterns in the river. The same dataset was used to calculate 10^{th} percentile of flow and the median flow as input to mass balance modeling for the typical spring, typical fall and 10^{th} percentile low flow fall scenarios.

Preliminary daily flows for 2020 were obtained from AEP to allow an assessment for spring 2020 conditions and to compare the 2020 spring flows to the median spring flows. These 2020 data have not undergone thorough quality assurance/quality control review and are therefore considered preliminary and may be subject to errors and future revision. For example, ice conditions in spring could impact the water level and subsequently result in changes of the stage-discharge relationship.

3.2 Water Quality Assessment

Associated assessed the potential impacts of the lagoon discharge on Beaverlodge River water quality using the approach of "reasonable potential to exceed (surface water quality guidelines)." The "reasonable potential to exceed" is the likelihood that a parameter will exceed guidelines at the edge of the mixing zone due to a point source discharge. The mixing zone is an area immediately downstream of the discharge point where chronic guideline exceedances are tolerated and in Alberta is defined as a portion (10%) of river low flows, or as the distance downstream from the discharge equal to 10 times the width of the river (Alberta Environmental Protection 1995).

Mass Balance

The mass balance dilution model with worst-case conditions was used to determine the "reasonable potential to exceed" an instream guideline. The "reasonable potential to exceed" was calculated by a mass balance equation where the effluent load is added to the river load to calculate downstream concentrations (Equation 1).

Equation 1:

$$C = (QeCe + ff(Qs)Cs)/(Qe + ff(Qs))$$

Where:

Qe = flow of effluent discharge
Qs = flow of receiving stream available for mixing
Ce = concentration of a substance in the effluent
Cs = upstream concentration of a substance
C = resultant concentration of substance after mixing
ff = fraction of flow (10%)

Background water quality was assessed by analyzing existing spring (April – June) and fall (September – November) data from water quality station AB07GD0040 provided by AEP as well as data collected by Associated staff on June 3, 2020. Effluent quality was assessed by analyzing all available data collected by the Town from 2017 to 2020 as well as data collected by Associated staff on June 3, 2020. As a conservative approach, all values below the detection limit were assumed to be the same value as the detection limit.

For developing regulatory WQBELs, the WQBEL Procedures Manual recommends using average or median background concentrations for the season of low flows to describe typical river water quality under low flow, 10% of the 7Q10 river flow, 99th percentile effluent concentrations of parameters of concern, and average effluent flows (Table 3-1). The purpose of this study was not to develop regulatory WQBELs, however. Therefore, the 7Q10 low flow statistic was not calculated. Instead, the purpose of this study was to understand the potential impacts of the effluent during the two discharges, in spring and fall, and relevant flows were used in these scenarios, as follows:

- 10% of the median spring flow rate for typical spring conditions;
- 10% of the median fall flow rate for typical fall conditions;
- 10% of the June 3, 2020 flow rate, to coincide with the June 3, 2020 field monitoring event; and
- 10% of the 10th percentile of fall flow data for the fall low flow scenario.

The median pH and temperature for each season were calculated because these parameters strongly influence the proportion of un-ionized ammonia. The WQBEL Procedures Manual recommends using the 85 percentile of total ammonia in the background; therefore, we calculated the 85 percentile of total ammonia using all available upstream data. Phosphorus is a nutrient and not a toxin; therefore, we calculated the downstream phosphorus concentration using the full flow rate.

Table 3-1
Input data for reasonable potential to exceed analysis

Input to Mass Balance	Type of Data	Data Manipulation	Source of Data
River flows	Daily discharge at WSC Station 07GD001, Beaverlodge River upstream of Beaverlodge	Median spring flow; median fall flow; 10th percentile of fall flows; preliminary June 3 flow	Water Survey of Canada
River water quality	Water quality data from Beaverlodge River upstream of Beaverlodge: Station number AB07GD0040 (1995 - 2014); water sample on June 3, 2020, collected in Beaverlodge River upstream of effluent confluence	Median for pH, temperature and phosphorus; 85th percentile for total ammonia	Alberta Environment and Parks; Associated Engineering
Effluent flows	Total volume of effluent released in spring and fall 2017, 2018, 2019	Average flow calculated separately for spring and fall	Town of Beaverlodge
Current effluent quality (total phosphorus, total ammonia)	Effluent samples (2017 to 2020)	99th percentile of all available data	Town of Beaverlodge

Results of the "potential to exceed" analysis will be compared to applicable chronic surface water quality guidelines. Environmental Quality Guidelines for Alberta Surface Waters (AEP 2018) have water quality guidelines for the protection of aquatic life (Table 3-2).

Table 3-2
Alberta water quality guidelines for ammonia and total phosphorus

Parameter	Chronic Guideline (AEP 2018)
Total phosphorus	For major rivers, nitrogen (total) and phosphorus concentrations should be maintained to prevent detrimental changes to algal and aquatic plant communities, aquatic biodiversity, oxygen levels, and recreational quality. Where priorities warrant, develop site-specific nutrient objectives and management plans.
Un-ionized ammonia nitrogen	0.016 mg/L*

*This value is always compared to un-ionized ammonia nitrogen in surface waters, which is calculated based on total ammonia nitrogen concentrations and field temperature and pH.

3.3 Un-ionized Ammonia Calculations

Un-ionized ammonia fractions were calculated using the equations below (CCME 2010). The modifying factors of temperature and pH collected in the field at the time of sample collection were used to calculate un-ionized ammonia from the total ammonia measured by the laboratory.

Equation 2:

$$pKa = 0.0901821 + 2729.92/T$$

Where:
T = water temperature in degrees Kelvin
pKa = dissociation constant for ammonia at temperature T

Equation 3:

$$f = 1/[10^{pKa-pH} + 1]$$

Where:
f = fraction of total ammonia that is un-ionized
pKa = dissociation constant from equation 2

3.4 Review of Fish Populations and Habitat

A desktop review of local fish populations and fish habitat was conducted to evaluate aquatic ecosystem vulnerability to water quality impacts from the Beaverlodge lagoon discharge. This involved a review of sensitive timing windows (e.g., spawning, incubation, emergence) for fish species potentially present in Beaverlodge River downstream of the outfall discharge site, and an assessment of the anticipated fish species present and their typical reproductive schedule (i.e, when fish are most critically impacted by changes in water quality).

Historical records of fish species observed between 1993 and 2020 within the Beaverlodge River were reviewed using the Fisheries and Wildlife Management Information System (FWMIS) provincial database to establish a list of potential fish impacted by the release.

4 RESULTS

4.1 Hydrology

Seasonal flow patterns in the Beaverlodge River are driven by a steady release of snowmelt from mid-April to mid-June. River flow typically decreases over summer and into fall, with short-duration high flows in response to storm events. Rain events are common during mid-summer. Flows are typically not recorded during winter or have little variation due to the presence of ice cover. Figure 4-1 provides a summary of flow at WSC Station 07GD001 for the period from 1987 to 2018[2].

Spring 2020 flows were higher than the upper quartile (75th percentile) of the last 30 years of historical data. 2020 flows, however, generally follow the typical seasonal patterns observed at this site. At the time of water quality sampling on June 3, river flows were above the upper quartile (75th percentile) of historical data. The river flows on June 3 resulted in a dilution ratio of approximately 64 when compared to effluent flows (Table 4-1). Under typical spring conditions, the dilution ratio was approximately 14. In the fall the effluent flows are much higher than the river flows thus resulting in almost no dilution.

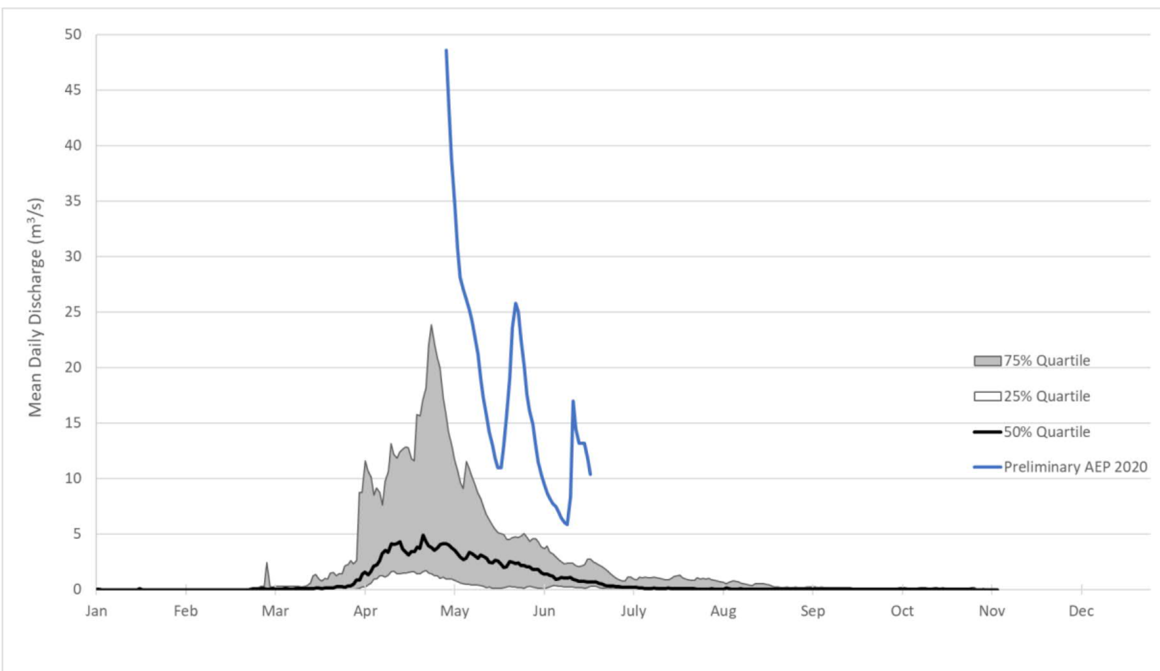


Figure 4-1
Hydrograph of Beaverlodge River 1987-2018[1] (WSC 07GD001)

[2] No data available for 2016 and 2017.

Table 4-1
Dilution capacity of Beaverlodge River for lagoon effluent for spring and fall flow statistics

Flow Stats	River Flow (m^3/s)	Effluent Flow (m^3/s)	Dilution Ratio Full Mixing	Dilution Ratio of 10% of River Flow
Spring Median	2.37	0.16	14.4	1.5
June 3	10.3	0.16	64.4	6.4
Fall Median	0.018	0.12	0	0
Fall 10^{th} Percentile	0.0001	0.12	0	0

4.2 Water Quality

4.2.1 Beaverlodge River Water Quality

Beaverlodge River upstream of the lagoon is elevated in ammonia and total phosphorus in spring, likely associated with spring runoff from the watershed, including agricultural lands (Table 4-2). Fall concentrations were about an order of magnitude lower, but TP levels were still indicative of eutrophic (nutrient-rich) conditions.

Table 4-2
Beaverlodge River water quality upstream of lagoon used in mass balance calculations

Parameter	Median	85^{th} Percentile	Number of Samples
Spring (April – June)			
Total Ammonia (mg/L)	-	0.28	20
Total Phosphorus (mg/L)	0.24	-	20
Temperature (˚C)	6.0	-	20
pH	7.8	-	20
Fall (September – November)			
Total Ammonia (mg/L)	-	0.056	7
Total Phosphorus (mg/L)	0.045	-	7
Temperature (˚C)	10.8	-	7
pH	8.1	-	7

4.2.2 Effluent Characterization

Total ammonia concentrations in the Beaverlodge lagoon effluent are significantly higher in spring (median concentration of 5.54 mg/L) than in fall (median concentration of 0.05 mg/L) (Table 4-3). The median concentration of total phosphorus was 1.42 mg/L.

Table 4-3
Effluent concentrations used in mass balance calculations

Parameter	Median	99th Percentile	Number of Samples
Total Ammonia (mg/L) - Spring	5.54	8.22	14
Total Ammonia (mg/L) - Fall	<0.05*	0.05	3
Total Phosphorus (mg/L)	1.42	1.65	10

*The Method detection limit of ammonia was 0.05 mg/L or 0.02 mg/L; all fall data were not detected.

4.2.3 Mass Balance

The downstream concentrations of un-ionized ammonia and total phosphorus were compared to the Environmental Quality Guidelines for Alberta Surface Waters (Table 3-2).

The mass balance calculations determined that both the typical fall conditions and the conditions with the 10th percentile of fall flow result in un-ionized ammonia concentrations below the guideline of 0.016 mg/L (i.e. un-ionized ammonia = 0.001 mg/L in both cases) (Table 4-4). On June 3, 2020, the flow in Beaverlodge River was high, providing a high dilution capacity. The total ammonia concentration at the edge of the mixing zone on June 3 was 0.008 mg/L, which is below the guideline. Under typical spring conditions, the flow rate in Beaverlodge River results in some dilution and the un-ionized ammonia concentration at the edge of the mixing zone was 0.028 mg/L. This concentration exceeds the guideline; therefore, a wasteload allocation[3] was calculated to determine the maximum concentration of total ammonia in the effluent to meet the guideline. The wasteload allocation for total ammonia in spring is 4.0 mg/L.

There is no numerical water quality guideline for total phosphorus. Instead, the goal is to prevent negative impacts on algae, plant communities and dissolved oxygen. The median total phosphorus concentration upstream in Beaverlodge River was 0.237 mg/L in spring and 0.045 mg/L in fall. The downstream concentrations of total phosphorus were elevated above background concentrations under all scenarios considered. Under typical spring conditions, the total phosphorus downstream was 0.330 mg/L. In fall, under typical conditions, the total phosphorus downstream was 1.43 mg/L compared to 0.045 mg/L upstream. This is a significant increase and has a large potential to result in eutrophication or nutrient enrichment of the river. This could potentially lead to increased algal growth and related diurnal fluctuations in dissolved oxygen.

[3] Wasteload allocation is "the back-calculation of allowable loadings required to support the instream guidelines" (Alberta Environmental Protection 1995).

Table 4-4
Modelled concentrations at the edge of the mixing zone during spring and fall conditions

Parameter	Typical Spring	June 3	Typical Fall	Fall Low Flows (10th Percentile)
Total Ammonia (mg/L)	3.52	0.96	0.05	0.05
Un-ionized Ammonia (mg/L)	**0.028**	0.008	0.001	0.001
Total Phosphorus (mg/L)	0.33	0.26	1.43	1.64

Note: Bold type indicates exceedance of the chronic guideline for the protection of aquatic life.

4.3 Fish Populations and Habitat

The Beaverlodge River is classified as a Large Permanent river (i.e. greater than 5 m wide) and a Class C watercourse with a Restricted Activity Period (RAP) from April 16 to July 15 based on the Grande Prairie management area mapping for the AEP *Code of Practice for Watercourse Crossings* (Government of Alberta 2006). Based on the projected regional spawning activity periods, a sensitive timing window was generated for these species and compared to the RAP and the typical timing of lagoon release (Table 4-5). The RAP coincides with the active spawning window of concern, whereas this assessment also considered the development and incubation of alevin and fry emergence, as a conservative approach.

Table 4-5
Critical life process evaluation for sensitive timing windows for species historically recorded in Beaverlodge River

Species		Sensitive Timing Window (Yellow Shading)											
Common Name	Scientific Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					Restricted Activity Period (April 16 to July 15)								
					Spring Release						Fall Release		
Arctic Grayling (locally extinct)	*Thymallus arcticus*												
Brook Stickleback	*Culaea inconstans*												
Bull Trout	*Salvelinus confluentus*												
Burbot	*Lota lota*												
Lake Chub	*Couesius plumbeus*												
Longnose Dace	*Rhinichthys cataractae*												
Longnose Sucker	*Catostomus catostomus*												
Mountain Whitefish	*Prosopium williamsoni*												
Northern Pike	*Esox lucius*												
Pearl Dace	*Margariscus margarita*												
Redside Shiner	*Richardsonius balteatus*												
Trout-Perch	*Percopsis omiscomaycus*												
White Sucker	*Catostomus commersoni*												

*Species-specific sensitive timing window for approximate spawning, incubation and development of alevin, and fry emergence indicated by yellow (Nelson and Paetz, 1970; Joynt and Sullivan, 2003; Derlukewich, 2019)

The spring release timeframe overlaps with all sensitive timing windows for fish historically observed in Beaverlodge River, whereas the fall release timeframe overlaps with mountain whitefish (*Prosopium williamsoni*) and bull trout (*Salvelinus confluentus*) only. This indicates the probability of impact to a critical life process of local fish species could be high if a lagoon release exceeds the regulated limit set by the EPEA code of practice permit for wastewater discharge or if surface water quality guidelines are exceeded in large areas of the river, outside of the regulatory mixing zone.

The following sections summarize fish habitat in the Beaverlodge River downstream of the lagoon that was gleaned from aerial imagery and the report "*Redwillow Watershed: An Overview of the History and Present Status of Fish Populations and Fish Habitat and Recommendations for Restoration*" (AECOM 2009. The discharge point is approximately 40 km upstream from the Beaverlodge confluence with the Redwillow River, which is located approximately 7 km upstream of the Redwillow River confluence with the Wapiti River.

Beaverlodge River is a highly sinuous watercourse with a regular meandering flow path, characterized by numerous oxbows and sidebars and an overall mean gradient of 0.18%. The banks are steep and incised with the upper slopes dominated by deciduous vegetation providing fair to moderate stream cover at the margins only. River substrate is composed of predominantly silt and clay with some sections of gravel, which is suspended by streamflow in sections exceeding 11.3 m^3/s, stabilizing gravel substrate under spring flow conditions. With the exception of brook stickleback (*Culaea inconstans*), northern pike (*Esox lucius*), and redside shiner (*Richardsonius balteatus*), all species listed in Table 4-5 depend on gravel substrates for reproduction.

The watercourse is considered a low-velocity river with sections of minor riffles and deep pools throughout creating overwintering habitat suitable for large-bodied and small-bodied fish (AECOM 2009). Surveys from 1968 and 1981 directly upstream of the Beaverlodge River confluence with Redwillow River indicated widths ranging from 6.1 to 9.1 m, wetted depths from 0.3 to 0.6 m, bankfull depth of approximately 0.9-1.2 m and an average pool depth of 0.9-1.5 m, reflects the capacity of a large permanent watercourse (AECOM 2009).

Since the collection of these data over 39 years ago, watercourse conditions likely have changed due to agricultural development of the watershed area. Current aerial imagery indicates river widths exceed 30 m in some locations within the same vicinity as the historical survey records.

An electrofishing survey of the Beaverlodge River conducted in fall 2008 during low-water conditions reported that the river consisted of a series of isolated pools separated by dry sections near the confluence, indicating that fall spawning may be limited in the Beaverlodge River (AECOM 2009). A report issued to AEP entitled "*Beaverlodge River Weir Monitoring Program – 2019 Summary Report*" details recent watershed restoration efforts undertaken by the Mighty Peace Watershed Alliance, including fish passage improvement structures upstream of the discharge point. As stated in the report:

> *The intent of the Project was to create the conditions needed to facilitate fish access to the upstream spawning and rearing habitat in the spring and just as importantly, to downstream habitat later in the summer and fall (i.e., overwintering in the Wapiti River)* (Matrix Solutions Inc 2020).

Although historically the Beaverlodge River has provided habitat to many fish species listed in Table 4-5, and overwintering and spawning habitat has been reported to support such species, anthropogenic development of the watershed has reduced the capacity of the Beaverlodge River fish habitat but also the dilution capacity of the flow within (AEP 2009). Current restoration and monitoring efforts by the Mighty Peace Watershed Alliance are ongoing to reinstate locally diminished or extinct fish populations historically present within the Beaverlodge River; therefore, fish habitat potential of the watercourse reflects both the current and lost fish habitat value.

5 SUMMARY AND RECOMMENDATIONS

Ammonia levels in Beaverlodge lagoon effluent vary seasonally, with typical spring concentrations of about 5 mg/L and regularly non-detected concentrations in fall. These low fall effluent concentrations result in river un-ionized ammonia concentrations below the applicable guideline of 0.016 mg/L during typical and low river flows in fall, despite very limited dilution capacity of the river at that time. Un-ionized ammonia is not expected to cause adverse effects to fish during the fall.

The un-ionized ammonia concentration at the edge of the mixing zone on June 3 was below the guideline due to above-average river flow and dilution; therefore, the release in spring 2020 was very unlikely to result in adverse effects to fish. However, results show that the un-ionized ammonia concentration at the edge of the mixing zone may exceed the applicable guideline under typical spring river flows and there may be adverse effects. The maximum effluent total ammonia concentration required to meet guidelines at the edge of the mixing zone under typical spring conditions is 4.0 mg/L.

Total phosphorus increases in the Beaverlodge River due to the lagoon discharge were significant, with a 40% increase in total phosphorus during typical spring conditions and an approximately 30-fold increase under typical fall conditions. The fall increase is significant in that it changes the trophic status of the river from eutrophic to hyper-eutrophic, which could potentially lead to increased growth of attached and floating algae which in turn can lead to unfavourable pH and dissolved oxygen levels.

Based on the results of this assessment, we recommend the following:

- Reduce phosphorus levels in the effluent to avoid large phosphorus increases in the river when river flows are low. Another strategy to reduce phosphorus effects is delaying discharge to late October to minimize resulting algae growth and potential oxygen depletion.
- When discharging in fall, monitor downstream water quality (at a minimum, ammonia, total phosphorus, algae, pH and early morning dissolved oxygen) to field-truth the predictions made in this report and assess the impact of the discharge on the Beaverlodge River, and
- Target an effluent concentration of 4 mg/L total ammonia nitrogen in spring to reduce the likelihood of exceeding chronic un-ionized ammonia guidelines in the receiving waters beyond the effluent mixing zone.

REFERENCES

AECOM Canada Ltd. 2009. Redwillow Watershed: an Overview of the History and Present Status of Fish Populations and Fish Habitat and Recommendations for Restoration.

Alberta Environmental Protection. 1995. Water Quality Based Effluent Limits (WQBEL) Procedure Manual. Available at: https://open.alberta.ca/dataset/f17edca8-f860-43c0-bf43-4507ea1ef456/resource/e207e0b8-998c-452d-b0ad-5d7469866342/download/waterqualitybasedeffluentlimits-manual.pdf Accessed July 2020.

Alberta Environment and Parks (AEP). 2018. Environmental quality guidelines for Alberta surface waters. Available at: https://open.alberta.ca/publications/9781460138731 Accessed July 2020.

Associated Engineering. 2020. Beaverlodge Operational Assistance - Water Quality Sampling, June 03, 2020. Report prepared for Town of Beaverlodge.

Canadian Council of Ministers of the Environment (CCME). 2010. Canadian Water Quality Guidelines for the Protection of Aquatic Life – Ammonia. Available at: http://ceqg-rcqe.ccme.ca/download/en/141. Accessed July 2020.

Derlukewich, S. 2019. *Fish of Alberta – Field Identification*. Self-published. Edmonton, Alberta.

Government of Alberta. 2006. Grande Prairie Management Area Map. Code of Practice for Outfall Structures on Water Bodies. Edmonton, Alberta.

Joynt, A., and M. Sullivan. 2003. *Fish of Alberta*. Lone Pine Publishing. Edmonton, Alberta.

Matrix Solutions Inc. 2020. Beaverlodge River Weir Monitoring Program – 2019 Summary Report. Report prepared for Mighty Peace Watershed Alliance.

Nelson, J.S., and M. Paetz. 1970. *Fishes of Alberta*. The Queen's Printer. Edmonton, Alberta.

Water Survey of Canada (WSC). 2020. Available at: https://wateroffice.ec.gc.ca/search/historical_e.html. Accessed June 2020.

Appendix A - Beaverlodge River Water Quality Data from AEP and AE for Input to Mass Balance

Season	Source	Station Number	Station Description	Sample Date/Time	Ammonia Dissolved (mg/L)	pH (field) pH units	Phoshporus Total (P) (mg/L)	Temperature Water (°C)
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/18/1995 14:45	0.3	7.53	0.242	4.98
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/4/2005 11:30	0.16	6.97	0.374	0.34
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/3/2006 13:20	0.42	7.77	0.527	-0.08
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/6/2006 12:30	0.139	7.78	0.339	0.05
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/10/2006 12:25	0.065	7.95	0.247	-0.04
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/12/2006 13:15	0.049	8.01	0.232	-0.08
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/18/2006 12:45	0.037	7.93	0.157	1.42
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/24/2006 13:10	0.02	8.19	0.119	9.65
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/26/2006 12:55	0.017	8.22	0.109	10.79
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/3/2006 12:50	0.014	8.22	0.087	10.78
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/17/2006 13:15	0.024	8.36	0.2	18.46
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/25/2006 12:20	0.014	8.34	0.062	15.96
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/19/2007 12:30	0.28	7.67	0.157	-0.12
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/25/2007 13:30	0.27	7.49	0.597	3.35
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/26/2007 12:45	0.2	7.43	0.74	3.44
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	4/30/2007 13:45	0.102	7.71	0.293	6.98
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/3/2007 13:15	0.07	7.73	0.27	7.7
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/9/2007 14:00	0.029	7.61	0.248	9.11
Spring	AEP	AB07GD0040	U/S OF BEAVERLODGE	5/14/2014 13:10	**0.05**	7.5	0.069	13.35
Spring	AE data	BR-US	1.4 km upstream from outfall	6/3/2020 0:00	0.05	8.02	0.126	15
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/21/1994 11:35	0.022	8.13	0.045	10.75
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	10/11/1995 13:20	0.015	8.1	0.027	6.14
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/2/2004 11:20	0.022	8.15	0.039	12.9
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	10/26/2004 10:20	0.036	7.47	0.072	0
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	2/9/2005 11:00	0.112	7.27	0.209	0.09
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/12/2006 12:45	0.031	9.48	0.128	15.81
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/16/2014 13:30	-	-	-	-
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/16/2014 13:30	-	-	-	-
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/16/2014 13:45	-	-	-	-
Fall	AEP	AB07GD0040	U/S OF BEAVERLODGE	9/16/2014 14:10	**0.05**	8.13	0.015	13.31

Spring (Apr-June)	0.2715	7.775	0.237	5.98
sample size	20	20	20	20

Fall (Sep-Oct)	0.0562	8.13	0.045	10.75
sample size	7	7	7	7

* bolded values were taken from Total Ammonia

Appendix B - Beaverlodge Lagoon Effluent Concentrations for Input to Mass Balance

Season	Source	Date	Sample ID	Ammonia, Total (as N) (mg/L)	Phosphorus Total (mg/L)
Spring	Town of Beaverlodge	8-May-20	SAMPLE # 2	6.36	1.65
Spring	Town of Beaverlodge	11-May-20	SAMPLE # 2	5.90	1.58
Spring	Town of Beaverlodge	12-May-20	SAMPLE # 2	5.94	1.57
Spring	Town of Beaverlodge	26-May-20	SAMPLE # 2	2.42	1.24
Spring	Town of Beaverlodge	27-May-20	SAMPLE # 2	2.78	0.51
Spring	Town of Beaverlodge	3-Jun-20	SAMPLE # 2	5.12	1.45
Spring	Town of Beaverlodge	4-Jun-20	SAMPLE # 2	6.12	1.59
Spring	Town of Beaverlodge	5-Jun-20	SAMPLE # 2	5.91	-
Spring	Town of Beaverlodge	18-Jun-20	SAMPLE # 2	5.80	0.95
Spring	Town of Beaverlodge	22-Jun-20	SAMPLE # 2	3.46	0.88
Spring	Town of Beaverlodge	24-Apr-19	SAMPLE # 2	4.16	-
Spring	Town of Beaverlodge	24-Apr-18	SAMPLE # 2	8.50	-
Spring	Town of Beaverlodge	16-Mar-17	SAMPLE # 2	4.65	-
Spring	AE	3-Jun-20	BR-OUT AVERAGE	5.28	1.40
Fall	Town of Beaverlodge	3-Sep-19	SAMPLE #2	0.05	-
Fall	Town of Beaverlodge	4-Sep-18	SAMPLE #2	0.05	-
Fall	Town of Beaverlodge	14-Sep-17	SAMPLE #2	0.02	-

Spring Summary	99%	8.22	1.64
	n	14	10
	median	5.54	1.42

Fall Summary	99%	0.05	
	n	3	
	median	0.05	

* AE data calculated as average of outfall and duplicate samples

Input Parameter	Total Ammonia (Spring)	Total Phosphorus (Spring)	Total Ammonia (Fall)	Total Phoshporus (fall)	Total Ammonia (Spring)	Total Phosphorus (Spring)	Total Ammonia (Fall)	Total Phosphorus (fall)
	10% of Median Flow - Spring		10% of Median Flow - Fall		10% of June 3 flow and June 3 effluent concentration		10% of 10th percentile flow	
River flow (L/s)	237	2370	1.8	18	1030	10300	0.01	0.1
River concentration us (mg/L)	0.272	0.237	0.056	0.045	0.2715	0.237	0.0562	0.045
River load (mg/s)	64	562	0.10	0.81	280	2441	0.0006	0.0045
Effluent flow (L/s)	164	164	117	117	164	164	117	117
Effluent concentration (mg/L)	8.22	1.64	0.05	1.64	5.275	1.395	0.05	1.64
Effluent load (mg/s)	1349	270	6	192	866	229	6	192
Downstream flow (L/s)	401	2534	119	135	1194	10464	117	117
Downstream load (mg/s)	1413	832	6.0	193	1145	2670	5.8495	192.3876
Downstream concentration (mg/L)	3.52	0.33	0.05	1.43	0.959	0.255	0.050	1.643
Downstream un-ionized ammonia (mg/L)	0.028		0.001		0.008		0.001	
Guideline	1.9		0.6		1.9		0.6	
WQBEL Load	678		75		1929		74	
WQBEL	4		1		12		1	

APPENDIX B – DESIGN CALCULATIONS (BOD REMOVAL PERFORMANCE)

				Note
		Spring	Fall	
Design Year		2045	2045	
Design flow	m3/d	2,005	2,005	
Influent				
BOD Concentration	mg/L	200	200	AESRD Guideline for Aerated Lagoon Design
BOD Load	kg/d	401	401	
Anaerobic Cell				
Influent BOD Concentration	mg/L	200	200	
Avg. BOD Removal Efficiency	%	20	30	Predominantly Sedimentaion during cold months
Effluent BOD Concentration	mg/L	160	140	
Facultative Cell				
Influent BOD Concentration	mg/L	160	140	
Influent BOD Load	kg/d	321	281	
Area	ha	4.0	4.0	
Influent BOD Loading Rate	kg BOD/ha/d	81	71	
Partial-Mixed Plug Flow Design Calculation				
BODe/BODi = exp (-kp*t)				BODe = effluent BOD, BODi = influent BOD
kp plugflow at 20 C			0.071	
K t = K20 θ^ (t-20)				
θ			1.090	Range: 1.02 - 1.12
WW lagoon temp. (design temperature)		2.0	20.0	
k partial mix at deign temperature			0.071	
Detention time		30	30	
Removal Efficiency	%	20	88	Sedimentation during cold months
Effluent BOD Concentration	mg/L	128	17	
Aerated Cell (Cell #1)				
Influent BOD Concentration	mg/L	128	17	
Influent BOD Load	kg/d	257	34	
Volume				
Cell #1A	m3	27,500	27,500	
Cell #1B	m3	24,750	24,750	
Total	m3	52,250	52,250	
Retention Time				
Cell #1A	d	14	14	
Cell #1B	d	12	12	
Total	d	26	26	
Partial-Mixed Plug Flow Design Calculation				
BODe/BODi = 1 / (1+kt)				BODe = effluent BOD, BODi = influent BOD
k partial mix at 20 C		0.276	0.276	
K t = K20 θ ^(t-20)				
θ		1.024	1.024	Range: 1.02 - 1.12
WW lagoon temp. (design temperature)	C	2.0	20.0	
k partial mix at deign temperature		0.18	0.28	
Cell #1A effluent cBOD	mg/L	37	4	
Cell #1B effluent cBOD	mg/L	11	0.8	
Effluent				
BOD Concentration	mg/L	11	1	Less than 25 mg/L
BOD Load	kg/d	22.9	1.6	

APPENDIX B - ALBERTA TRANSPORTATION - PRELIMINARY DRAWINGS OF THE FUTURE HWY 43 CORRIDOR

BEAVERLODGE - CN BYPASS

ARA ENGINEERING
CONSULTING ENGINEERS

Title Sheet and Drawing List

PLAN No.	DRAWING TITLE
SITE - GENERAL	
00-CT000	Cover Sheet and Drawing List
00-CT001	Layout Plan
00-CT101	Plan/Profile Sta. 0+000 to Sta. 0+900
00-CT102	Plan/Profile Sta. 0+900 to Sta. 2+400
00-CT103	Plan/Profile Sta. 2+400 to Sta. 3+800
00-CT104	Plan/Profile Sta. 3+800 to Sta. 5+300
00-CT105	Plan/Profile Sta. 5+300 to Sta. 6+559.57
00-CT201	Yard Track Profiles
00-CT301	Cross Sections Sta. 0+000 to Sta. 1+560
00-CT302	Cross Sections Sta. 1+590 to Sta. 3+330
00-CT303	Cross Sections Sta. 3+360 to Sta. 5+280
00-CT304	Cross Sections Sta. 5+310 to Sta. 6+540
00-CT401	Typical Sections
00-CT701	Proposed Crossing - New Mile 78.17

SITE DEVELOPMENT

CN GRANDE PRAIRIE SUBDIVISION,
MILE 77.60 to MILE 80.15
ALBERTA SERVICE AREA

PRELIMINARY

MAY 6, 2011

AECOM PROJECT NO. - 60188683

Issue Date:

AECOM

Set No.:

PROJECT NUMBER	PLAN NUMBER	ISSUE/REVISION
60188683	00-CT000	

AECOM FILE NAME: 60188683-00-CT0000.dgn

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
LAYOUT PLAN

Government of Alberta Transportation

CONSULTANT

JOB No. 60188683 | PLAN No. CT0001

ARA ENGINEERING CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE

DESIGNER — DATE

CHECKER — DATE

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00:02		1 of 1

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

BAR CODE

PLAN No. | CONTRACT No. | SITE No.

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

BY	DATE
HRZ	FEB 2011
KLB	MAY 2011
BLC	APRIL 2011

SURVEYED / DESIGNED / CHECKED / DRAWN

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09

PLAN DESCRIPTION
HWY 43:00 & 02
S. of TWP RD 723 to N. of HWY 723

CONSULTANT
JOB No. 60188683 | PLAN No. CT101

ARA ENGINEERING
CONSULTING ENGINEERS
AECOM

PERMIT TO PRACTICE

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

DESIGNER
CHECKER

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
PLAN/PROFILE

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		1 of 5

No	DATE	BY	REVISION
1	2011.05.09	PSL	ISSUED FOR AT PRELIMINARY DESIGN REVIEW

	DATE	BY
SURVEYED		
DESIGNED	FEB 2011	HRZ
CHECKED	MAY 2011	KLB
DRAWN	APRIL 2011	BLC

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

PLAN No. | CONTRACT No. | SITE No.

BAR CODE

CONSULTANT

JOB No. 60188683 | PLAN No. CT102

ARA ENGINEERING
CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

DATE ________ DATE ________

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
PLAN/PROFILE

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		2 of 5

Government of Alberta ■
Transportation

HORIZONTAL
VERTICAL

PLAN DESCRIPTION
HWY 43:00 & 02
S. of TWP RD 723 to N. of HWY 723

BAR CODE

PLAN No. | CONTRACT No. | SITE No.

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

DATE	BY	
FEB 2011	HRZ	SURVEYED
MAY 2011	KLB	DESIGNED
APRIL 2011	BLC	CHECKED
		DRAWN

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09


HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
PLAN/PROFILE
Government of Alberta
Transportation
CONSULTANT
JOB No. 60188683
PLAN No. CT103
ARA ENGINEERING
CONSULTING ENGINEERS
AECOM
PERMIT TO PRACTICE
DESIGNER
CHECKER
PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011
REGION PEACE
PLAN No.
PROJECT Hwy 43:00/02
CONTRACT No.
SHEET 3 of 5
PLAN DESCRIPTION
HWY 43:00 & 02
S. of TWP RD 723 to N. of HWY 723
BAR CODE
ISSUED FOR AT PRELIMINARY DESIGN REVIEW
TO HYTHE & DAWSON CREEK
FROM GRANDE PRAIRIE
SEE CT104
SEE CT103
MATCH LINE STA. 3+800
MATCH LINE STA. 2+400
PROPOSED R/W
PROPOSED HIGHWAY 43
PROPOSED CUT/FILL LINE
PROPOSED DITCH
℄ PROPOSED CN MAIN TRACK
SE3 72-10-6
SW3 72-10-6
NE36 72-10-6
NW35 72-10-6
Twp Rd 720
Rge Rd 102
CURVE 6
DELTA = 41°01'13.234"
D = 1°22'50"
Lc = 896.215
R = 1265.000
Ls = 9.45
CURVE 5
DELTA = 10°07'11.200"
D = 3°0'
Lc = 83.931
R = 582.192
Ls = 18.90
SC 3+387.03
TS 3+377.58
ST 2+664.22
CS 2+645.33
SC 2+561.40
TS 2+542.50
713.441
712.796
712.151
711.506
710.861
710.181
709.481
708.781
708.080
707.380
706.680
705.980
705.374
704.794
704.917
Ls 9.449
Ls 18.898
R -582.192
VPI 3+362.581
EL 710.398
VPI 2+679.224
EL 705.613
VPI 2+460.588
EL 704.344
STA 2+534.0597
EL 704.77
STAGE 1 HWY 722 GRADE CROSSING
STA 2+447.423
EL 704.433
ULTIMATE HWY 722 OVERPASS
PROPOSED CN MAIN TRACK
TOP OF RAIL
EXISTING GROUND
SOUTH DITCH
NORTH DITCH
PROPOSED CULVERT
L 30.000
L 47.600
0.700%
0.580%
-0.580%
730
720
710
700
690
3+800
3+600
3+400
3+200
3+000
2+800
2+600
2+400

CONSULTANT

JOB No. 60188683 | PLAN No. CT104

ARA ENGINEERING CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
PLAN/PROFILE

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		4 of 5

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

No.	REVISION	BY	DATE
	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09

	BY	DATE
SURVEYED	HRZ	FEB 2011
DESIGNED	KLB	MAY 2011
CHECKED	BLC	APRIL 2011
DRAWN		

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
PLAN/PROFILE

Government of Alberta ■ Transportation

CONSULTANT: ARA ENGINEERING CONSULTING ENGINEERS / AECOM

JOB No. 60188683 | PLAN No. CT105

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		5 of 5

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

DATE	BY	
FEB 2011	HRZ	SURVEYED
MAY 2011	KLB	DESIGNED
APRIL 2011	BLC	CHECKED
		DRAWN

No	DATE	BY	REVISION
1	2011/05/09	PSL	ISSUED FOR AT PRELIMINARY DESIGN REVIEW

CONSULTANT

JOB No. 60188683 | PLAN No. CT201

ARA ENGINEERING CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

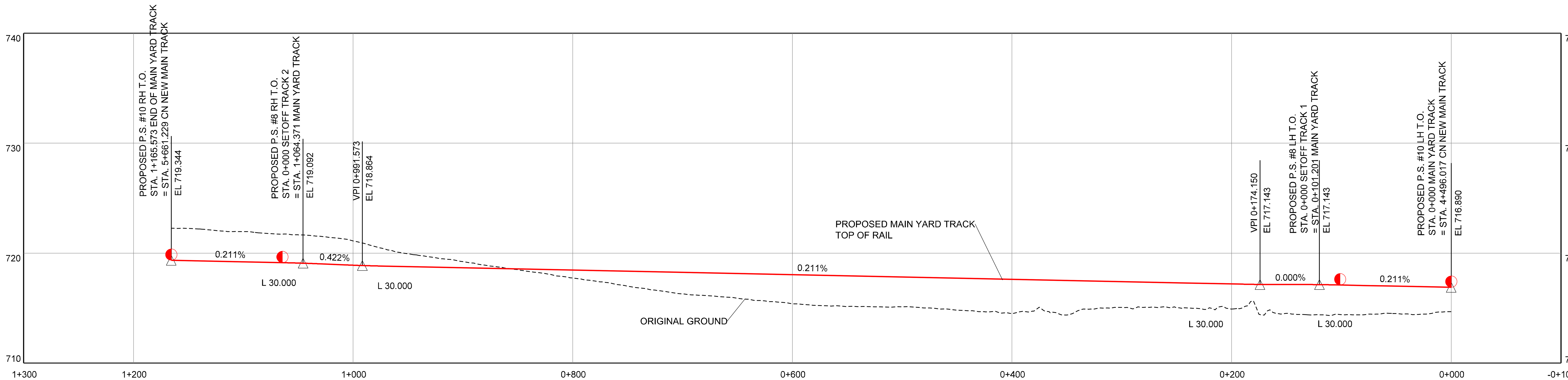
DATE ______ DATE ______

HWY 43 S. of TWP 723 RD to E. of HWY 723 BEAVERLODGE CN BYPASS CN GRANDE PRAIRIE SUBDIVISION Mi 77.60 to Mi 80.15 YARD TRACK PROFILES

Government of Alberta ■ Transportation

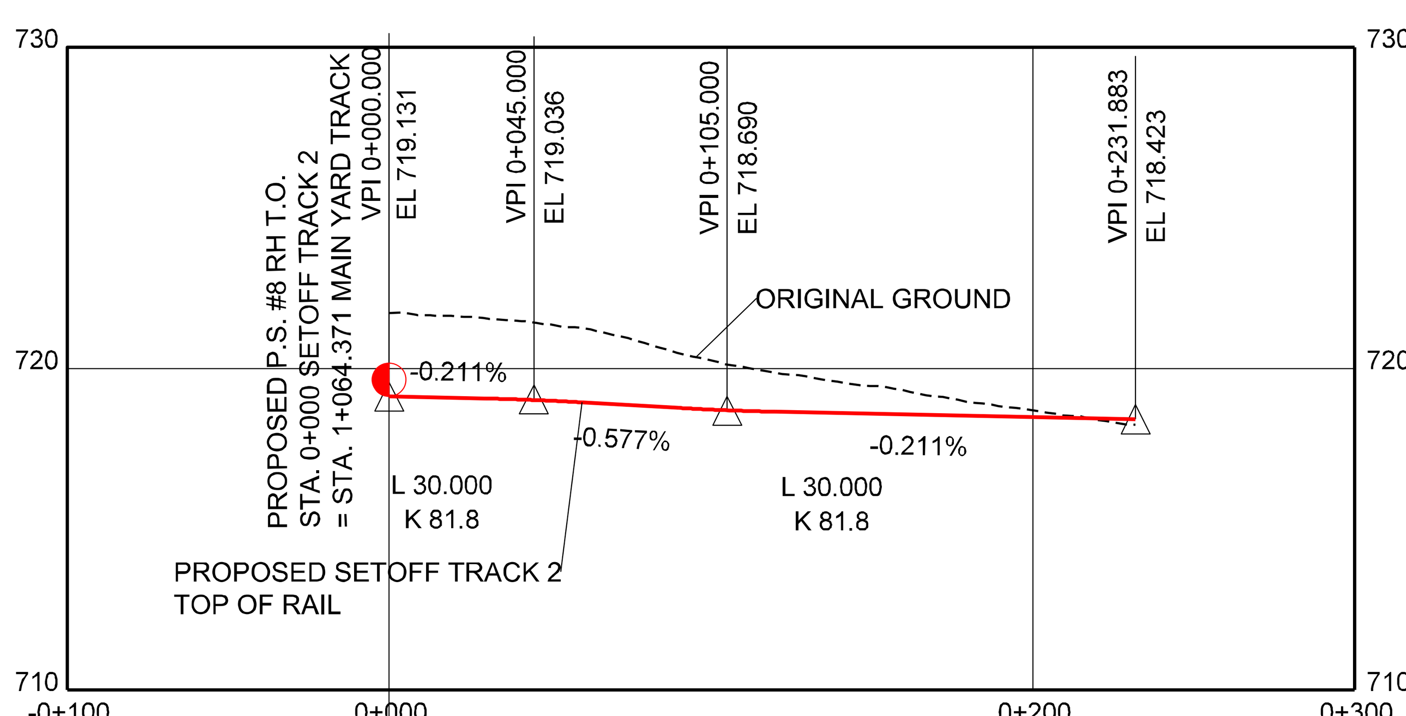
REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		1 of 1

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723 YARD TRACK PROFILES



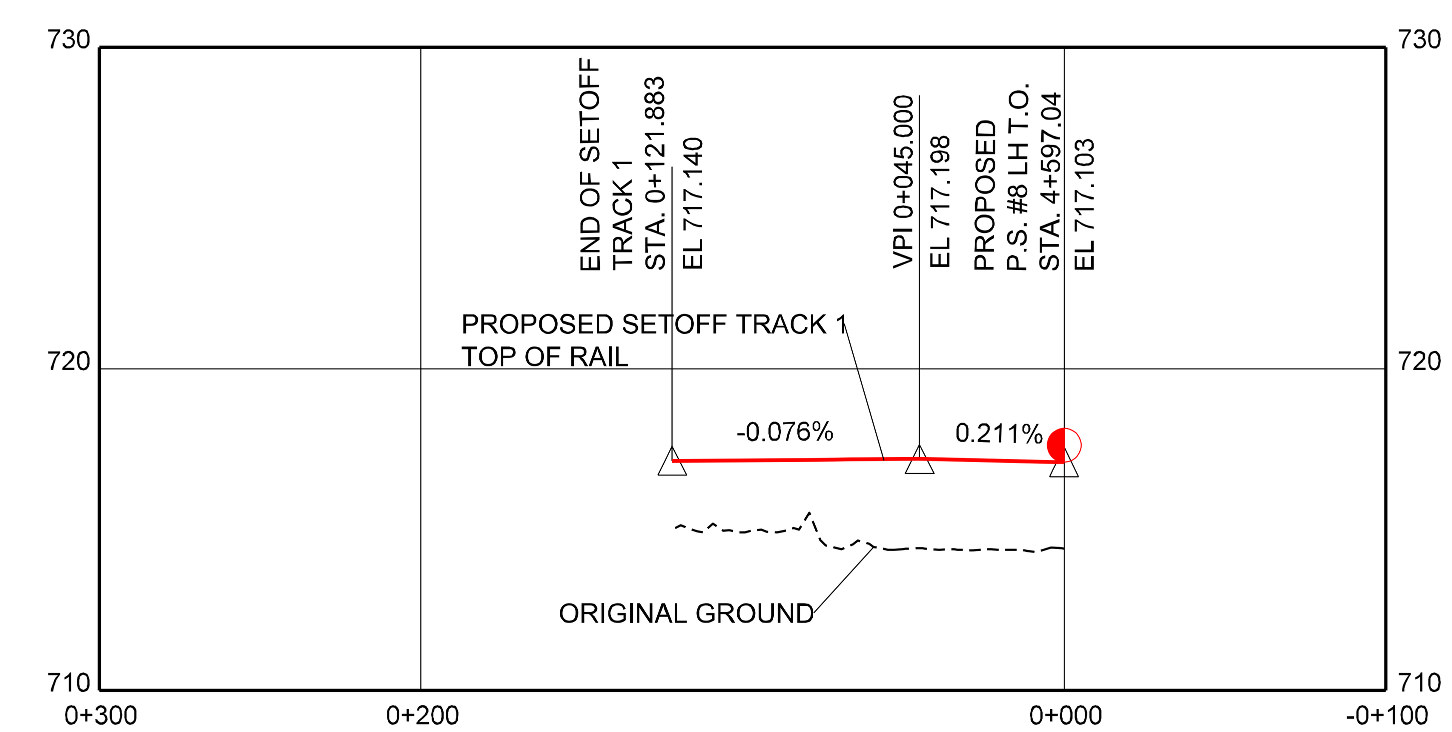
R -291.196 R -291.196	CURVATURE
721.96 719.425 721.11 718.824 719.23 718.415 717.74 718.204 716.30 717.994 715.40 717.783 715.11 717.573 714.48 717.362 715.07 717.152 714.91 717.049 714.40 717.259 714.67 717.109	PROPOSED

MAIN YARD TRACK



CURVATURE	R -184.040
EXISTING	721.73 720.25 718.70

SETOFF TRACK 2



R -184.040	CURVATURE
717.046 717.257	PROPOSED

SETOFF TRACK 1

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09

	BY	DATE
SURVEYED		
DESIGNED	HRZ	FEB 2011
CHECKED	KLR	MAY 2011
DRAWN	BLC	APRIL 2011

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

PLAN No. | CONTRACT No. | SITE No.

BAR CODE

HWY 43:00 & 02
S. of TWP RD 723 to N. of HWY 723

PLAN DESCRIPTION

BAR CODE

PLAN No.	CONTRACT No.	SITE No.
PHOTO No.	TITLE SEARCH DATE	GRAPHICS FILE

	DATE	BY
SURVEYED	FEB. 2011	HRZ
DESIGNED	MAY 2011	KLB
CHECKED	APRIL 2011	BLC
DRAWN		

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09

CONSULTANT

JOB No. 60188683 | PLAN No. CT301

ARA ENGINEERING
CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE

DESIGNER

CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

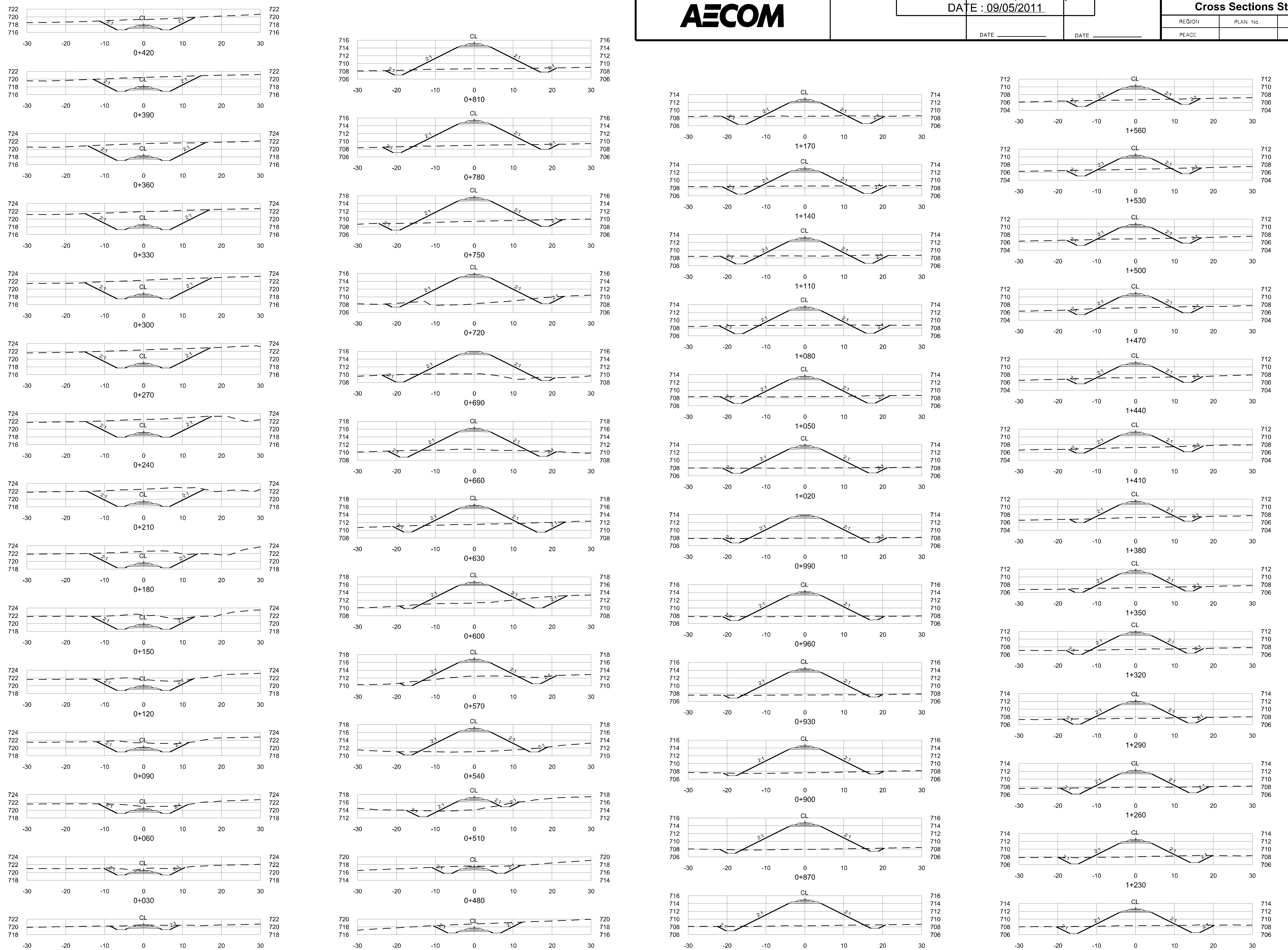
DATE ________ DATE ________

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
Cross Sections Sta. 0+000 to Sta. 1+560

Government of Alberta ■
Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		1 of 4

HORIZONTAL
VERTICAL



CONSULTANT

JOB No. 60188683 | PLAN No. CT302

ARA ENGINEERING
CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

DATE ____ DATE ____

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
Cross Sections Sta. 1+590 to Sta. 3+330

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		2 of 4

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

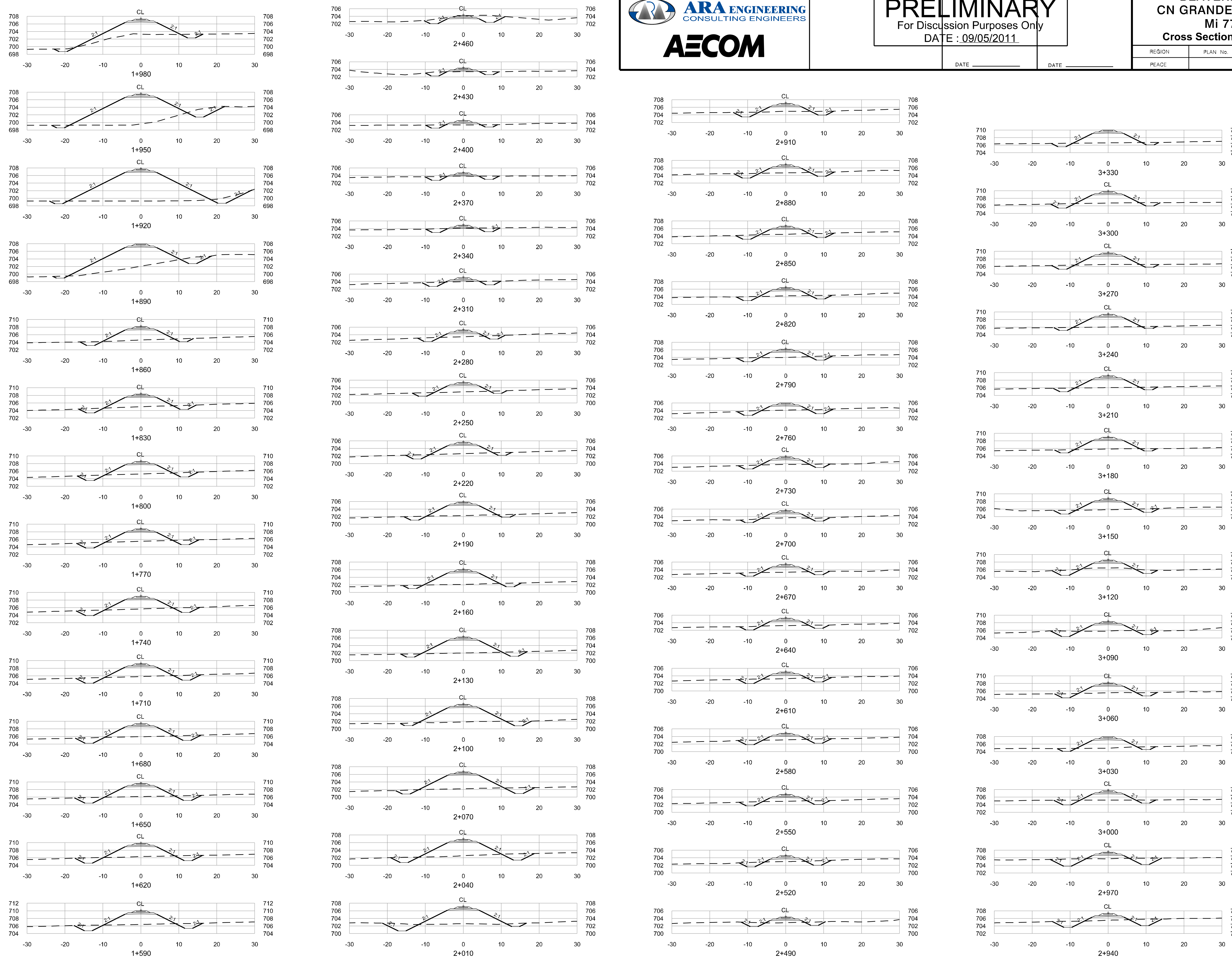
BAR CODE

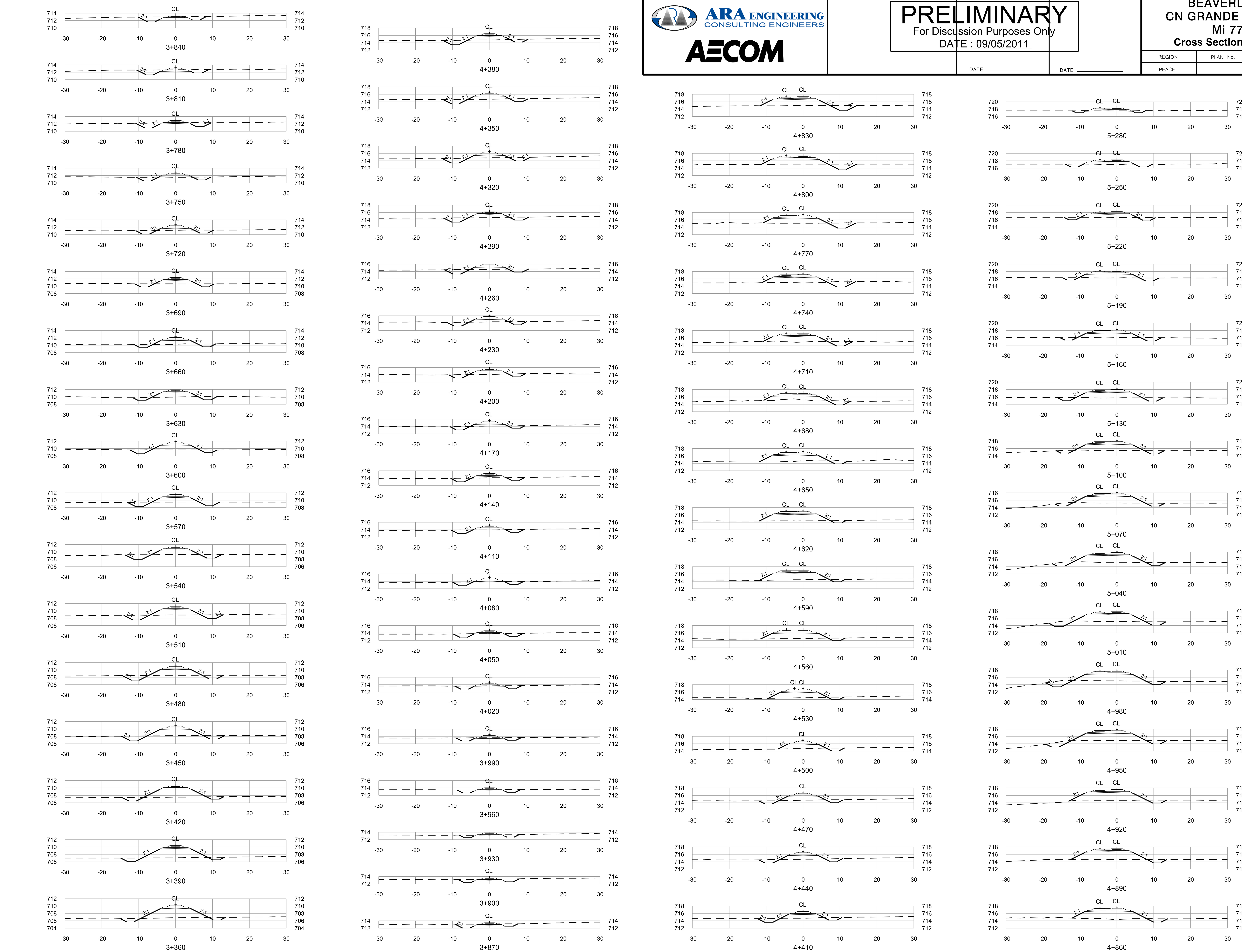
PLAN No. | CONTRACT No. | SITE No.

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

DATE	BY	
FEB 2011	HRZ	SURVEYED
MAY 2011	KLB	DESIGNED
APRIL 2011	BLC	CHECKED
		DRAWN

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09





CONSULTANT	
JOB No. 60188683	PLAN No. CT303

ARA ENGINEERING
CONSULTING ENGINEERS
AECOM

PERMIT TO PRACTICE

DESIGNER — DATE ____

CHECKER — DATE ____

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
Cross Sections Sta. 3+360 to Sta. 5+280

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		3 of 4

Government of Alberta ■
Transportation

HORIZONTAL
VERTICAL

PLAN DESCRIPTION
HWY 43:00 & 02
S. of TWP RD 723 to N. of HWY 723

BAR CODE

PLAN No.	
CONTRACT No.	
SITE No.	

PHOTO No.	
TITLE SEARCH DATE	
GRAPHICS FILE	

	BY	DATE
SURVEYED		
DESIGNED	HRZ	FEB 2011
CHECKED	KLB	MAY 2011
DRAWN	BLC	APRIL 2011

No.	REVISION	BY	DATE
4			
3			
2			
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
Cross Sections Sta. 5+310 to Sta. 6+540

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00/02		4 of 4

CONSULTANT

JOB No. 60188683 | PLAN No. CT304

ARA ENGINEERING CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

DATE ________ DATE ________

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

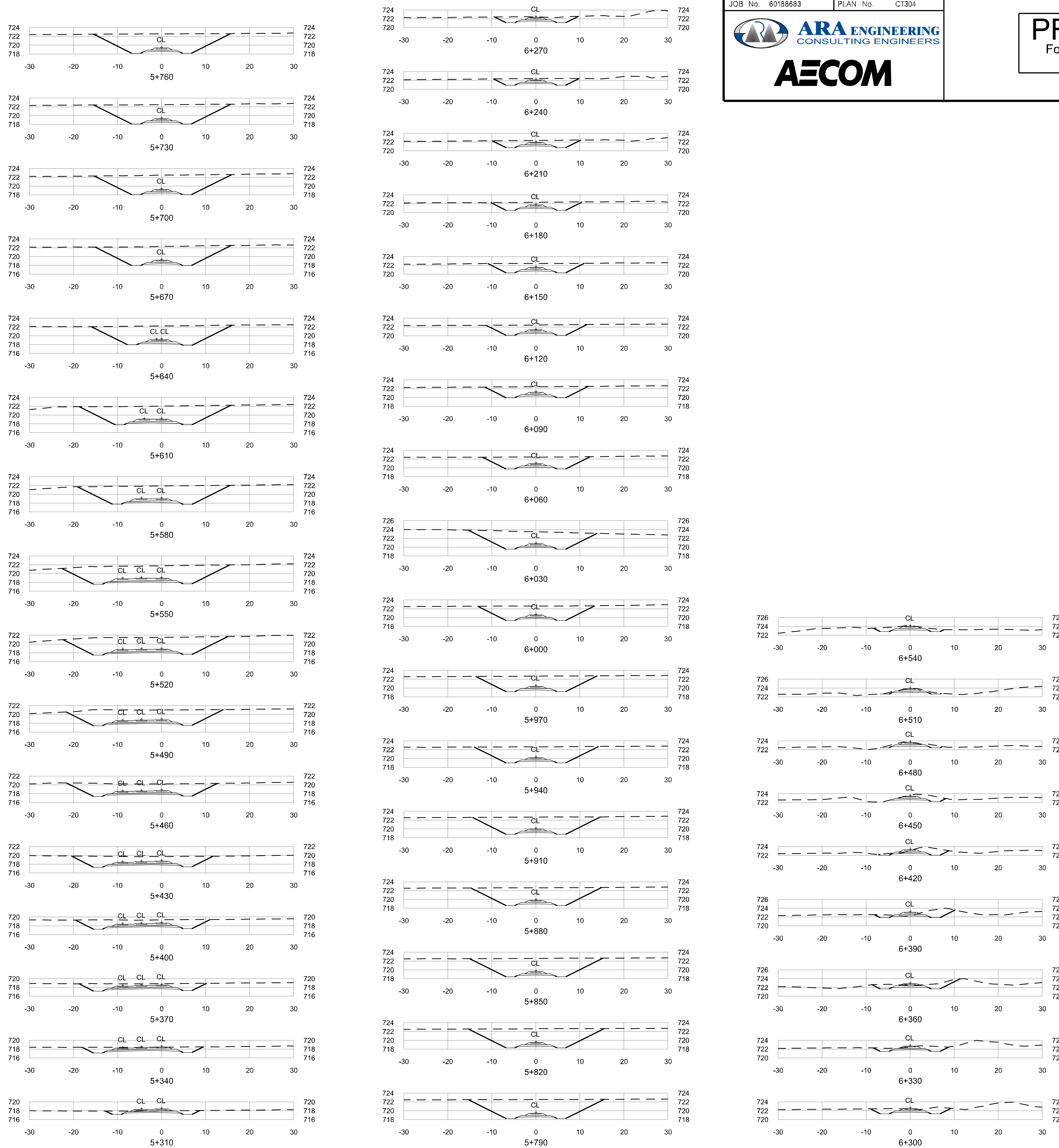
BAR CODE

PLAN No. | CONTRACT No. | SITE No.

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

	DATE	BY
SURVEYED	FEB 2011	HRZ
DESIGNED	MAY 2011	KLB
CHECKED	APRIL 2011	BLC
DRAWN		

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09



CONSULTANT

JOB No. 60188683 | PLAN No. CT401

ARA ENGINEERING CONSULTING ENGINEERS

AECOM

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 09/05/2011

DATE ______ DATE ______

HWY 43 S. of TWP 723 RD to E. of HWY 723
BEAVERLODGE CN BYPASS
CN GRANDE PRAIRIE SUBDIVISION
Mi 77.60 to Mi 80.15
TYPICAL SECTIONS

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE		Hwy 43:00:02		1 of 1

Government of Alberta ■ Transportation

NTS

PLAN DESCRIPTION: HWY 43:00 & 02 S. of TWP RD 723 to N. of HWY 723

BAR CODE

PLAN No. | CONTRACT No. | SITE No.

PHOTO No. | TITLE SEARCH DATE | GRAPHICS FILE

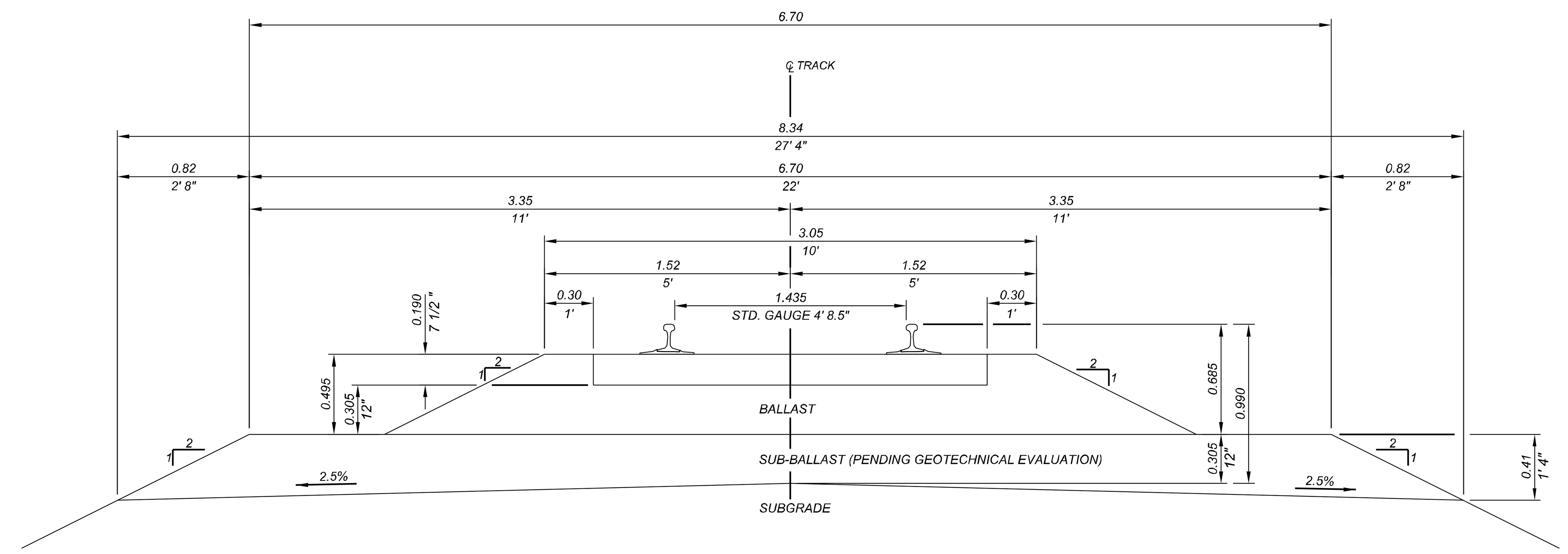
	BY	DATE
SURVEYED	HRZ	FEB 2011
DESIGNED	KLB	MAY 2011
CHECKED		
DRAWN	BLC	APRIL 2011

No.	REVISION	BY	DATE
1	ISSUED FOR AT PRELIMINARY DESIGN REVIEW	PSL	2011/05/09
2			
3			
4			

GENERAL NOTES:

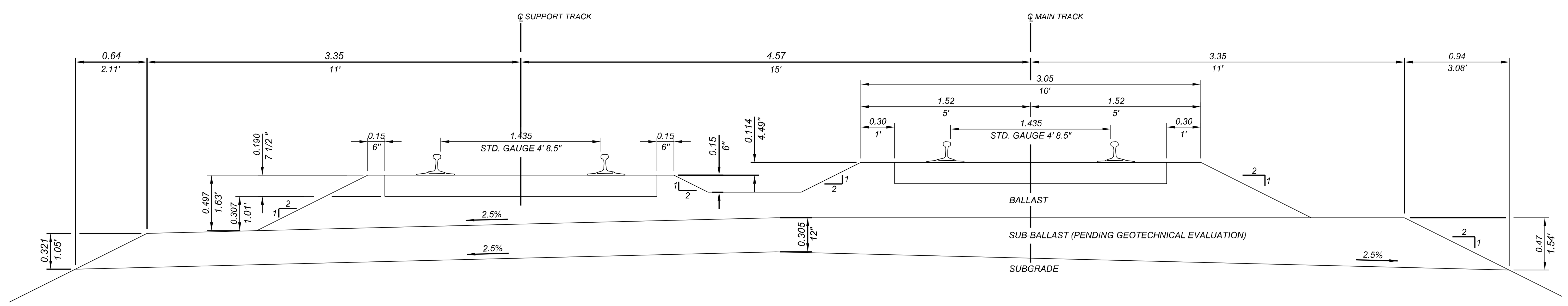
1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

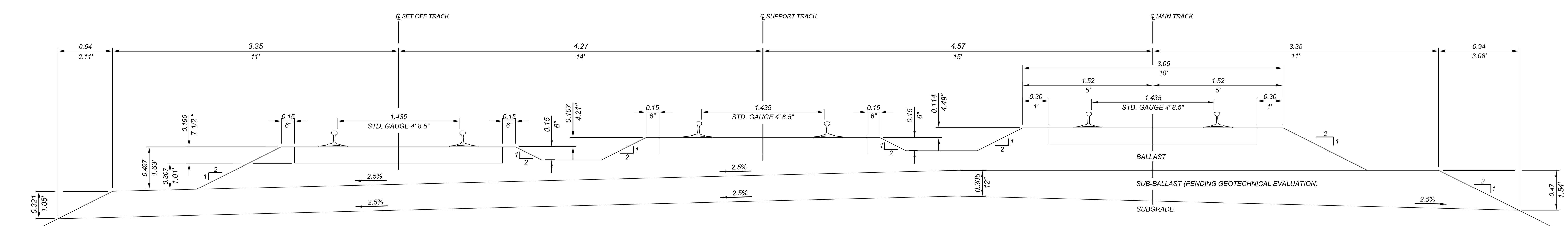
BEAVERLODGE CN MAIN TRACK



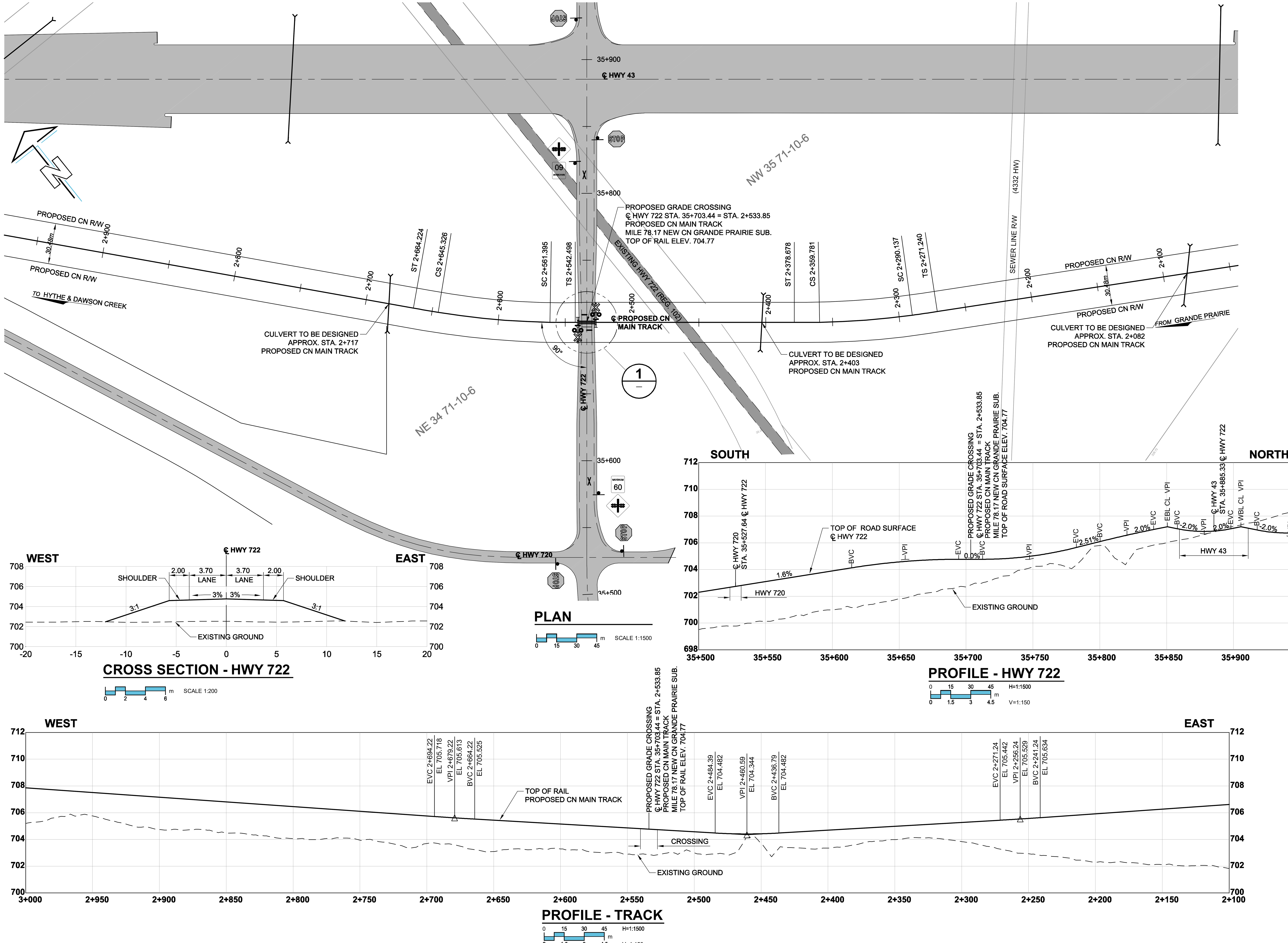
PRELIMINARY TYPICAL TRACK SECTION

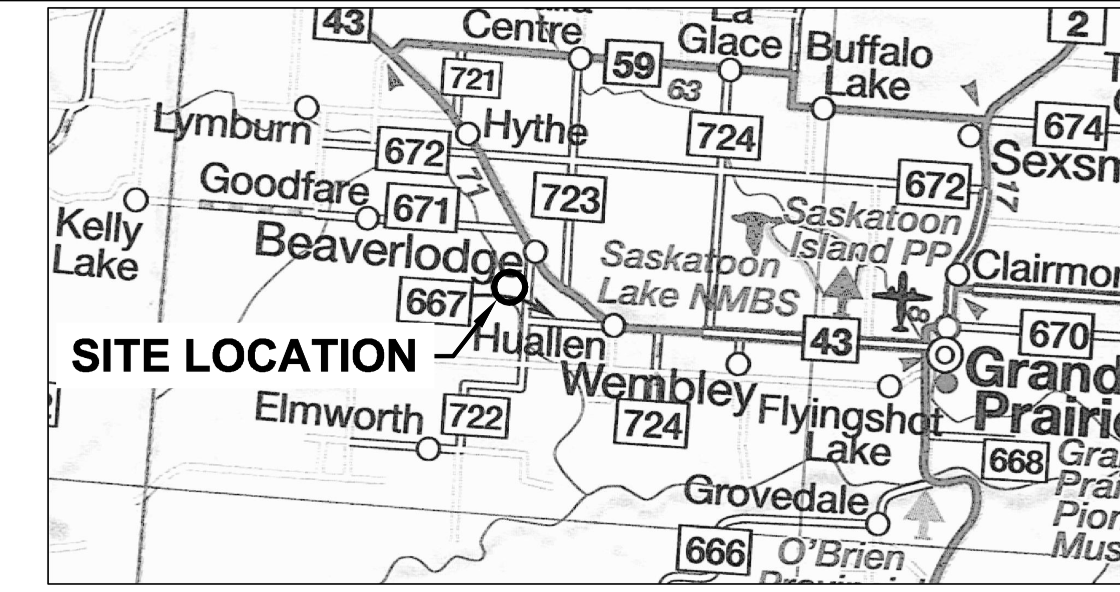
CN MAINLINE TRACK		
TYPE	INCHES	mm
RAIL (115#)	6 5/8	168
TIE PLATE (14")	7/8	22
TIE (WOOD NO.1)	7 1/2	190
BALLAST	12	305
SUBBALLAST	12	305
TOTAL	39	990





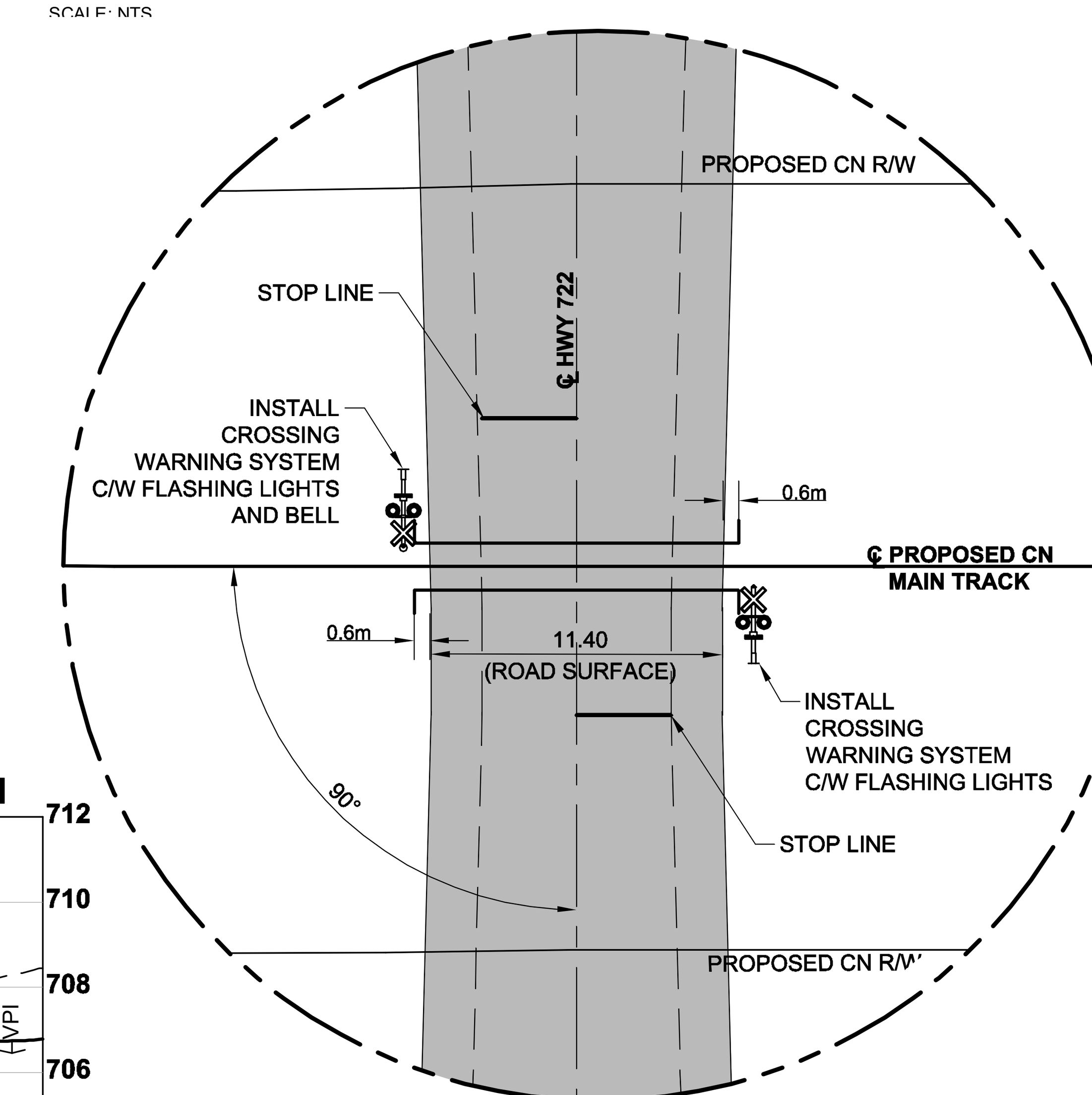
PRELIMINARY TYPICAL SECTIONS AT YARD TRACK LOCATION





LOCATION PLAN

SCALE: NTS



DETAIL

SCALE 1:250

GENERAL NOTE:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. SURVEY CONTROL IS BASED ON ASSUMED DATUM TO BE CONFIRMED.
3. CONTRACTOR IS RESPONSIBLE FOR LOCATING AND PROTECTING ALL BURIED UTILITIES WHETHER IDENTIFIED OR NOT.
4. CONSTRUCTION TO BE IN ACCORDANCE WITH CTC1980-8-RAIL.
5. RAILWAY CROSSING WARNING SYSTEM TO BE LOCATED IN ACCORDANCE WITH HIGHWAY CROSSINGS PROTECTIVE DEVICES REGULATIONS GENERAL ORDER E-6 REQUIREMENTS.
6. ALL UNDERGROUND UTILITY LOCATIONS TO BE PROTECTED AS PER TRANSPORT CANADA GENERAL ORDER E10 FOR RAILWAY LOADING AND OVERHEAD UTILITIES AS PER TRANSPORT CANADA GENERAL ORDER E11.
7. ROAD SURFACE: 7.4m ASPHALT AND 2.0m SHOULDER EACH SIDE CROSSING SURFACE: PRECAST CONCRETE PANELS WITH RUBBER RAIL SEAL CROSSING SURFACE TO EXTEND MINIMUM 0.6m BEYOND ROAD SURFACE IN BOTH DIRECTIONS.
8. VEHICLE SPEED:60 kph
9. TRAIN SPEED: 25 mph
10. ADVANCE CROSSING WARNING SIGNS AND PAVEMENT MARKING IN ACCORDANCE WITH CURRENT VERSION OF THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES.

ROAD AUTHORITY

ALBERTA TRANSPORTATION

LEGEND:

- RAILWAY CROSSING WARNING SYSTEM
- PROPOSED TRACK CENTERLINE
- PROPOSED CROSSING PLANKS
- ROAD SURFACE
- PROPOSED CULVERT

PROFESSIONAL SEALS

I/R	YY/MM/DD	ISSUE/REVISION DESCRIPTION	DRN	CHK	DES	ENG	IDR	APP
0A	11/05/10	Issued For AT Preliminary Design Review	TW	BDC	TW	KLB	PSL	-

AECOM

Alberta Transportation
Highway 722 Proposed Grade Crossing
Near Beaverlodge, AB
Mile 78.17 - CN Grande Prairie Sub. New Alignment

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60188683	00-CT701	0A

D SIZE 22" x 34" (558.8mm x 863.6mm)

PLOT: 11/05/10 12:00:01 PM

Saved By: wut

AECOM FILE NAME: 60188683-00-CT701-R0A.dwg

CONSULTANT	PERMIT TO PRACTICE	DESIGNER	CHECKER
JOB No. 210490 PLAN No. XXX			

ARA ENGINEERING
CONSULTING ENGINEERS

ISSUED FOR REVIEW

PRELIMINARY
For Discussion Purposes Only
DATE : 15/03/2011

HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723
TO E. OF HWY 723

Government of Alberta ■
Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE	210490-01	43:00/02	XXX	1 of 4

PLAN DESCRIPTION
HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723 TO E. OF HWY 723

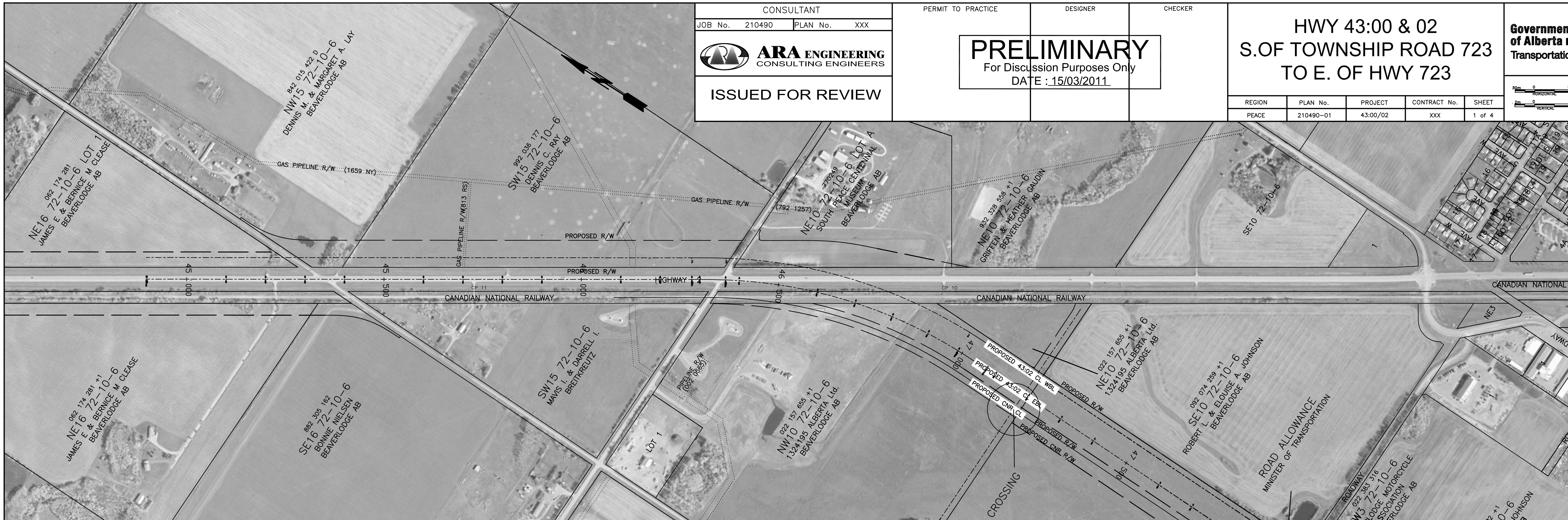
BAR CODE

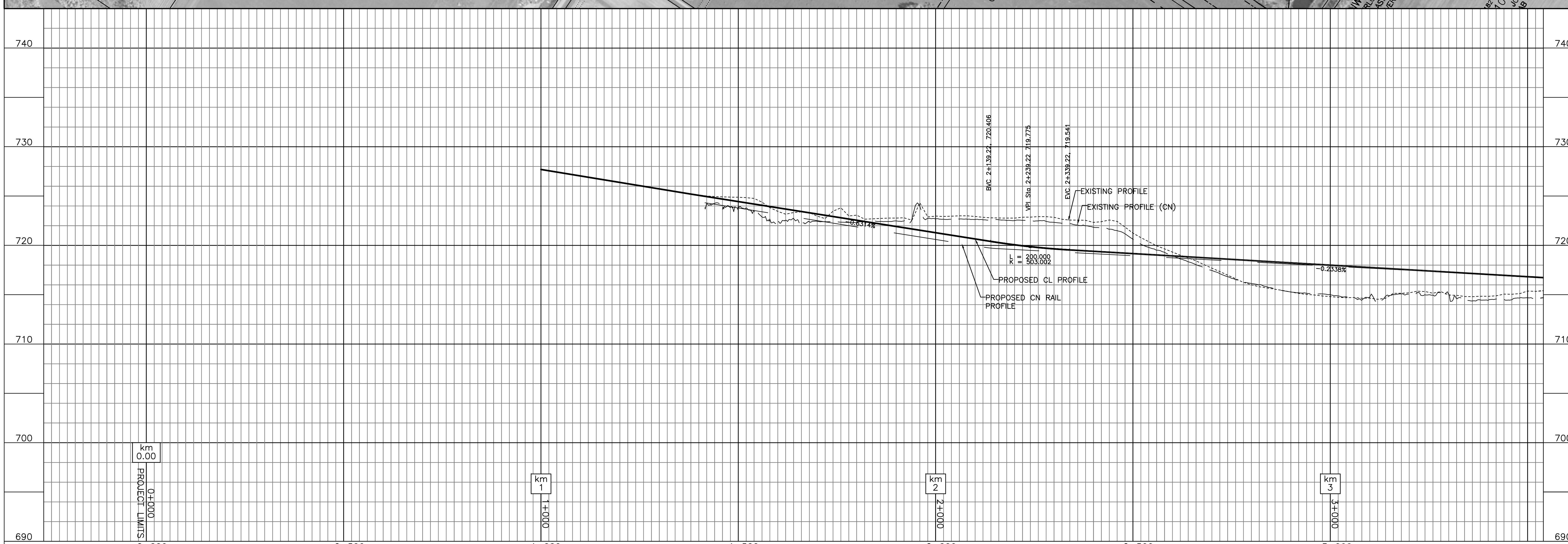
PLAN No.	XXX
CONTRACT No.	XXX
SITE No.	

PHOTO No.
TITLE SEARCH DATE
GRAPHICS FILE

	BY	DATE
SURVEYED	ARA ENG	2010
DESIGNED	D. TAYLOR	09/10
CHECKED	K. CHOUDHARY	09/10
DRAWN	P. MOK	09/10

No.	REVISION	BY	DATE





210490-01

CONSULTANT

JOB No. 210490 PLAN No. XXX

ARA ENGINEERING
CONSULTING ENGINEERS

ISSUED FOR REVIEW

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 15/03/2011

HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723
TO E. OF HWY 723

Government of Alberta
Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE	210490-02	43:00/02	XXX	2 of 4

PLAN DESCRIPTION
HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723 TO E. OF HWY 723

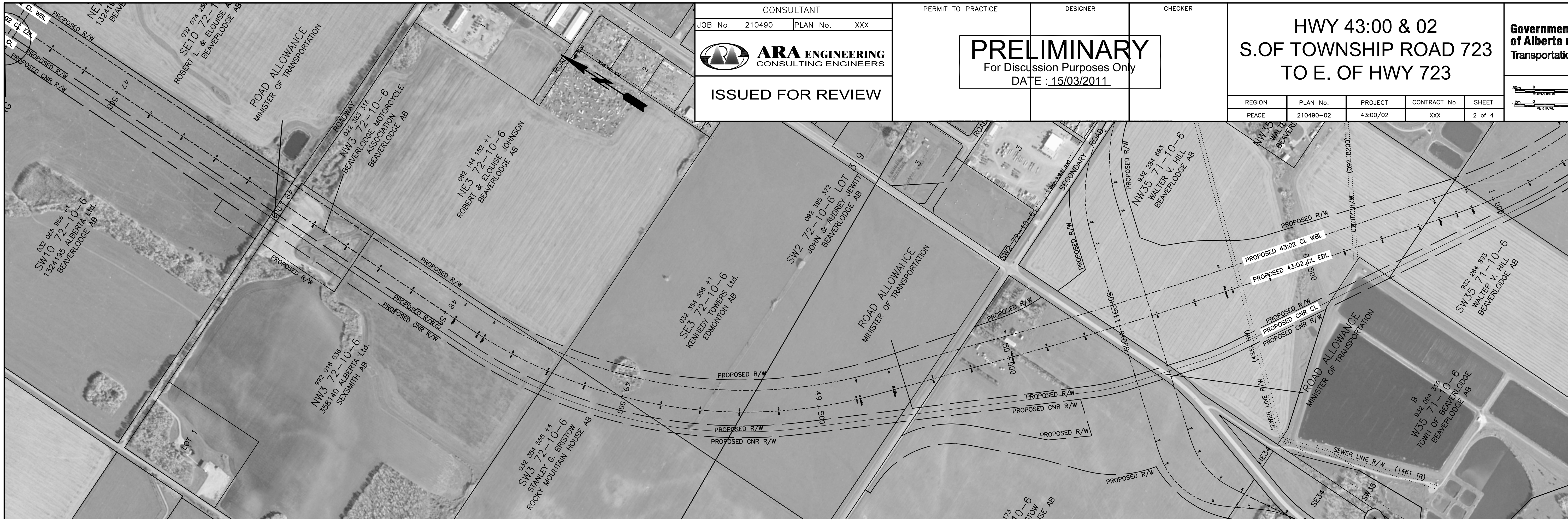
BAR CODE

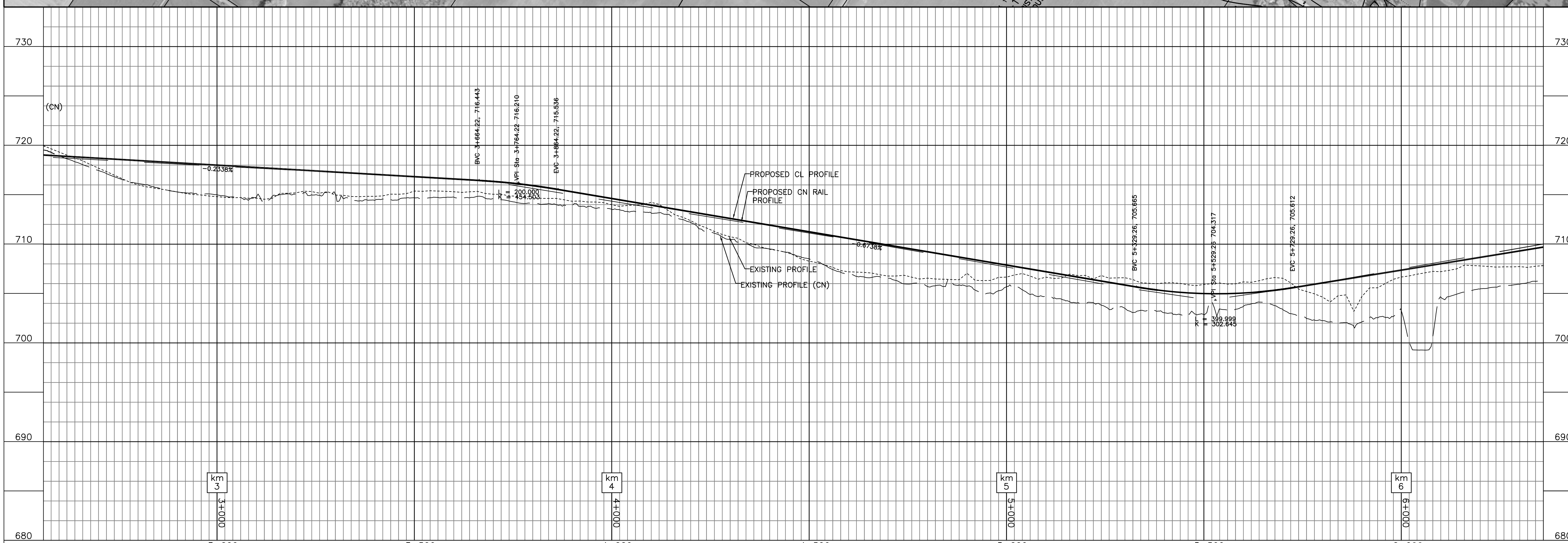
PLAN No.	XXX
CONTRACT No.	XXX
SITE No.	

PHOTO No.
TITLE SEARCH DATE
GRAPHICS FILE

	BY	DATE
SURVEYED	ARA ENG	2010
DESIGNED	D. TAYLOR	09/10
CHECKED	K. CHOUDHARY	09/10
DRAWN	P. MOK	09/10

REVISION | No. | BY | DATE





CONSULTANT	PERMIT TO PRACTICE	DESIGNER	CHECKER
JOB No. 210490 PLAN No. XXX			

ARA ENGINEERING
CONSULTING ENGINEERS

ISSUED FOR REVIEW

PRELIMINARY
For Discussion Purposes Only
DATE : 15/03/2011

HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723
TO E. OF HWY 723

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE	210490-03	43:00/02	XXX	3 of 4

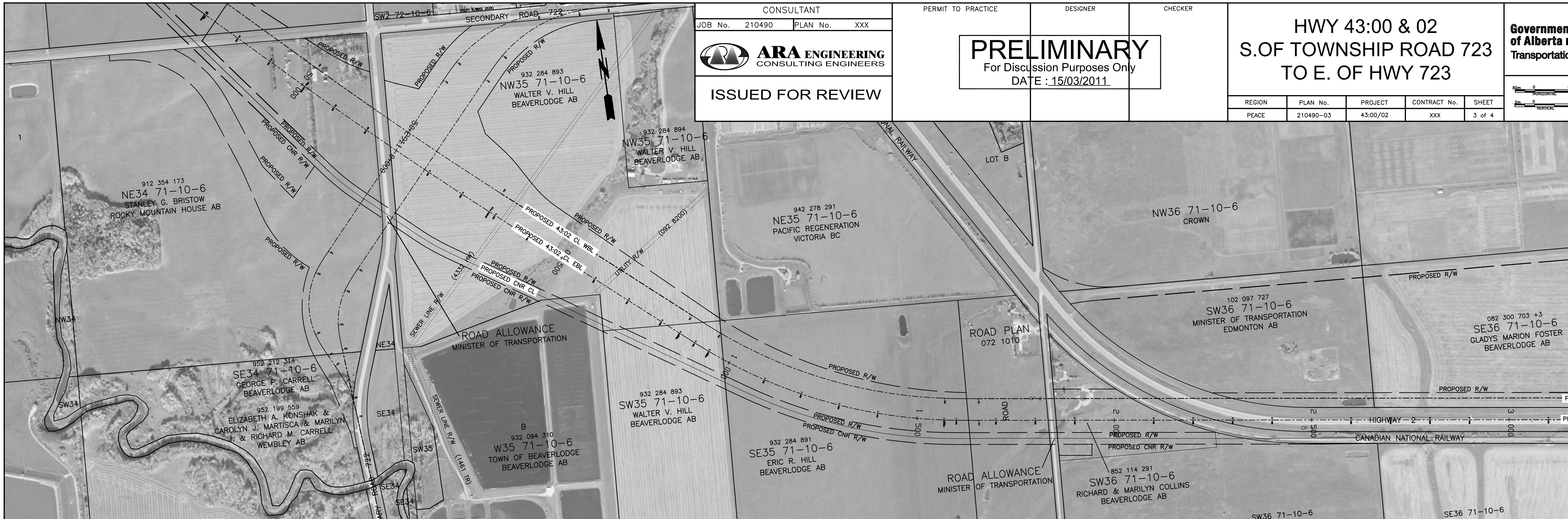
PLAN DESCRIPTION
HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723 TO E. OF HWY 723

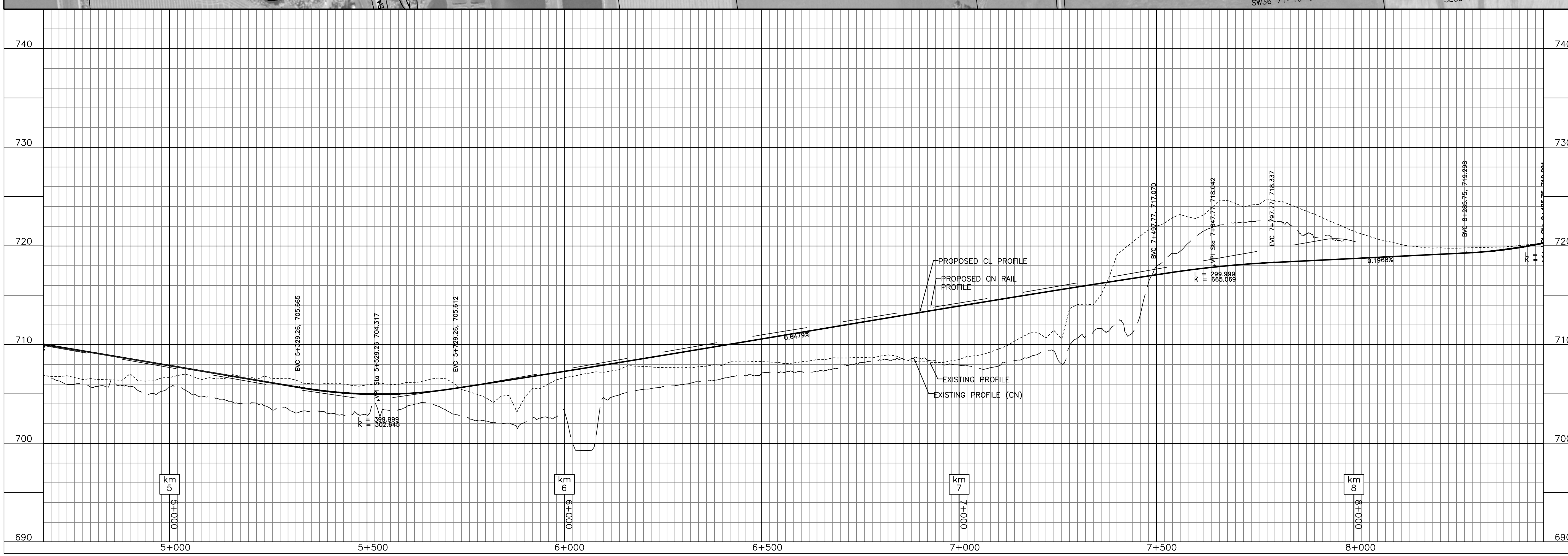
BAR CODE

PLAN No.	XXX
CONTRACT No.	XXX
SITE No.	
PHOTO No.	
TITLE SEARCH DATE	
GRAPHICS FILE	

	BY	DATE
SURVEYED	ARA ENG	2010
DESIGNED	D. TAYLOR	09/10
CHECKED	K. CHOUDHARY	09/10
DRAWN	P. MOK	09/10

No.	REVISION	BY	DATE





CONSULTANT

JOB No. 210490 PLAN No. XXX

ARA ENGINEERING
CONSULTING ENGINEERS

ISSUED FOR REVIEW

PERMIT TO PRACTICE | DESIGNER | CHECKER

PRELIMINARY
For Discussion Purposes Only
DATE : 15/03/2011

HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723
TO E. OF HWY 723

Government of Alberta ■ Transportation

REGION	PLAN No.	PROJECT	CONTRACT No.	SHEET
PEACE	210490-01	43:00/02	XXX	4 of 4

PLAN DESCRIPTION
HWY 43:00 & 02
S.OF TOWNSHIP ROAD 723 TO E. OF HWY 723

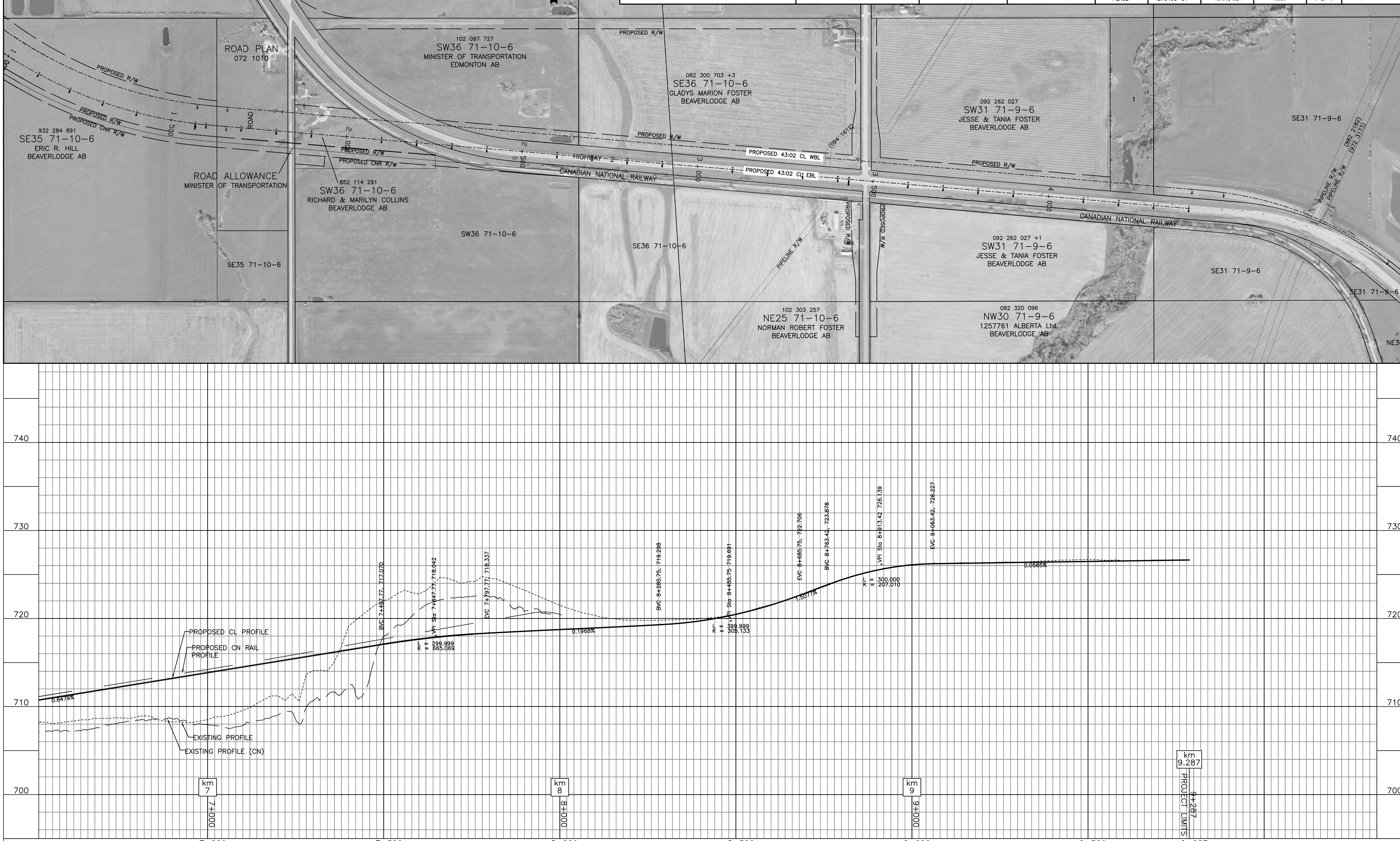
BAR CODE

PLAN No.	XXX
CONTRACT No.	XXX
SITE No.	

PHOTO No.
TITLE SEARCH DATE
GRAPHICS FILE

	BY	DATE
SURVEYED	ARA ENG	2010
DESIGNED	D. TAYLOR	09/10
CHECKED	K. CHOUDHARY	09/10
DRAWN	P. MOK	09/10

REVISION | BY | DATE | No.



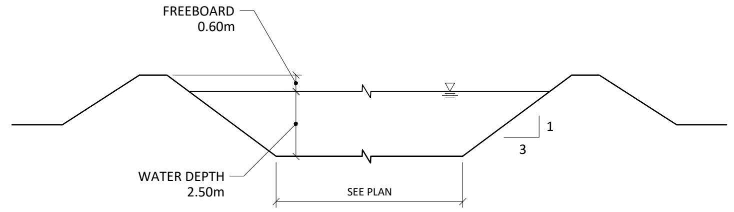
APPENDIX C - NEXOM PROPOSAL - CELL #1 AERATION SYSTEM UPGRADES

PLOT SIZE: 610mm x 914mm (24" x 36")

REDUCED SIZE PLOT - DO NOT SCALE

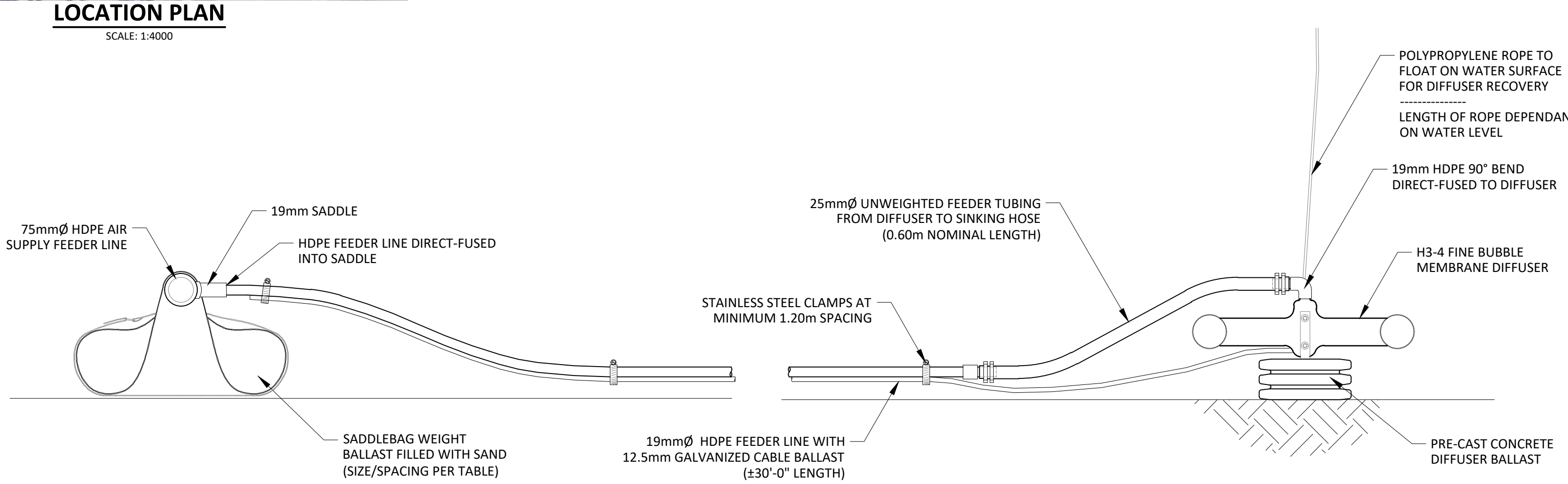
LOCATION PLAN

SCALE: 1:4000



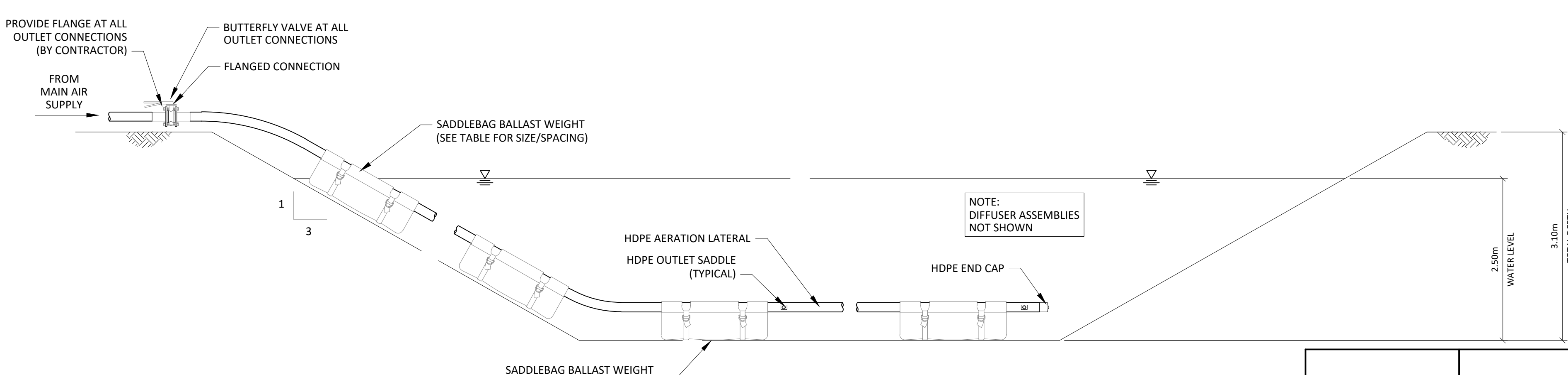
TYPICAL SECTION - CELL #2

SCALE: N.T.S.



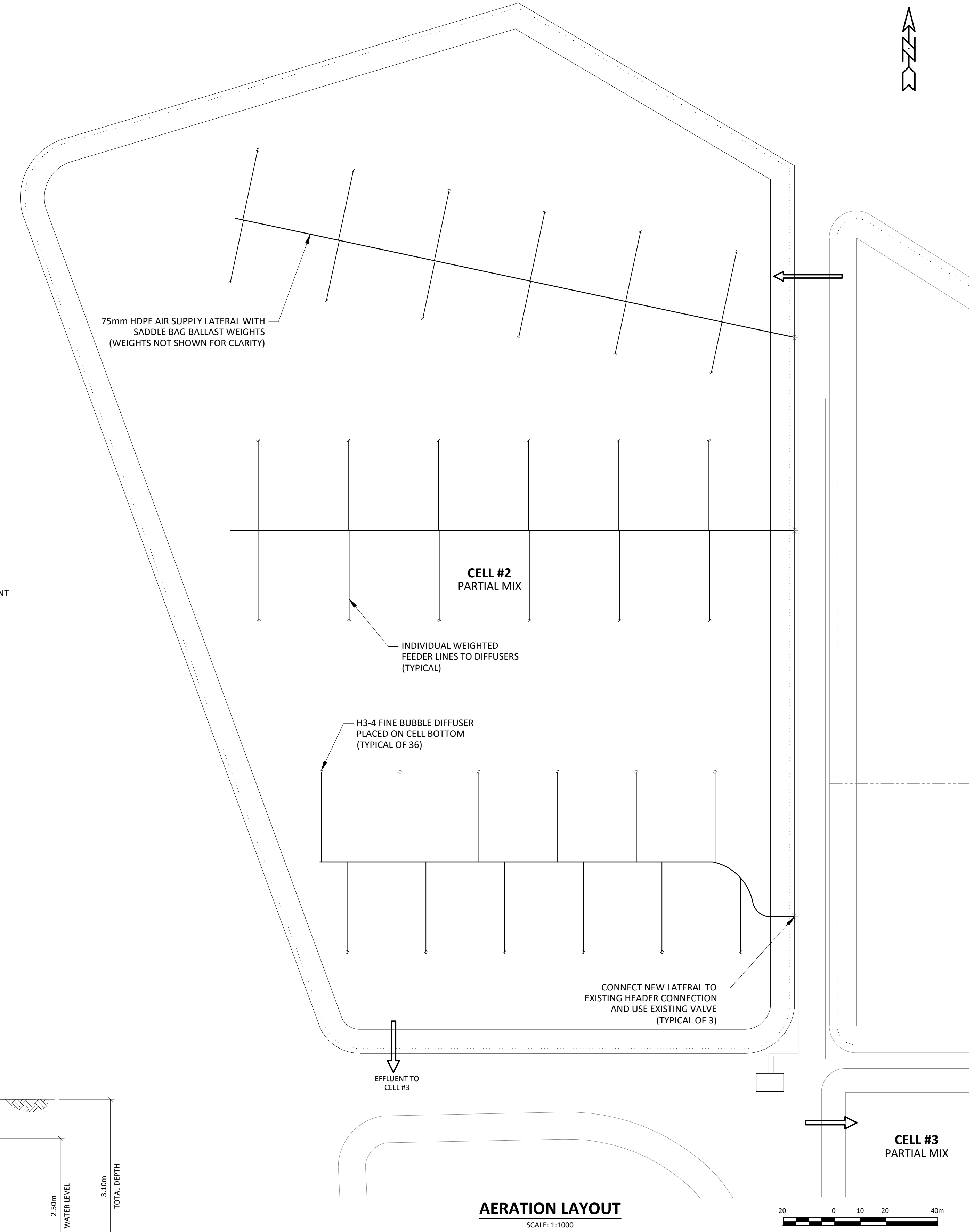
DIFFUSER DETAIL

SCALE: 1:10



AERATED LAGOON SECTION

SCALE: N.T.S.



AERATION LAYOUT

SCALE: 1:1000

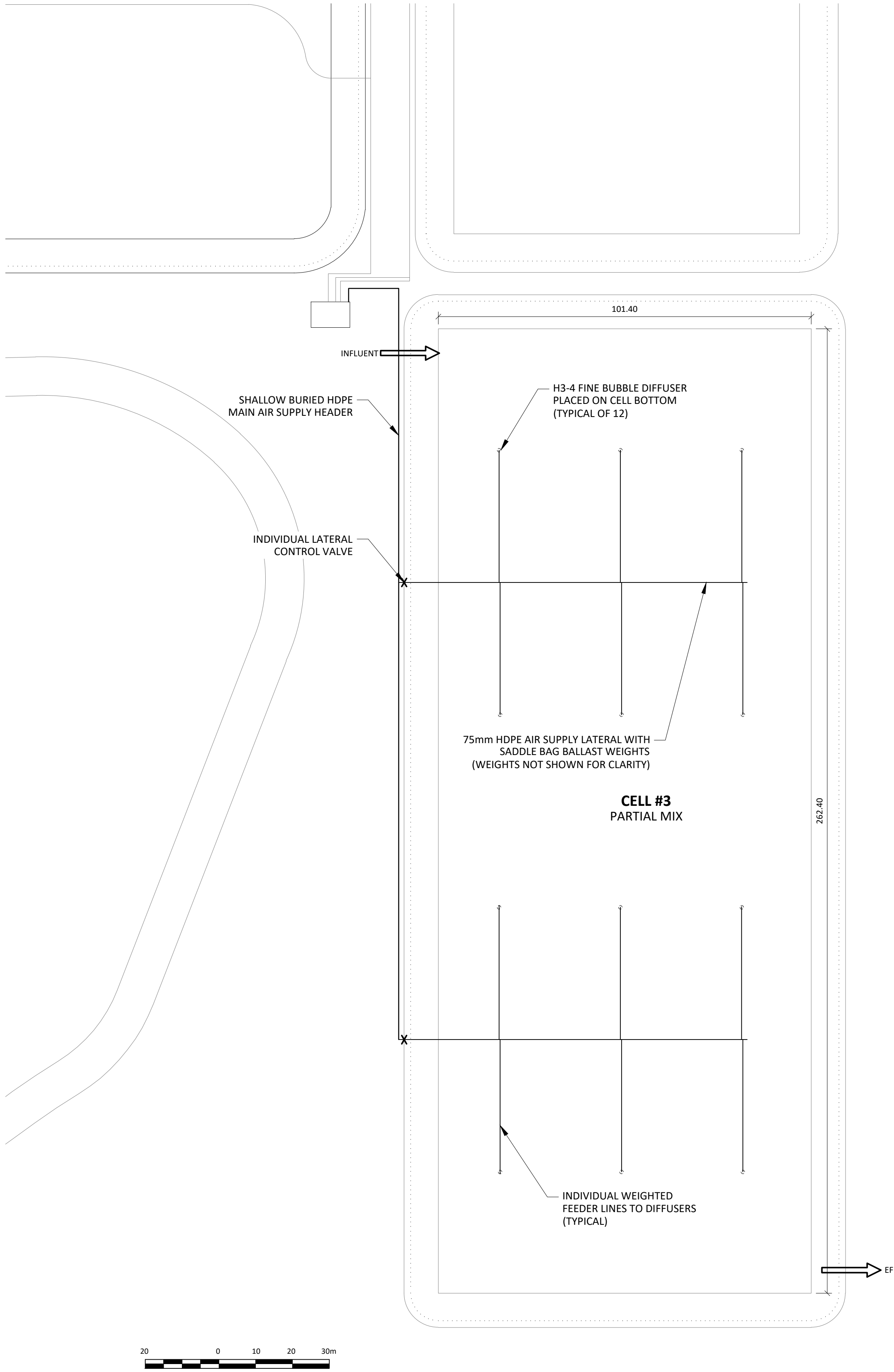
Nexom
technologies for cleaner water

5 Burks Way
Navin, Manitoba
Canada R5T 0C9
888-426-8180
www.nexom.com

PROJECT:	BEAVERLODGE LAGOON EXPANSION, AB PROPOSED WASTEWATER TREATMENT SYSTEM
TITLE:	OPTAER SYSTEM AERATION LAYOUT CELL #2 & #3, TYPICAL SECTION, LOCATION PLAN
DRAWN BY:	MR
APPROVED BY:	DK
SCALE:	AS NOTED
DATE:	2022/02/23
FILE #	CD10582.02
DRAWING NO.	NE02
SHT.	2 of 4
REV.	0

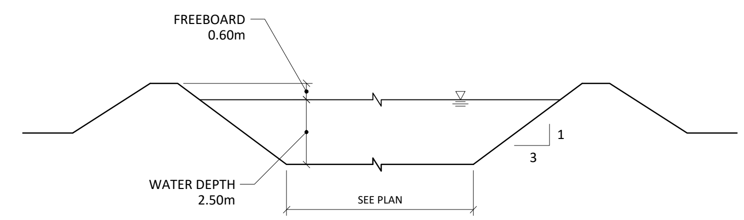
PLOT SIZE: 610mm x 914mm (24" x 36")

REDUCED SIZE PLOT - DO NOT SCALE



AERATION LAYOUT

SCALE: 1:800

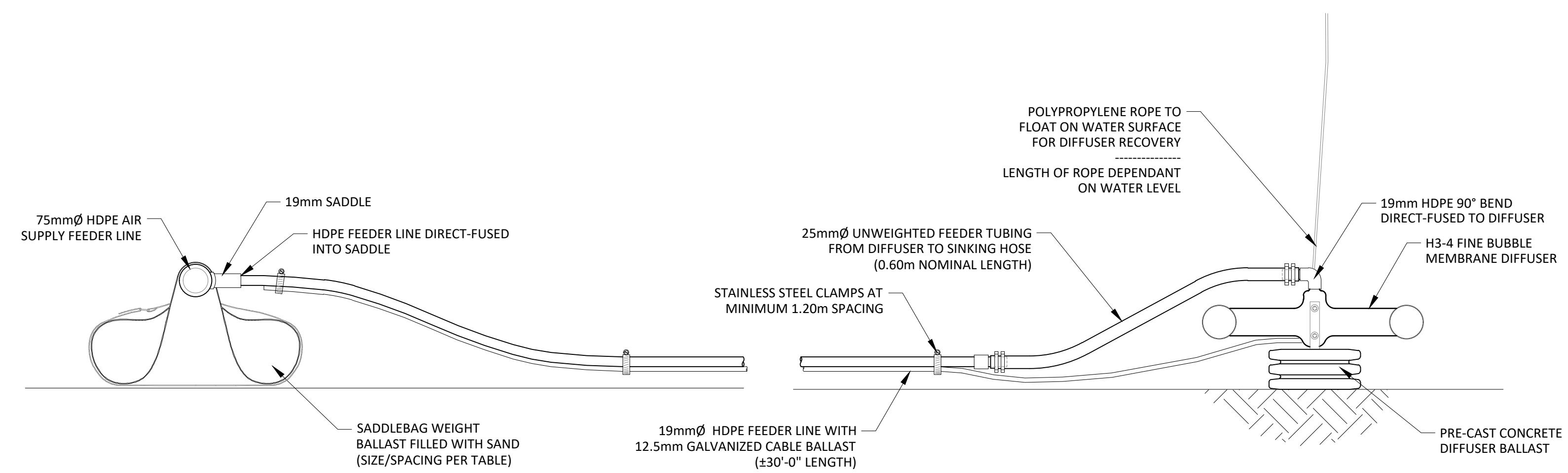


TYPICAL SECTION - CELL #2

SCALE: N.T.S.

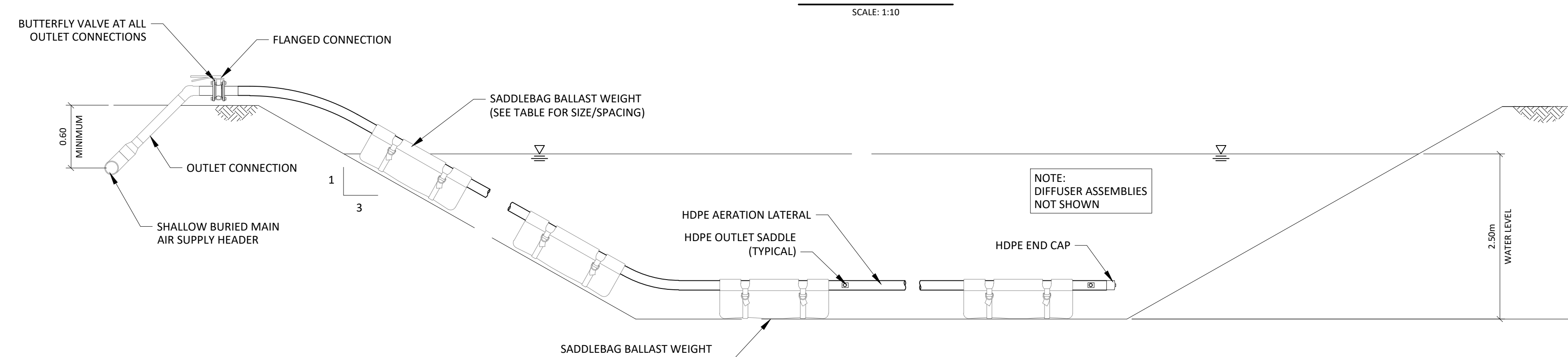
LOCATION PLAN

SCALE: 1:4000



DIFFUSER DETAIL

SCALE: 1:10



AERATED LAGOON SECTION

SCALE: N.T.S.

Nexom
technologies for cleaner water

5 Burks Way
Navin, Manitoba
Canada R5T 0C9
888-426-8180
www.nexom.com

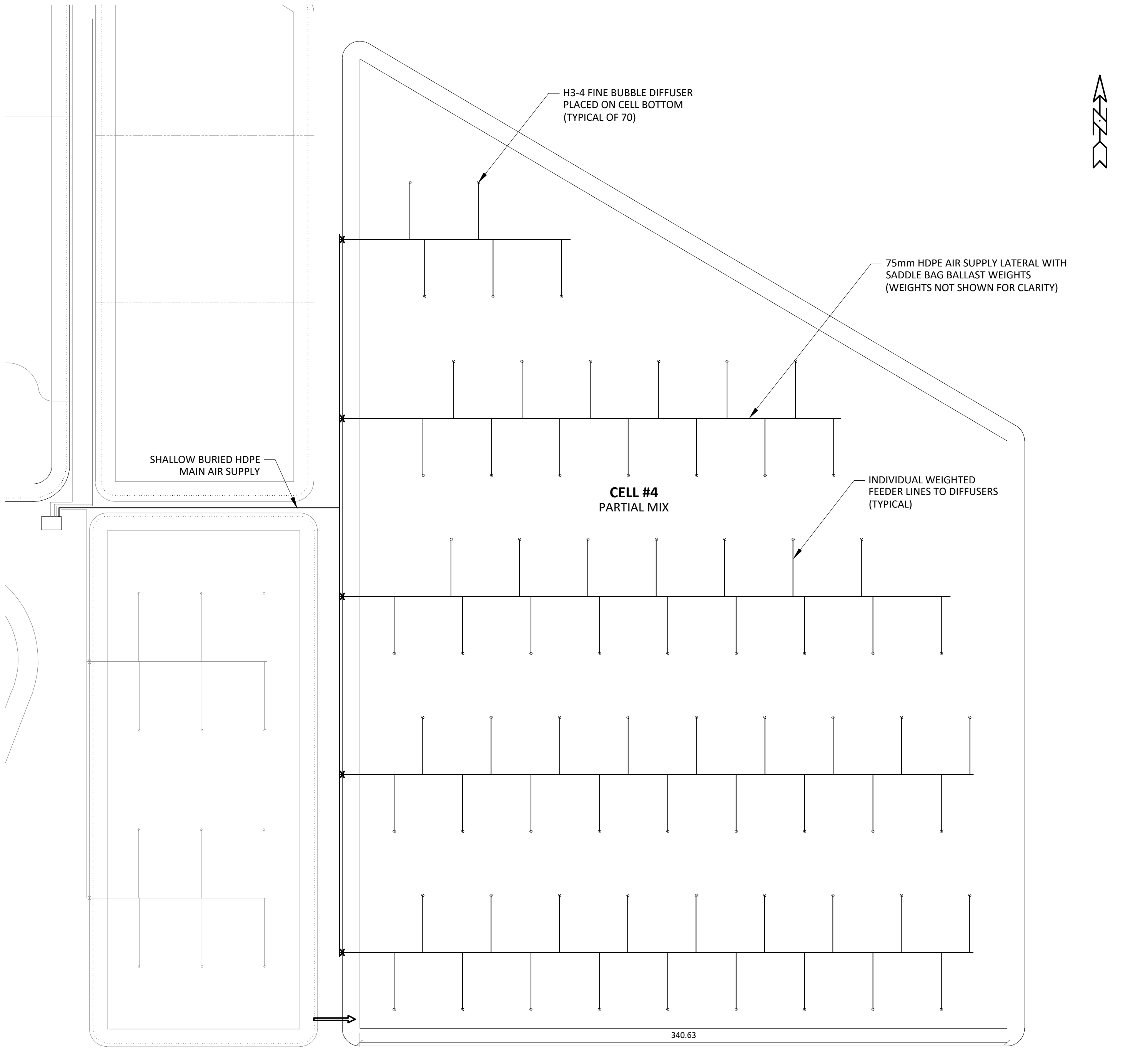
PROJECT: **BEAVERLODGE LAGOON EXPANSION, AB**
PROPOSED WASTEWATER TREATMENT SYSTEM

TITLE: OPTAER SYSTEM
AERATION LAYOUT CELL #3, TYPICAL SECTION, LOCATION PLAN

DRAWN BY:	APPROVED BY:	SCALE:	DRAWING NO.	SHT.	REV.
MR	DK	AS NOTED	NE03	3 of 4	0
DATE: 2022/02/23	FILE # CD10582.02				

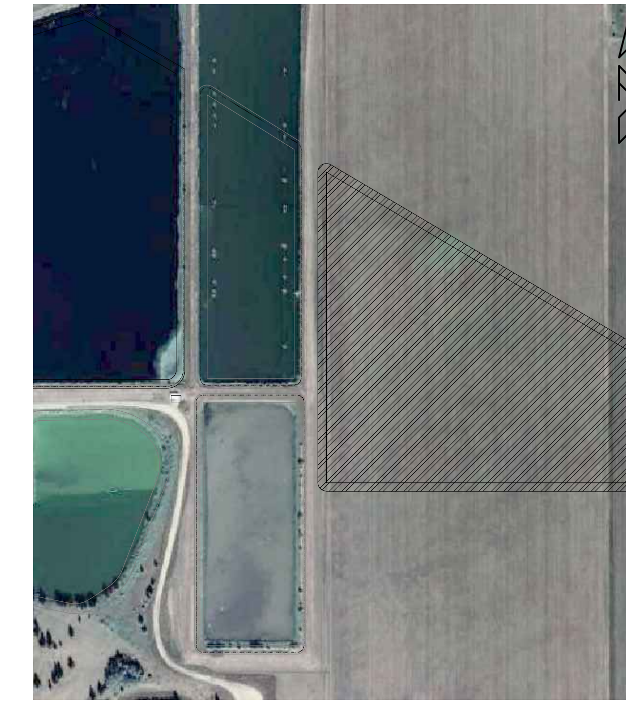
PLOT SIZE: 610mm x 914mm (24" x 36")

REDUCED SIZE PLOT - DO NOT SCALE



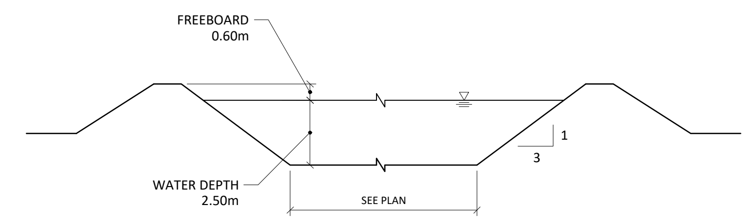
AERATION LAYOUT

SCALE: 1:1500



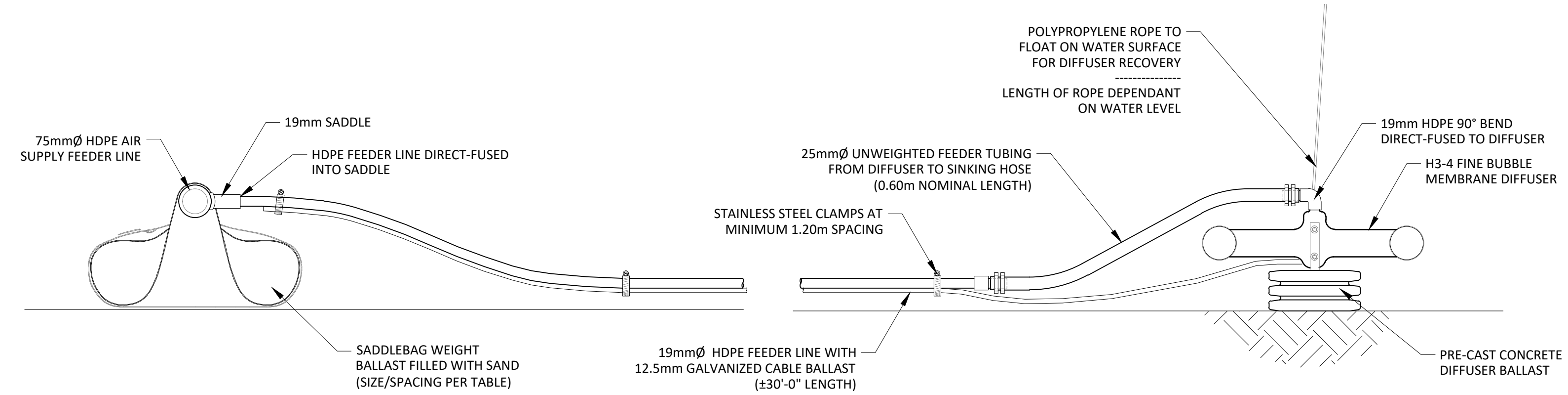
LOCATION PLAN

SCALE: 1:4000



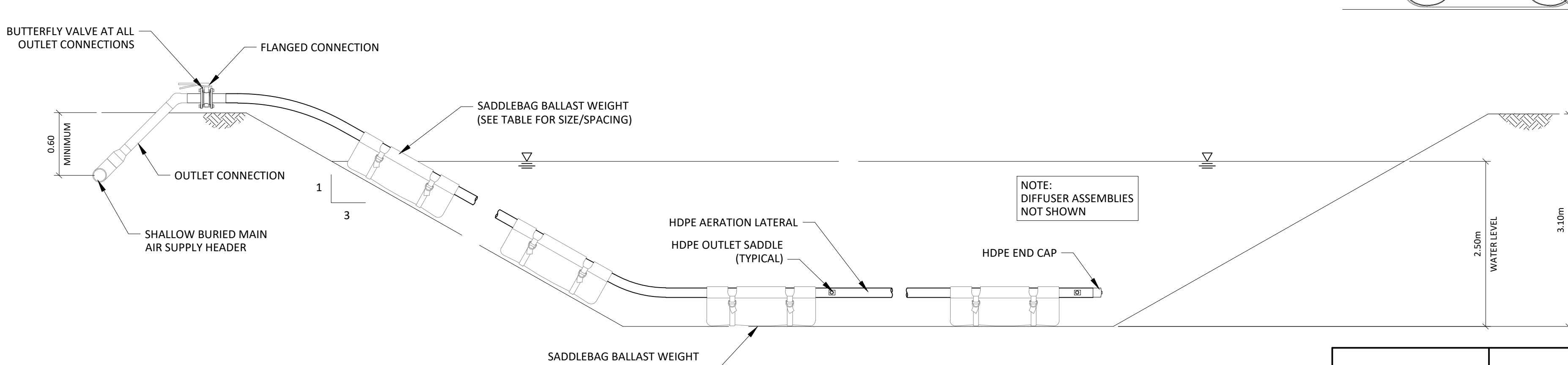
TYPICAL SECTION - CELL #2

SCALE: N.T.S.



DIFFUSER DETAIL

SCALE: 1:10



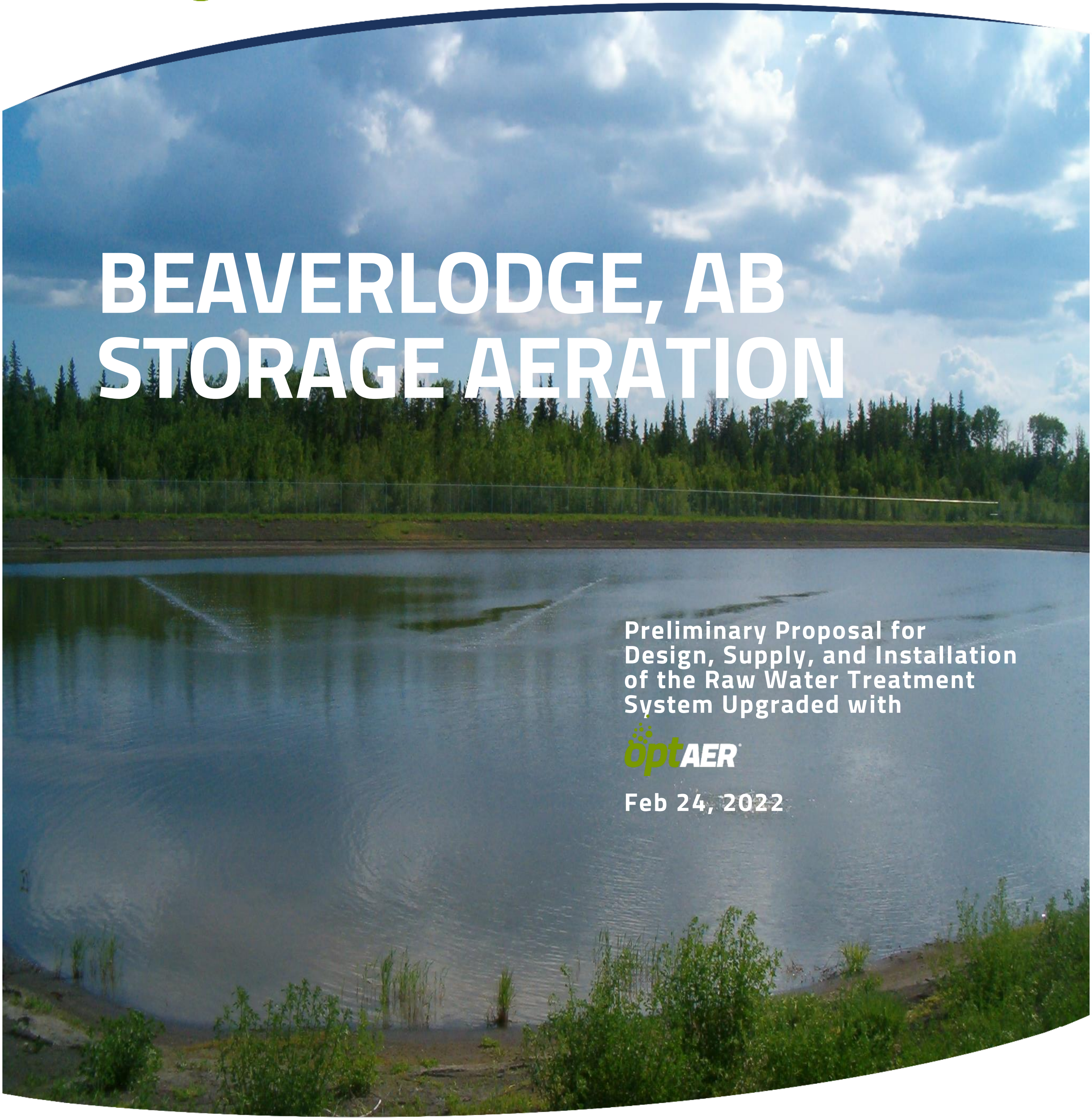
AERATED LAGOON SECTION

SCALE: N.T.S.

Nexom technologies for cleaner water

5 Burks Way
Navin, Manitoba
Canada R5T 0C9
888-426-8180
www.nexom.com

PROJECT:	BEAVERLODGE LAGOON EXPANSION, AB PROPOSED WASTEWATER TREATMENT SYSTEM
TITLE:	OPTAER SYSTEM AERATION LAYOUT CELL #4, TYPICAL SECTION, LOCATION PLAN
DRAWN BY:	MR
APPROVED BY:	DK
SCALE:	AS NOTED
DRAWING NO.	NE04
SHT.	4 of 4
REV.	0
DATE:	2022/02/23
FILE #	CD10582.02



BEAVERLODGE, AB STORAGE AERATION

Preliminary Proposal for Design, Supply, and Installation of the Raw Water Treatment System Upgraded with

optAER

Feb 24, 2022

technologies for cleaner water

5 Burks Way · Winnipeg MB · R2J 3R8
888·426·8180 • **www.nexom.com**

Project Overview

An OPTAER™ aeration system is proposed for the Beaverlodge, AB wastewater treatment facility. The proposed system would consist of the following processes:

- Implement OPTAER® fine bubble partial mix aeration with floating laterals in treatment cells 1a, 1b, and 1c. (*See separate proposal*)
- Construct two new storage cells (4A and 4B), by others.
- Decommission existing in-water aeration equipment in cells 2 and 3.
- Implement OPTAER® fine bubble aeration diffusers with submerged laterals and weighted feeder lines in cells 2, 3, and 4A.
- Retain existing shallow buried main header piping for air supply to cells 2 and 3.
- Implement new shallow buried main header piping for air supply to cell 4A.
- Implement new positive displacement air supply blowers (*to provide air for storage aeration and treatment aeration in cells 1a,b,c as outlined in separate proposal*).

Aeration is designed to improve mixing of the water in the storage cells and increase the oxygen concentration. In a long term this will improve water quality.

System Design Parameters

Raw water aeration design parameters are presented in the following table:

	Cell 2	Cell 3	Cell 4A	Totals
Water Depth (m)	2.5	2.5	2.5	
Approximate Water Surface Area (m2)	92,823	32,289	180,671	
Approximate Water Volume (m3)	220,429	73,524	435,734	729,687
Turnover time (min)	200	200	200	
Turnovers per day	7.2	7.2	7.2	
# of H2-4 diffusers (Fine Bubble)	36	12	70	118
Airflow per diffuser (SCFM)	5.0	5.0	5.0	
Total Airflow Required (SCFM)	180	60	350	590

OPTAER® Storage Treatment

The primary purpose of the aerated ponds is to provide oxygen and residence and contact time to natural bacteria, which ultimately convert residual wastewater contaminants (BOD_5, ammonia, and TSS) to carbon dioxide, water, and inert ash and nitrates. Aeration and subsequent oxidation eliminate undesirable odors that emanate from decaying organic matter, while providing useful food to support a desirable mix of organisms which can act to out-compete undesirables, such as algae, for available nutrients. The first step in natural water treatment is to ensure that there are adequate oxygen levels throughout the water column. Fine bubble aeration system provides optimal oxygen transfer and mixing while minimizing turbulence and allowing for solids sedimentation. The location and number of diffusers is designed to prevent thermoclines and anaerobic zones from developing.

H2-4 FINE BUBBLE MEMBRANE DIFFUSERS

Fine bubble diffusers are used to provide oxygen. The diffusers consist of an air distribution body with individual tubular EPDM membranes extending outwards in a horizontal plane. This design prevents bubbles from coalescing, and results in an excellent oxygen transfer rate with minimal head loss.

The diffusers rest on the bottom of the cell. A marker float and marine grade rope is attached to each unit for ease of diffuser retrieval. Each diffuser is attached to a small concrete weight, encased in HDPE pipe. Diffuser assemblies can be retrieved from a boat with no special equipment.

AIR DISTRIBUTION SYSTEM: SUBMERGED LATERALS

Diffusers are fed by a submerged flow distribution lateral. The laterals are ballasted to rest on the bottom of the cell. ¾" ballasted feeder lines from the lateral to each diffuser allow individual diffusers to be brought to the surface for repair or maintenance.

All maintenance can be performed from a boat with a 2-person crew. All header, lateral, and feeder piping is designed to accommodate increased airflow for high pressure and volume cleaning without increasing header friction losses by more than 1 psi. This allows for management of additional organic load, improved diffuser maintenance and additional odor control.

Positive Displacement Blowers

Positive displacement blowers are used to provide air supply for the treatment system. Blowers are designed to provide the required airflow at normal system operating pressure and have the capability of operating at the maximum required pressure intermittently for diffuser purging. The blowers are equipped with sound attenuating enclosures.

Blowers are summarized in the following table:

		Treatment Cells (1a,b,c)	Storage Cells (2,3,4A)
Number of blowers total		2	1
Number of blowers on duty		1	1
Number of blowers on standby		1*	0*
Motor nameplate horsepower	hp	40	40
Design airflow per blower	SCFM	594	590
Normal operating pressure	psi	5.5	5.3
Maximum Operating Pressure	psi	6.8	6.5
Estimated Power Consumption	bhp	22.9	22.1
Actual Sound level	dB(A)	72	72

*Common standby for treatment and storage cells

**Blower supply scope includes air supply for treatment cells 1a, b, and c (treatment aeration details in separate proposal).

Budgetary Capital Costs

Included in the aeration system capital cost are:

- Nexom System Process Design (Alberta P. Eng. Stamped)
- CAD Drawings and specifications (Alberta P. Eng. stamped)
- ***Equipment installation/start-up/commissioning/training***
- Operation and maintenance manuals
- Project Record Drawings

OPTAER® AERATION

- HDPE shallow buried main header piping (for new cell 4A only)
- Submerged feeder laterals with individual control valves and sandbag ballasts
- H2-4 diffuser assemblies complete with EPDM membranes, pre-cast diffuser weights, marker floats and retrieval ropes.
- Removal of existing linear aeration diffusers and feeder lines

AIR SUPPLY

- Three (3) 40 hp positive displacement blowers
- Blower control panel with VFDs
- Galvanized metal blower header and connection pipe (heat dissipation)

BUDGETARY COST FOR THE ABOVE SCOPE:

$897,000 CAD (Shipping allowed to jobsite, plus all taxes)

All prices are subject to final design review.

The quote being provided is in effect for 60 days. Should a purchase order be awarded during that 60-day period, it is understood that shipment of the product will be allowed within a period of 180 days from the date of the purchase order. Should the goods not be required to be delivered until after that time horizon, the company reserves the right to adjust pricing to reflect inflationary changes incurred and expected until the shipment date is reached.

ITEMS SPECIFICALLY NOT INCLUDED:

- Treatment equipment for cells 1a, 1b, 1c (see separate proposal)
- Disposal of decommissioned equipment from cells 2 and 3
- Material offloading and secure on-site storage.
- Civil works including pond design and construction, liner, transport piping, inter-cell piping, discharge piping, manholes, valves, access roads to site, site roads and landscaping etc. if required.
- Shallow buried main header piping for existing storage cells 2 and 3 (or modifications to existing header piping, if required)
- Building or upgrades to building, including concrete, electrical, and HVAC
- Site Preparation and Restoration

Questions or Comments?

Any questions or comments can be directed to:

Damian Kruk, Ph.D.
Regional Sales Manager/Applications Engineering
damian.kruk@nexom.com
204-227-7255

Nexom
Info@nexom.com
888-426-8180
5 Burks Way · Winnipeg MB · R5T 0C9
www.nexom.com

APPENDIX D - EXISTING PIPES - DETAILED DESIGN DATA

DESCRIPTION	LOCATION		PEAK DESIGN	EXISTING														PEAK DESIGN	
	FROM	TO	FLOW Q(d) (L/s)	LENGTH (m)	PIPE SIZE (m)	INVERT 1 (m)	INVERT 2 (m)	DROP	PIPE TYPE	GRADE (%)	CAPACITY (L/s)	CAPACITY (m3/day)	VELOCITY (m/s)	RIM 1 (m)	RIM 2 (m)	COVER (m)	COVER 2 (m)	DEPTH (m)	VELOCITY (m/s)
1	224	236	90	101.2	0.375	711.75	711.50		PVC	0.25%	**96**	8,273	0.87	714.96	714.55	2.84	2.68	0.29	0.99
2	236	237	90	120.1	0.375	711.47	710.32	0.02	PVC	0.96%	**188**	16,209	1.70	714.55	713.81	2.70	3.11	0.19	1.70
3	237	238	90	119.8	0.375	710.31	708.61	0.01	PVC	1.42%	**228**	19,703	2.06	713.81	712.01	3.13	3.02	0.17	1.94
4	238	239	90	119.7	0.375	708.60	706.89	0.01	PVC	1.43%	**229**	19,769	2.07	712.01	709.64	3.03	2.38	0.17	1.95
5	239	240	90	119.9	0.375	706.88	705.08	0.01	PVC	1.50%	**235**	20,266	2.12	709.64	707.83	2.38	2.38	0.17	2.00
6	240	241	90	119.9	0.375	705.07	702.18	0.01	PVC	2.41%	**297**	25,681	2.69	707.83	704.60	2.38	2.05	0.15	2.45
7	241	242	90	116.3	0.375	702.17	699.37	0.01	PVC	2.41%	**297**	25,665	2.69	704.60	701.45	2.06	1.71	0.15	2.45
8	242	243	90	123.6	0.375	699.36	696.94	0.01	PVC	1.96%	**268**	23,144	2.43	701.45	699.33	1.72	2.01	0.15	2.21
9	243	247	90	119.6	0.375	696.94	696.15	0.00	PVC	0.66%	**156**	13,444	1.41	699.33	698.59	2.01	2.07	0.21	1.47
10	247	245	90	95.9	0.450	696.14	695.94	0.01	PVC	0.21%	**142**	12,269	0.89	698.59	697.96	2.00	1.57	0.26	0.95
11	245	244	90	96.3	0.450	695.93	695.68	0.01	PVC	0.26%	**158**	13,693	1.00	697.96	697.54	1.58	1.41	0.25	1.04
12	244	246	90	76.5	0.450	695.67	695.49	0.01	PVC	0.24%	**151**	13,031	0.95	697.54	697.42	1.42	1.48	0.25	0.99
13	246	258	90	97.2	0.450	695.48	695.27	0.01	PVC	0.22%	**145**	12,488	0.91	697.42	697.65	1.49	1.93	0.26	0.96
14	258	INLET	90	43.7	0.450	695.26	695.09	0.01	PVC	0.39%	**194**	16,750	1.22	697.65	697.14	1.94	1.60	0.23	1.22

APPENDIX E - DETAILED PERCENTAGE BREAKDOWN OF THE ALLOCATIONS

Associated Engineering

Project

TOWN OF BEAVERLODGE
LAGOON UPGRADE ASSESSMENT

Subject:

Preliminary Cost Estimate and Funding Allowcation

Proj. No. 2021-3219 Date 10-May-22

By: Carlie Pittman P.Eng

						Town of Beaverlodge		Alberta Transportation	
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Extension**	**%**	**Funding Allocation**	**%**	**Funding Allocation**
1.0	**GENERAL REQUIREMENTS**								
1.1	Temporary Facilities and Controls	LS	1	$400,000	$400,000	50%	$200,000	50%	$200,000
1.2	Survey	LS	1	$20,000	$20,000	0%	$0	100%	$20,000
1.3	ECO Plan and Env Controls	LS	1	$20,000	$20,000	50%	$10,000	50%	$10,000
TOTAL PART 1.0 - GENERAL REQUIREMENTS					**$440,000**		**$210,000**		**$230,000**
2.0	**TRUNK SEWERS**								
2.1	Supply and Install Sanitary Sewer Pipe – Open Cut								
	.1 450mm Diameter HDPE DR17	lm	510	$500	$255,000	0%	$0	100%	$255,000
	.2 450mm Diameter HDPE DR17 c/w Steel Casing	lm	40	$2,000	$80,000	0%	$0	100%	$80,000
2.2	Supply and Install Sanitary Sewer Manhole								
	.1 12000 mm Diameter	vm	24	$4,000	$96,000	0%	$0	100%	$96,000
2.3	Tie-in to Existing Sanitary Sewer System	ea	2	$20,000	$40,000	0%	$0	100%	$40,000
2.4	CCTV Sewer Inspection								
	.1 Substantial Completion	lm	550	$20	$11,000	0%	$0	100%	$11,000
	.2 Final Completion	lm	550	$20	$11,000	0%	$0	100%	$11,000
TOTAL PART 2.0 - TRUNK SEWER					**$493,000**		**$0**		**$493,000**
3.0	**LAGOON EARTHWORK**								
3.1	Cell 4 Topsoil Stripping and Stockpiling (assume 300mm)	m2	160000	$2	$320,000	50%	$160,000	50%	$160,000
3.2	Cell 1C Common Excavation and Backfill (Fill Cell)	m3	60000	$10	$600,000	0%	$0	100%	$600,000
3.3	Cell 2 Common Excavation and Backfill (Fill Cell)	m3	20000	$10	$200,000	0%	$0	100%	$200,000
3.4	Cell 4 Common Excavation and Backfill (Fill Berms)	m3	50000	$12	$600,000	50%	$300,000	50%	$300,000
3.5	Cell 4 Common Excavation to Stockpile (Remainder)	m3	120000	$8	$960,000	50%	$480,000	50%	$480,000
3.6	Clay to Stockpile	m3	60000	$5	$300,000	50%	$150,000	50%	$150,000
3.7	Intercell Piping	ea	5	$20,000	$100,000	50%	$50,000	50%	$50,000
3.8	Lagoon Sludge/Silt Removal	m3	1500	$10	$15,000	50%	$7,500	50%	$7,500
TOTAL PART 3.0 - LAGOON EARTHWORK					**$3,095,000**		**$1,147,500**		**$1,947,500**
4.0	**LAGOON TREATMENT**								
4.1	Supply and Install Cell 1 Aeration Equipment	LS	1	$258,000	$258,000	0%	$0	100%	$258,000
4.2	Supply and Install Cell 2, 3 Aeration Equipment	LS	1	$324,000	$324,000	50%	$162,000	50%	$162,000
4.3	Supply and Install Cell 4A Aeration Equipment	LS	1	$473,000	$473,000	0%	$0	100%	$473,000
4.4	Blower Building Upgrades								
	.1 Blowers and Blower Control Pannel with VFD	ea	3	$30,000	$90,000	0%	$0	100%	$90,000
	.2 Blowers lower header and connection pipe	ea	1	$10,000	$10,000	0%	$0	100%	$10,000
	.3 Electrical Upgrades	LS	1	$10,000	$10,000	0%	$0	100%	$10,000
4.6	Metal Salt Delivery System								
	.1 Pre-Engineered Building (Superstructure and Envelope)	LS	1	$32,000	$32,000	100%	$32,000	0%	$0
	.2 Pre-Engineered Building (Foundation)	LS	1	$8,000	$8,000	100%	$8,000	0%	$0
	.3 Chemical Delivery Skid	LS	1	$42,000	$42,000	100%	$42,000	0%	$0
	.4 Spill Containment Pad	ea	4	$2,000	$8,000	100%	$8,000	0%	$0
	.4 Piping replace and flowmeter	LS	1	$35,000	$35,000	100%	$35,000	0%	$0
TOTAL PART 4.0 - LAGOON TREATMENT					**$1,290,000**		**$252,000**		**$1,003,000**
5.0	**LAND ACQUISITION**								
5.1	ADDITIONAL LAND ACQUISITION	ACRE	50	$2,000	$100,000	0%	$0	100%	$100,000
TOTAL PART 5.0 - LAND AQUISITION					**$100,000**		**$0**		**$100,000**
TOTAL PART 1.0 - GENERAL REQUIREMENTS					**$440,000**		**$210,000**		**$230,000**
TOTAL PART 2.0 - TRUNK SEWER					**$493,000**		**$0**		**$493,000**
TOTAL PART 3.0 - LAGOON EARTHWORK					**$3,095,000**		**$1,147,500**		**$1,947,500**
TOTAL PART 4.0 - LAGOON TREATMENT					**$1,290,000**		**$252,000**		**$1,003,000**
TOTAL PART 5.0 - LAND AQUISITION					**$100,000**		**$0**		**$100,000**
TOTAL PARTS =					**$5,418,000**		**$1,609,500**		**$3,773,500**
CONTINGENCY (30% OF TOTAL PARTS)=					**$1,626,000**		**$483,000**		**$1,133,000**
ENGINEERING INCLUDING GEOTECHNICAL INVESTIGATION (15% OF TOTAL PARTS)=					**$813,000**		**$242,000**		**$567,000**
TOTAL =					**$7,857,000**		**$2,334,500**		**$5,473,500**