Sandhill Estates Stormwater Management Report

112849578

Prepared for:
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July 8, 2016

Sign-off Sheet

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Angelica Prieto

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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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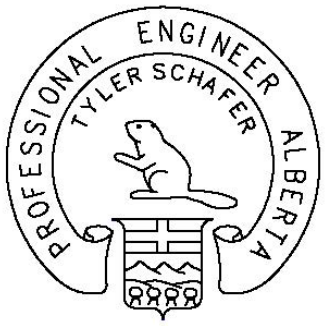

RESPONSIBLE ENGINEER

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1.0 Introduction

This stormwater management report (SWMR) was prepared on behalf of 1842107 Alberta Ltd. in accordance with the requirements of the County of Lacombe Design Guidelines. It will serve as a supplement to the engineering design drawings prepared by Stantec Consulting Ltd. for Sandhill Estates. Sandhill Estate is located in the Burbank Plan area that is south east of the Town of Blackfalds as shown on **Figure 1.1**.

The objective of this study is to demonstrate that the proposed stormwater management facility will meet Alberta Environment and Parks (AEP) criteria for permissible release rate and water quality improvement. It will also outline the proposed configuration for the drainage systems within the residential development.

Figure 1.2 shows the lands within the Sandhill Estate study area. The existing land surrounding the development site was looked at in order to gain understanding of where existing drainage was going.

2.0 Site Description

2.1 DRAINAGE AREA

Sandhill Estate development will be a country residential community of 10.77 ha which will feature a dry storm pond. The development is located within the following legal land parcel.

SW1/4 24-39-27-W4M

Figure 2.1 illustrates the locations of the primary land uses that are relevant to this SWMR as presented in the Area Structure Plan (ASP).

The nature of this development necessitates that the study area be divided into drainage subcatchment areas for the purpose of the hydrologic analysis which is described later in section 4.0. The drainage subcatchments are established on the basis of areas that drain to the stormwater management facility (SWMF). These subcatchments include the Sandhill Estates development and off-site catchment areas that will be routed through the Sandhill Estates Pond. The drainage subcatchment areas are shown on **Figure 2.2** and described in **Table 2.1.**

Table 2.1 Drainage Subcatchment Areas

Subcatchment	Description	Area (ha)
Sandhill_1	Proposed Acreage Lots, MR	5.59
Sandhill_2	Proposed Acreage Lots, MR, PUL	1.96
Sandhill_3	Proposed Acreage Lots, MR	3.22
Offsite_1	Existing Acreage Lot	1.59
	Total to Sandhill Estates Pond	**12.36**

2.2 TOPOGRAPHY

The site topography consists of a ridge that runs north/south that splits the study area in half. The land drains from the north to the south on both sections. The west area of the study area has a low area that outlets through infiltration, and the east area drains to a low area that discharges under the CPR through a culvert. **Figure 2.3** illustrates the contours and direction of the drainage throughout the study area.

2.3 ENVIRONMENTALLY SIGNIFICANT AREAS

Due to the high sands in the soils, there are no environmentally significant areas that have to be treated like wetlands. The soils have a high infiltration rate and the runoff drains away from the land very effectively.

3.0 Stormwater Management Concepts

3.1 DRAINAGE CONCEPTS

Sandhill Estates will be a typical country residential community, which incorporates standard stormwater management features that have been utilized throughout the County of Lacombe In accordance with the Red Deer Regional Stormwater Runoff Chart (preliminary), the Burbank Plan area is close to the 2 L/s/ha pre-development. See **Appendix C** for more info. As well there was the Master Drainage Plan for the Wolf Creek and Whelp Brook Watersheds (MPE Engineering Ltd., January 2014), which is nearby that includes the northwest part of the Town of Blackfalds that limits discharge rates to 2 L/s/ha.

Drainage from Sandhill Estates is to be in accordance with the objectives set forth as mentioned above. The following specific targets are applicable for the Sandhill Estates lands:

- Discharges to the Red Deer River are to be limited to a Unit Area Release Rate (UARR) of 2.0 L/s/ha for the 100 year service level.
- Storm ponds within the development area are to meet current regulatory requirements; removing 85% of Total Suspended Solids for particles greater than or equal to 75 microns in diameter.

This drainage to Red Deer River will occur by overland ditch drainage, with discharges regulated so that the peak flow does not exceed the above UARR. A stormwater management facility (SWMF) shown on **Figure 2.2** as Sandhill Estate Pond; along with on-site ditch storage will be incorporated into the development to contain the excess flows.

3.2 WATER QUALITY IMPROVEMENT

Alberta Environment and Parks requires that at least 85 % of the sediment contained in the stormwater that is greater than or equal to 75 microns ($\geq$ 75 μm) is to be removed prior to discharging to receiving watercourses.

The SWMF will be the primary water quality treatment mechanisms for Sandhill Estates. The majority of sediments will originate from the roads but since it is all overland drainage, the ditches and drainage channels will remove a majority of the sediments before they reach the dry pond. Based on past experiences, the size of SWMFs being required for the Sandhill Estates area along with on-site ditch storage and overland drainage will remove more than 85% of the sediments that wash off the catchment areas.

In addition to the above quality control, it is equally important to practice temporary sediment and erosion controls during construction of the new developments. Erosion control measures will also be implemented during construction.

3.3 OVERLAND DRAINAGE SYSTEMS

The Sandhill Estates development will consist of an overland drainage network. The proposed development shall be graded such that the majority of the development can have the overland flows drain\spill to the proposed stormwater management facility by roadway ditches and culverts.

Previsions will be made and detailed design will be done in order to route all of the off-site drainage (from the west) through the proposed lots within Sandhill Estates through grass swales.

All runoff inside the site location will flow overland via roadways, swales, ditches and culverts. It is important that developments have a properly designed overland drainage system because poorly designed developments will still experience overland drainage, but often with consequences. In Alberta, overland drainage systems are typically designed such that property will not experience flood damage for storms up to and including the 1:100 year return period, and this is the standard that the Sandhill Estates development will be designed to.

Overland drainage shall conform to the County of Lacombe Design Guidelines, and also the water velocity and depth relations as outlined in the AEP Stormwater Management Guidelines.

4.0 Post-Development Analysis Methodology

A post-development hydrologic-hydraulic analysis was performed to provide the following information based on the stormwater management concepts and principles discussed in Section 3.0:

- Sizing of the SWMF;
- Required ditch storage;
- Stormwater retention using source control measures;
- Water balance computations.

4.1 PRECIPITATION-RUNOFF ANALYSIS

4.1.1 Single Storm Event

The most common method of analysis used for stormwater management is based on a single storm event; either a real historic storm or a theoretical design storm. A one in one hundred (1:100) year return period design storm was used, with the Chicago distribution. This distribution does not necessarily reflect the shape that such a rare storm event would exhibit in the Burbank area, but it represents two important characteristics for design purposes:

- The total precipitation of the Chicago storm, for any duration, is the same as the total precipitation defined statistically for the 1:100 year event.
- The peak intensity of the Chicago Storm, for any time increment, is the same as the peak intensity defined statistically for the 1:100 year event.

The storm duration was 24 hour and the rainfall time increment was 5 minutes.

Rainfall intensities for the Chicago distribution are determined from an *intensity-duration-frequency* (IDF) relationship that is described as

$$i = \frac{a}{(t+b)^c} \qquad [1]$$

where i is intensity (mm/hr), a, b and c are IDF parameters and t is the time duration (minutes). The time to storm peak is determined by

$$\frac{t_p}{t_d} = r \quad \text{or} \quad t_p = r(t_d) \qquad [2]$$

where t_p is the time to peak and r is the ratio of time to peak versus storm duration, t_d.

The following parameters were used to derive the rainfall intensities for this design storm as provided by AES for the County of Red Deer:

1:100 year: a = 187 b = 1.6 c = 0.51 r = 0.3 (24 hour duration)

Table 4.1 lists the rainfall intensities for the design storm.

Table 4.1 24-hour, Chicago Design Storm IDF Values

1:100 Year Storm Event	
Time (min)	**Intensity (mm/hr)**
5	71.4
10	53.6
15	44.6
30	32.1
60	22.9
120	16.2
360	9.3
720	6.5
1440	4.6

4.1.2 Continuous Simulation

Continuous simulation was the approach used to quantify catchment runoff and confirm the size of the SWMF and onsite ditch storages for the development.

Historic precipitation was used for the period 1964 to 2007 inclusive. This data includes both rainfall and snowfall. The precipitation data for the period 1964 to 2007 were obtained from Environment Canada and reformatted for use with the computer model by Stantec for the purpose of this SWMR report.

Frequency analysis was performed of the peak annual storage volumes to determine the 100 year storage volume requirements for the SWMFs. This was undertaken using a frequency analysis Excel spreadsheet.

4.2 COMPUTER MODEL

The PCSWMM computer model software Version 6.0.2071 Professional 2D was used for this analysis. This software, which is developed by Computational Hydraulics International (CHI), is a GIS based

interface which provides a front end pre and post processor for the USEPA SWMM5 model as the computational "engine", with no internal modifications.

The EPA SWMM5 model is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps. It contains a flexible set of hydraulic modeling capabilities used to route runoff and external inflows through the drainage system network of pipes, channels, storage/treatment units and diversion structures.

The post-development drainage system was discretized into various elements which describe the components of the physical drainage system. **Figure 2.2** illustrates the post-development model elements in terms of subcatchments and a SWMF while **Figure 4.1** is a schematic representation.

The various model elements are discussed further in the following sections.

4.3 RUNOFF COMPUTATION

Computation of runoff by SWMM5 is based on a number of physical parameters which includes catchment area, length/width, slope, imperviousness, Manning 'n', depression storage and infiltration. Summaries of the parameter values that were used are provided in **Appendix A**. The following sub-sections describe some of the key parameters used for catchment runoff.

4.3.1 Imperviousness

Catchment runoff is a direct function of the amount of land surface that is impervious surface coverage which depends on the land use characteristics. The imperviousness for the various catchments are based on the proposed land uses as represented by the Sandhill Estates Area Structure Plan (ASP). The parameter values for imperviousness that were input into the PCSWMM models are listed in **Appendix A**. These values are based on the various land uses and assignment of imperviousness for each land use.

4.3.2 Length

Catchment length is not a sensitive parameter in-so-far as pond storage requirement is concerned because storm pond sizing is not sensitive to peak runoff due to the relatively small UARR from the SWMF (i.e. 2.0 L/s/ha). But catchment length will affect peak overland flows which can affect the routing of overland flows through the ditches. Generally a catchment length of 150-300 m was used for the larger residential subcatchments.

4.3.3 Slope

As with catchment length, catchment slope is not critical for detention storage whereas it is more relevant to overland flow rates. A slope of 2% was generally used for the country residential areas.

4.3.4 Infiltration

SWMM5 provides options for handling abstraction losses associated with pervious surfaces (Horton infiltration, SCS Curve Number, Green-Ampt). The Green-Ampt method was used for calculation of catchment infiltration by the PCSWMM model. The Green-Ampt parameters were assumed to be Sandy Loam. The City of Calgary parameters were used as there are no parameters for the Burbank area in terms of the Green-Ampt analysis. Typical Green-Ampt values for Sandy Loam were used, per the City of Calgary's guidelines (2011), which are as follows:

Hydraulic Conductivity (K) = 10.922 mm/hr.

Suction Head (ψ) = 110 mm

Initial Moisture Deficit (IMD) = 0.36

This is considered to be a more accurate representation then using the Curve Number (CN) method that is commonly used in the Red Deer and surrounding Area.

4.3.5 Snow Melt

The PCSWMM model has the capability to simulate snowmelt using a Snow Pack routine along with temperature, evaporation and wind data. Snowmelt was incorporated in the continuous simulation analysis using maximum and minimum temperature data that was obtained from Alberta Environment. The various parameters that were specified for Snow Pack and snowmelt are listed in **Appendix A**.

4.4 EVAPORATION LOSSES

The PCSWMM model computes evaporation losses from two sources; depression storage on the catchment surface and the water surface in storage locations. Monthly evaporation obtained from Evaporation and Evapotranspiration in Alberta (April 2013) for Lacombe Lake was converted to daily evaporation for use in the PCSWMM model. The evaporation data is summarized in **Appendix A**.

4.5 STORAGE ROUTING

4.5.1 Storage Rating Relationship

Storage routing was performed to simulate the Sandhill Estates SWMF and onsite ditch storage. The SWMF storage is represented by a depth - area relationship which is based on the layouts and

preliminary grading contours that were developed for this SWMR and which are presented in Section 5.0.

The on-site ditch storage locations were simulated with a lump storage node for the east and the west cul-de-sacs. A functional storage curve was derived in order to get a maximum storage required for each cul-de-sac.

Evaporation is allowed to occur at the SWMF and other on-site storage locations using a factor of 1.0 times the evaporation rates that are input into the model (see Section 5.5).

Infiltration is encouraged at the on-site storage locations and the SWMF, therefore infiltration was turned on for these locations in the model.

The storage rating data for the SWMF is provided in **Tables 4.2**. The data used in the PCSWMM model for the storage location is provided in **Appendix A**.

4.5.2 Discharge Relationship

The controlled discharge from the SWMF was facilitated in the PCSWMM model as outlet rating curve which were computed using orifice control that included head losses through the submerged outlet pipe between the pond and the orifice.

The detailed outlet rating data for the SWMF controlled discharges are provided in **Appendix A**. **Tables 4.2** summarizes the discharge rates for the SWMF.

Table 4.2 Storage Rating Data for Sandhill Estates Pond

Elevation (m)	Area (m^2)	Storage (m^3) Active	Discharge Rate (m^3/s) Sandhill Estate
858.00 Bottom	16	0	0
858.20	190	21	0.010
858.40	325	72	0.015
858.50	514	114	0.017
858.60	681	174	0.019
858.70	852	250	0.020
858.80	1,026	344	0.022
859.00 HWL	1,383	585	0.025

4.5.3 Sediment removal analysis

Water quality modeling was performed by the PCSWMM model for sediment removal from the SWMF. This requires input data for pollutant *build-up*, pollutant *washoff* and pond *settling velocities* which was based on data provided in the City of Calgary guidelines.

The procedure used in the PCSWMM model for pollutant simulation is as follows:

- Pollutants are identified and given certain attributes. For this sediment simulation modelling TSS was listed for five size ranges as noted in the City of Calgary manual; (1) 0-10 µm, (2) 10-20 µm, (3) 20-50 µm, (4) 50-150 µm and (5) > 150 µm.
- A fraction of total sediment is assigned to these sediment sizes as noted in the City of Calgary manual.
- Land uses are identified, each with a set of buildup and washoff parameters. For this study the land uses identified included (1) Landscaped and (2) Hardscape (Pavement).
- Removal efficiencies for source control BMPs can be assigned for each land use, but for this SWMR study an efficiency of 0 % was used as a conservative assumption.
- Removal of TSS in the SWMF is simulated by turning on the Treatment flag and assigning a removal expression based on the settling velocities for each of the TSS particle sizes as provided in the City of Calgary guidelines.

5.0 Stormwater Management Facility

5.1 DESCRIPTION

One detention storage facility is proposed for Sandhill Estates at the location shown on **Figure 2.2**; referred to as Sandhill Estates. Sandhill Estates Pond is going to be constructed as a dry storm pond in accordance to the County of Lacombe and Alberta Environment guidelines. **Figure 5.1**, shows the layout, design grades and associated storm infrastructure while **Figure 5.2** shows the designated cross sections for the Sandhill Estates Pond.

There will also be on-site ditch storage incorporated into the site plan. **Figure 5.3** shows a typical ditch storage plan view and cross sections. Based on that typical design, the ditch can provide 3 m^3 of storage per 10 meters of linear ditch. Note, due to the maximum ponding of 0.4m and a longitudinal slope of 1%, the linear ditch cannot be longer then 40m without have a ditch block to tier the storage.

Table 5.1 summarizes the preliminary design data for the Sandhill Estates Pond based on the concepts shown on **Figure 5.1**. This table shows how the Sandhill Estates subdivision pond will function.

Table 5.1 Design Data for Sandhill Estates Dry Storm Pond

	Sandhill Estates Pond
Contributing Drainage Area	10.54 ha
Bottom Elevation	856.00
NWL Elevation	858.00
HWL Elevation	859.00
Area at HWL	1.38 ha
Active Storage Volume at the HWL	585 m^3
Side Slopes Between the NWL and HWL	7H:1V
Side Slopes Above the HWL	7H:1V
Discharge Rate at the HWL	25 L/s
1:100 Volume, Continuous Simulation	577 m^3
1:100 Volume, Single Event	568 m^3
Governing 1:100 Elevation	858.99
Governing 1:100 Peak Discharge	24 L/s
Freeboard Elevation	859.60

The High Water Level (HWL) is the design maximum operating level, which contains (at least) the 1:100 year event storage volume. As mentioned previously in Section 3.1, the maximum discharge rate for the 100 year level is 2.0 L/s/ha for the Sandhill Estates Pond. As noted in **Table 5.1**, the 100 year discharge rate from this facility is less than the respective target.

Table 5.2 summarizes the required storage for the on-site ditch storages.

Table 5.2 Design Data for Sandhill Estates Ditch Storage

	West Cul-de-sac	East Cul-de-sac
1:100 Volume, Continuous Simulation	26 m^3	18 m^3
1:100 Volume, Single Event	33 m^3	22 m^3
Required length of linear ditch	110 m	75 m
Estimated number of ditches	5	3
Estimated Average length of ditches	22 m	25 m

- The typical ditch storage (Figure 5.3) estimates 3 m^3 of storage per linear 10m of ditch.
- The linear ditch cannot be longer than 40 m (See Section 5.1 above)

5.2 DISCHARGES TO RED DEER RIVER

Discharges from Sandhill Estates Pond will be made overland through an existing drainage channel to the Blindman River which discharges into the Red Deer River. The existing drainage channel that Sandhill Estates will release to is located directly south of Sandhill Estates that flows through a culvert under the CPR. From that discharge point it drains about 150 m till it reaches the Blindman River which then flows into Red Deer River which is about 1 km southwest. The Sandhill Estates pond will be controlled by an orifice in a concrete weir that incorporates two levels of operation:

- An ICD will provide normal unregulated control using orifice flow principles. The ICD will be sized to pass the target flow of 25 L/s (10.54 ha @ 2.0 L/s/ha) based on water levels in the storage facility at HWL.
- An overflow weir will accommodate increased flows when water levels rise above the HWL (i.e. > 100 year event).

Figure 5.4 provides preliminary details for the ICD and weir that will be used for Sandhill Estates Pond.

5.3 EMERGENCY OVERFLOW

Based on the design of the Sandhill Estates storm pond, the concrete weir will act as an emergency overflow that will allow the pond to discharge down the ditch towards Red Deer River at levels above the HWL (i.e. > 100 year event).

5.4 FREQUENCIES OF STORAGE

Figure 5.5 illustrates the frequency of storage volumes for Sandhill Estates Pond based on the frequency analysis of the continuous simulation results.

Table 5.3 provides the 100 year storage volumes for the Sandhill Estates SWMF as determined by the frequency analysis of the continuous simulation results. These results are less than the volumes determined by the 100 year single storm event and so the single event will govern for design purposes.

Table 5.3 Frequency analysis for Sandhill Estates

Sandhill Estates Pond	
	Active Storage Volumes (m^3)
Return Period (Years)	Sandhill Estates
2	150
5	244
10	315
25	413
50	493
100	577

5.5 SEDIMENT REMOVAL

Table 5.4 summarizes the results of sediment washoff and final loadings that are ultimately discharged to Red Deer River. These results demonstrate that the target efficiency of 85 % removal of ≥ 75 µm particle sizes is being met.

Table 5.4 Sediment Loadings for the Iron Gate SWMF

Sediment Size (µm)	Sandhill Estates Pond	
	Catchment Washoff (kg)	Discharges at Outfall (kg)
< 10	2,557	907
10-20	396	41
20-50	4,962	0
50-150	975	4
> 150	2,785	0
Totals	**11,675**	**952.0**

6.0 Conclusions

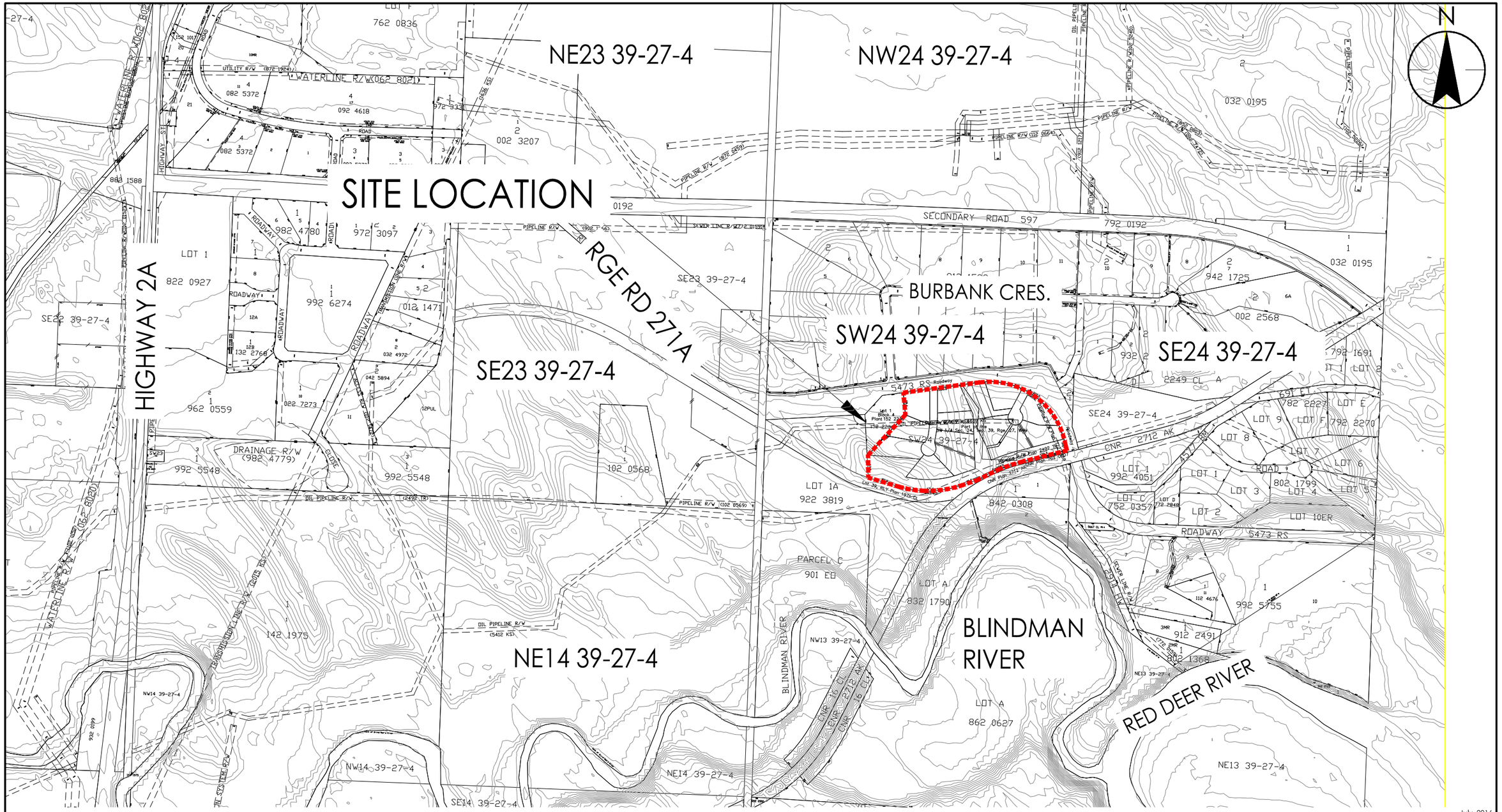
The Sandhill Estates development and storm drainage system are located in the SW$^1/_4$ 24-39-27-W4M. There is going to be a constructed dry storm pond on site in order to control the discharge rate for Sandhill Estates. There will also be linear on-site storage in the ditches along the cul-de-sac roads to provide additional storage.

The Country residential development draining to Sandhill Estates dry Pond will have an overland drainage system with ditches, culverts and swales. Overland drainage shall conform to the County of Lacombe Design Guidelines, and also the water velocity and depth relations as outlined in the Alberta Environment (AEP) Stormwater Management Guidelines.

The dry storm pond (Sandhill Estates Pond) will have an active depth of 1.0 m. The pond discharge will be controlled at or below the pre-development release rate (2.0 L/s/ha) and will discharge to the southeast towards Red Deer River via overland drainage and the Blindman River. There will be a flow-through from existing lands to the west. The pond will not store any of the drainage from these pre-development lands but rather provide discharge based on the same pre-development release rates that Sandhill Estates is designed for.

The pond will be controlled by an orifice in a control structure set at the bottom of the pond and a weir set at HWL in order to accommodate levels in the pond greater than the 1:100 year storm event.

The PCSWMM Single Event modeling and the continuous modeling demonstrates that Sandhill Estates Pond has adequate live storage to attenuate the peak flows resulting from a 24 hour duration, 1:100 year design storm event and 44 years' worth of precipitation data along with a frequency analysis. This model also shows that the available active storage and discharge rate demonstrates that the facility will provide a detention time of greater than 24 hours.



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Legend

Site Boundary

Notes

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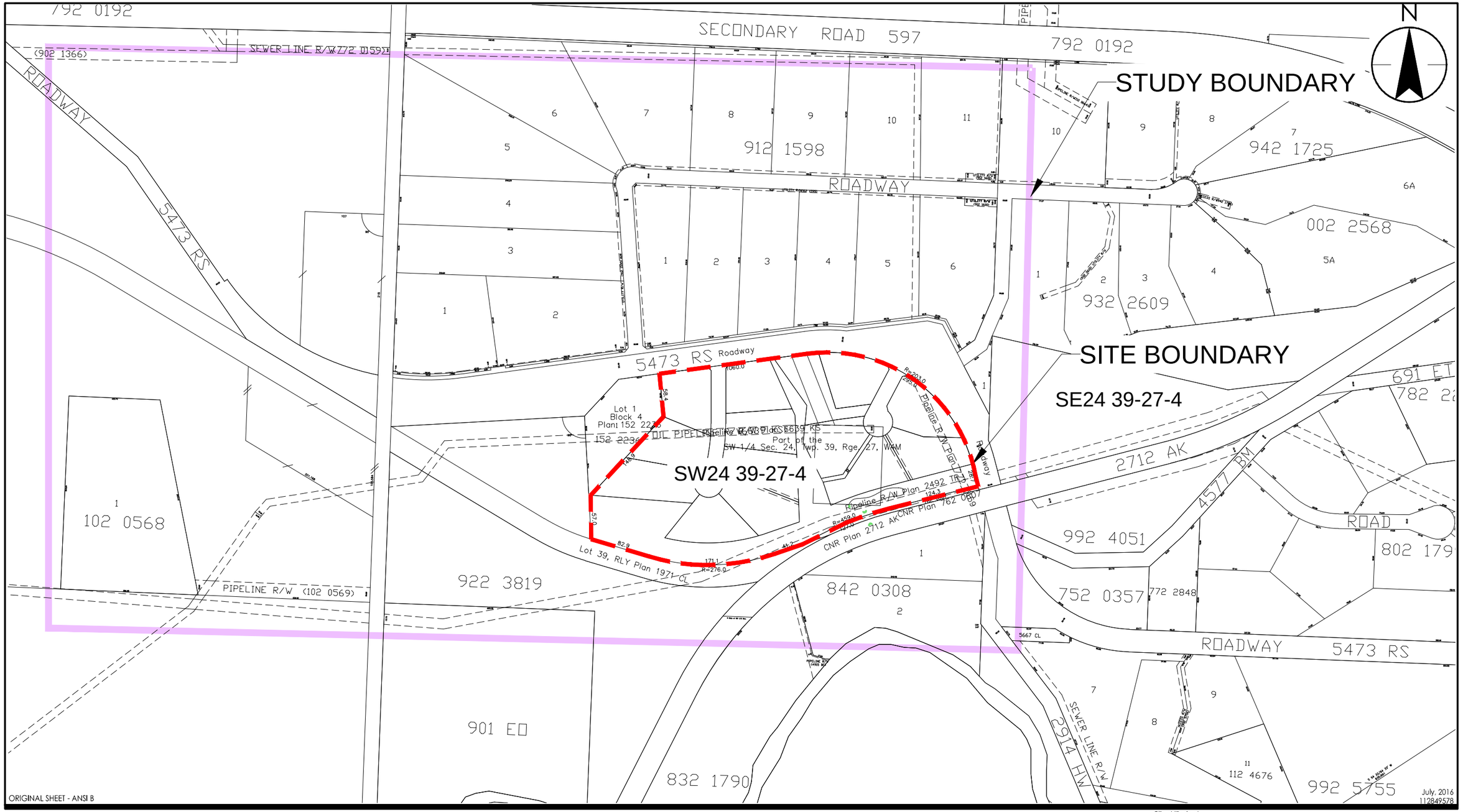
Sandhill Estates

Figure No.
1.1

Title
SITE LOCATION



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Legend

Site Boundary

Study Area

Notes

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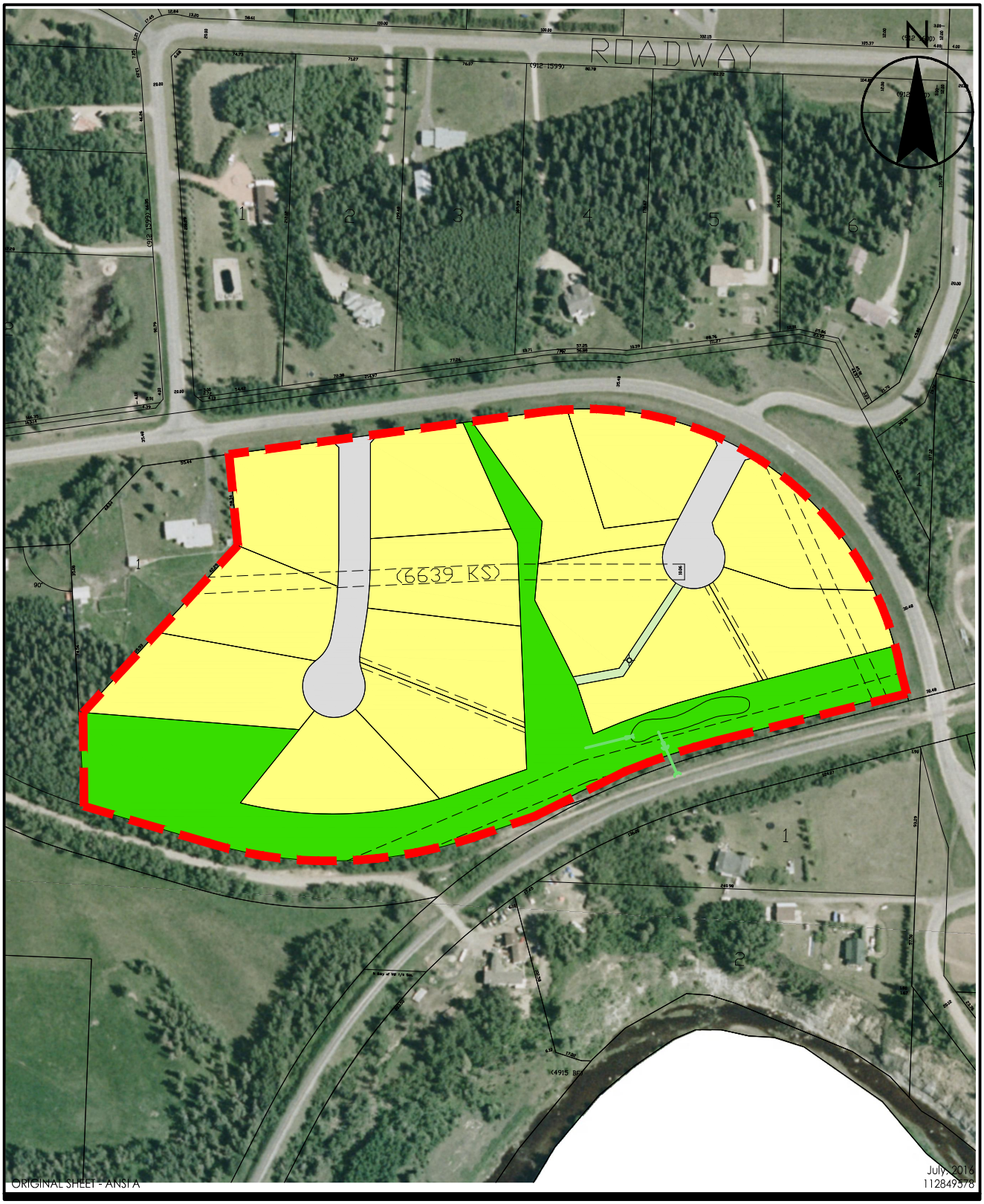
Figure No.
1.2

Title
STUDY AREA



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- Country Residential
- ER/MR/PUL

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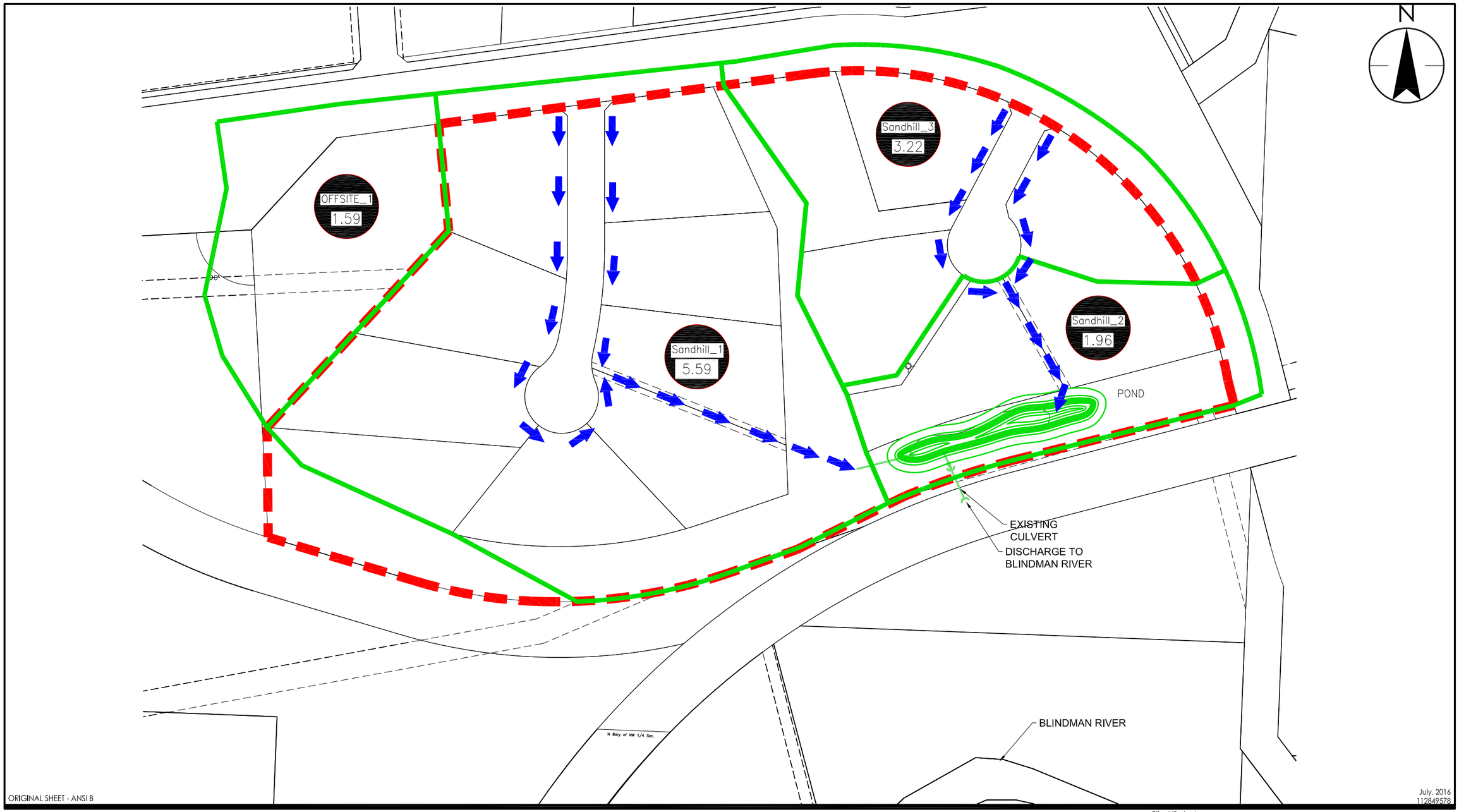
Figure No.
2.1

Title
PROPOSED
LAND USE



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Legend

- Site Boundary
- Subcatchments
- Linear On-site Storage Ditches

Notes

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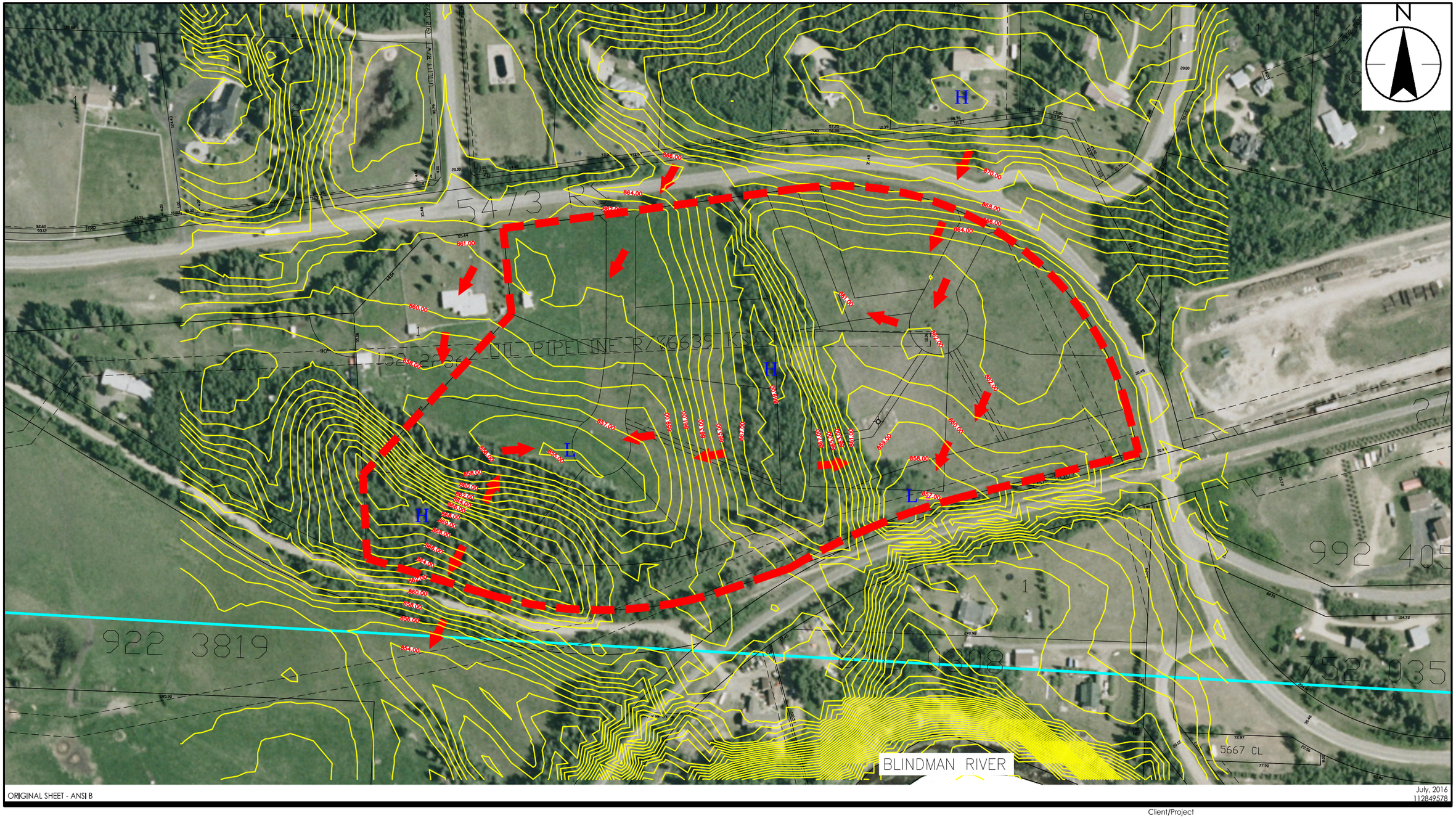
Figure No.
2.2

Title
DRAINAGE AREAS



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Legend

- Site Boundary
- High Point (H)
- Natural Low Area (L)
- Direction of Overland Flow

Notes

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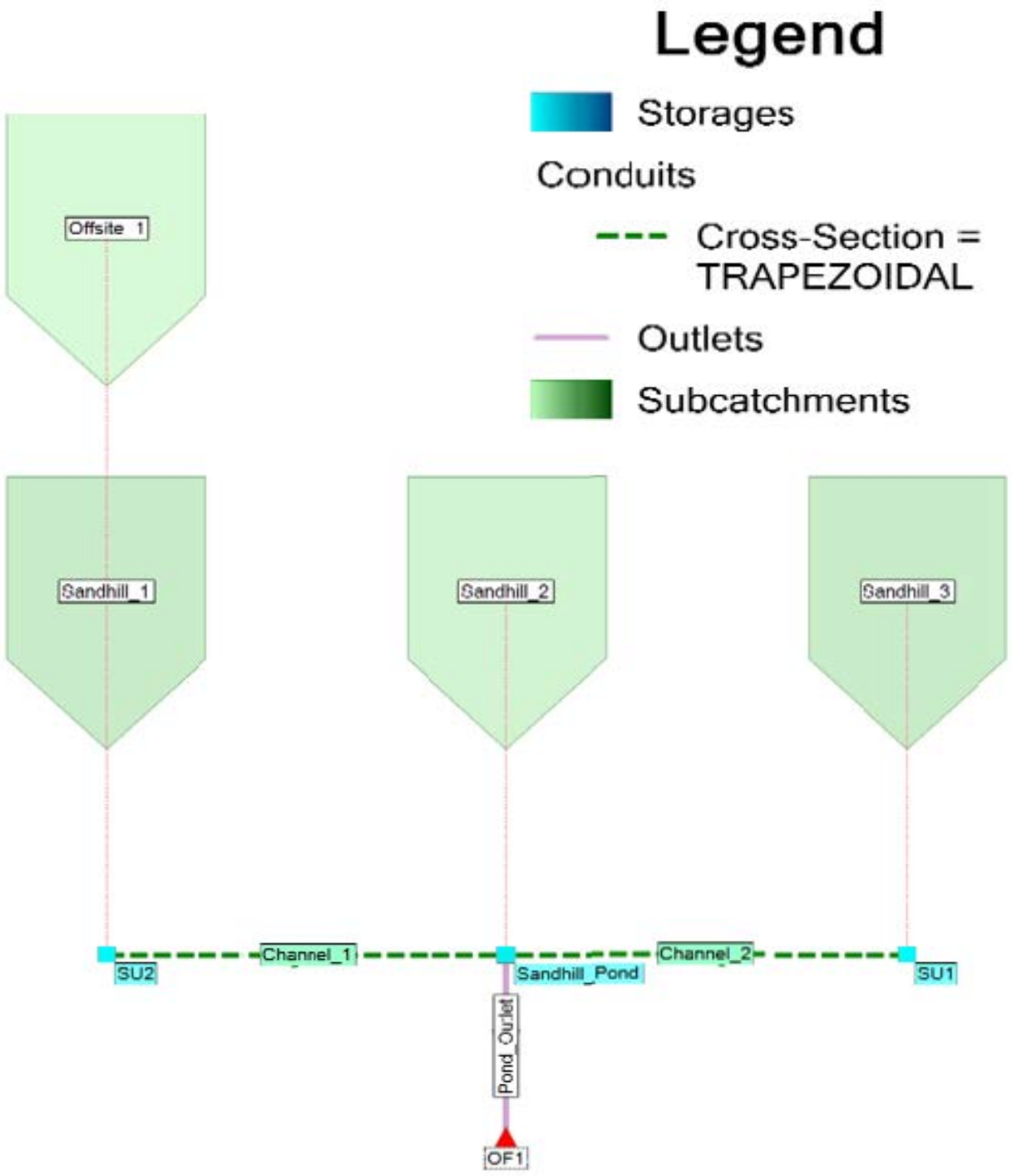
Sandhill Estates

Figure No.
2.3

Title
EXISTING TOPOGRAPHY



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Sandhill Estates

Figure No.

4.1

Title

SCHEMATIC

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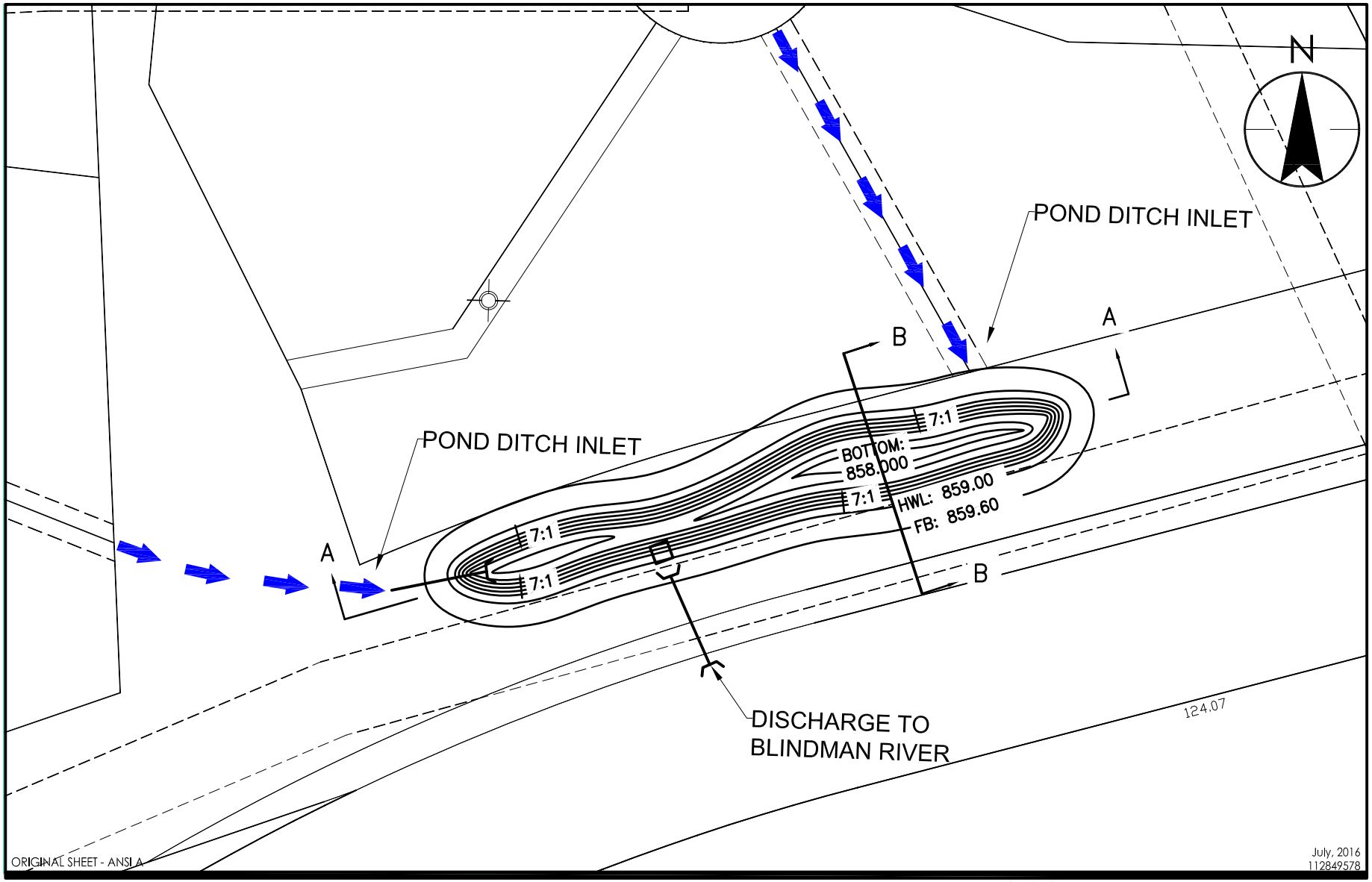

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2016/07/07 3:54 PM By: Prieto, Angelica

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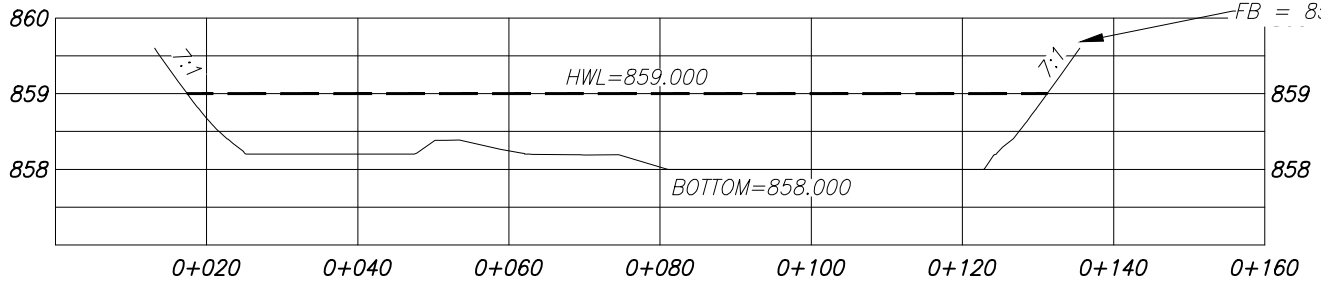
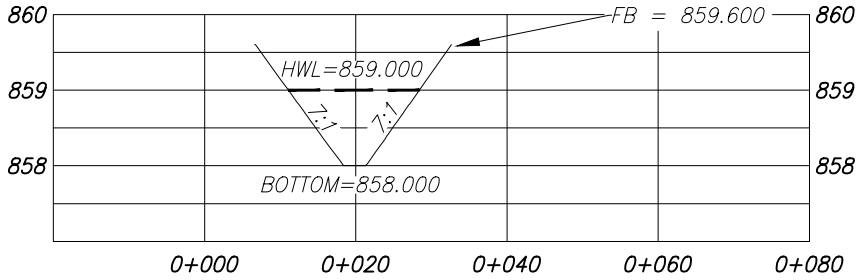
Figure No.
5.1

Title
CONCEPTUAL
SANDHILL ESTATES
DRY POND





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ORIGINAL SHEET - ANSI A

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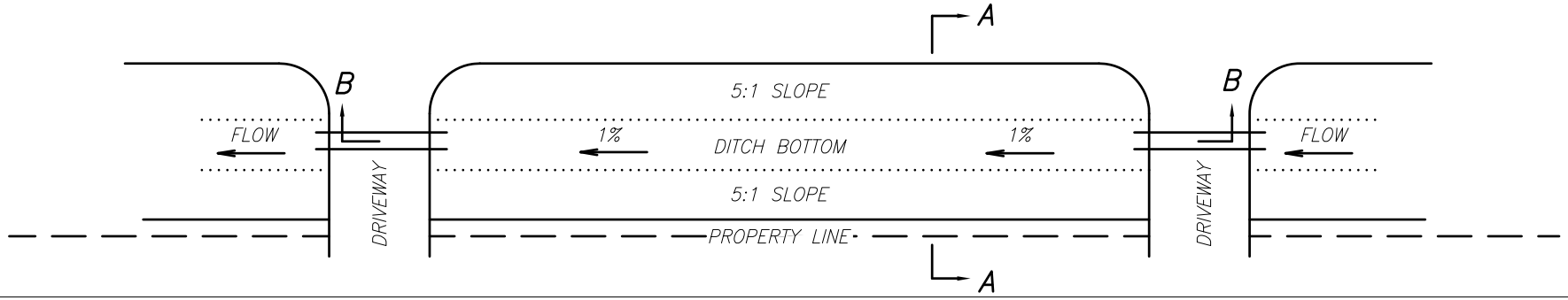
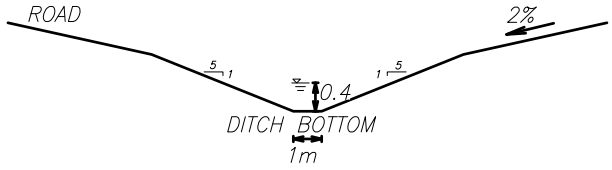
Figure No.
5.2

Title
CONCEPTUAL
SANDHILL ESTATES
DRY POND



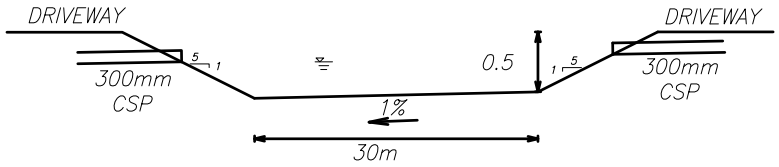
TYPICAL DITCH STORAGE

NTS



SECTION A–A

NTS



SECTION B–B

NTS

ORIGINAL SHEET - ANSI A

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2016/07/07 3:59 PM By: Prieto, Angelica

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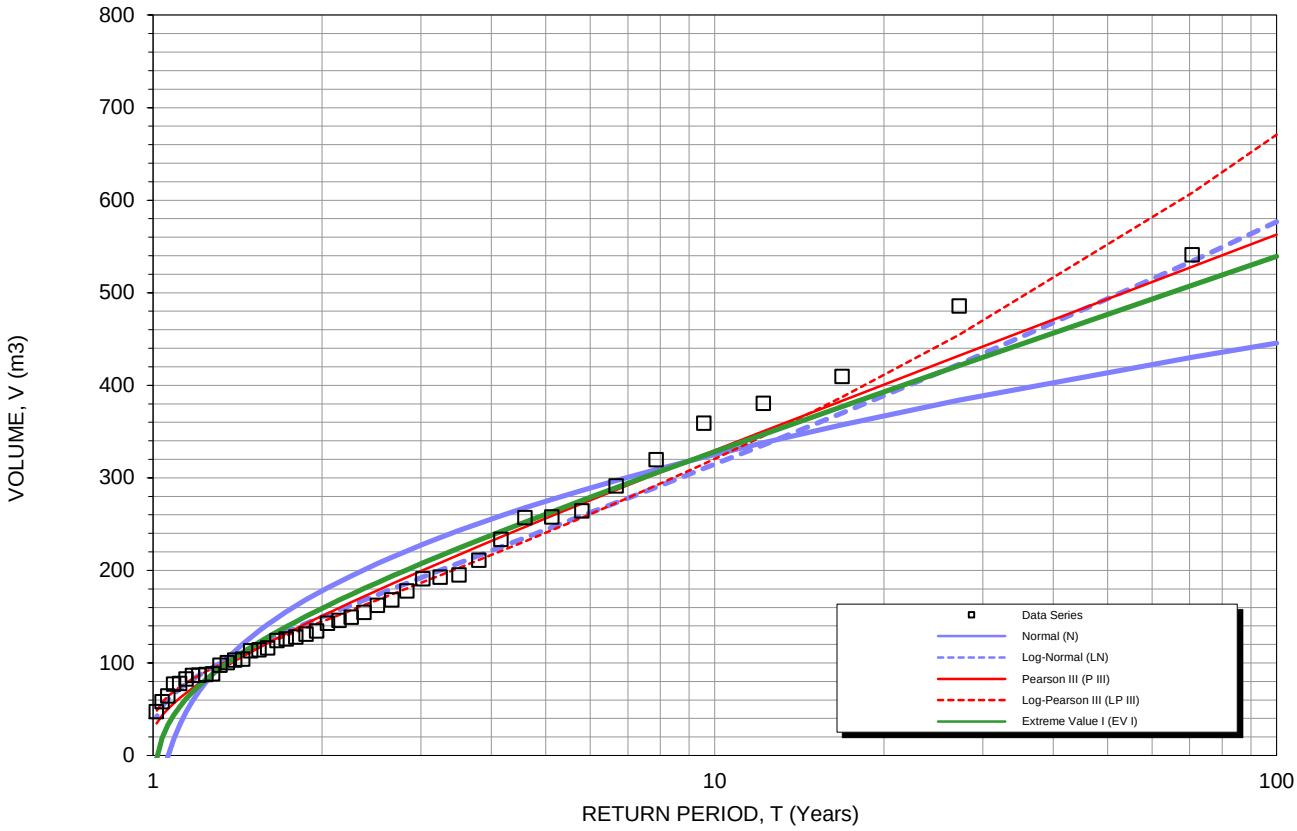
Figure No.
5.3

Title
SANDHILL ESTATES
DITCH CROSS SECTION

Figure 5.4 Sandhill Estates Pond Infrastructure



Summary of Results

T (Years)	Total Volume, Including Permanent (m3)					Active Volume
	N	LN	P III	LP III	EV I	for LP III (m3)
2	178	150	151	145	159	150
5	275	244	256	241	261	244
10	325	315	330	321	328	315
25	379	413	424	442	413	413
50	414	493	493	549	477	493
100	446	577	563	671	539	577
Correlation	0.917	0.992	0.991	0.989	0.978	
Std. Error	45	13	15	16	23	

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Sandhill Estates

Figure No.

5.5

Title

Frequency Distributions
Sandhill Estates Pond
Post Development Condition

REFERENCES

1. Alberta Environmental Protection; Stormwater Management Guidelines for the Province of Alberta; January, 1999

2. County of Lacombe; Operations Standards Manual; January, 2011

3. City of Calgary; Stormwater Management & Design Manual; 2011

4. Computational Hydraulics International; Users' Guide to SWMM5; 2010

5. Alberta Environmental Protection; Municipal Policies and Procedures Manual; April, 2001

6. MPE Engineering Ltd.; Master Drainage Plan for the Wolf Creek and Whelp Brook Watersheds; 2014