PRAIRIE GATEWAY
MASTER DRAINAGE PLAN
ISSUED FOR SUBMISSION

May 13, 2024

Prepared for:
Rocky View County (Planning Services)
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Issued for Submission

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Issued for Submission

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The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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Executive Summary

On behalf of Rocky View County (Planning Services), this Master Drainage Plan (MDP) has been prepared to support the Prairie Gateway Area Structure Plan (ASP) submission. The MDP study area is located in Rocky View County (RVC), on the eastern boundary of the City of Calgary (CoC) and includes the ASP lands (903 ha) and the east external upstream contributing drainage area (655 ha). Adjacent areas to the north, northwest, west and south were evaluated only for storm trunk sizing purposes and were not analyzed in detail.

The ASP lands and east external upstream contributing lands were both modelled to represent an existing condition (undeveloped), an interim condition (ASP lands are fully developed and external upstream lands are under the existing condition), and an ultimate condition (ASP lands and external upstream lands are fully developed). These model runs and the analysis of existing topography, hydrogeology and wetland assessments, informed the stormwater management concept.

ASP Study Area Stormwater Management Concept

Under existing conditions, the ASP lands largely pond stormwater in 5 main internal wetlands, and recharge the groundwater, with a small 141 ha area that drains north to existing wetlands between the ASP lands and the Shepard Slough Complex. The five main internal wetlands are currently shown in the MDP as being removed, but this assumption is only related to stormwater management facility sizing and is intended to be reviewed with a Wetland Retention Decision Matrix in this report.

The proposed stormwater management concept breaks up the ASP lands into four main catchments with three Stormwater Management Facilities (SWMFs) (1, 2 and 3) that will convey the flow to the west to a proposed storm trunk that flows south following RR 284, and then west along TWP 231 until it connects to the existing Shepard Ditch south of the Shepard Wetland. Each of the proposed SWMFs is comprised of cells that are separated by berms that are intended to be a route for rail or roads to cross the water bodies. The cells are connected by conduits under the berms.

An overland emergency flow path for SWMFs 1 and 3 runs north to the existing wetlands between the ASP lands and the Shepard Slough Complex. The proposed SWMF 2 does not have a desirable overland emergency flow path due to difficult grading and there being no eventual outlet beyond the railway crossing. Therefore, it was determined that oversizing the outlet pipe from SWMF 2 was a preferable design to accommodate an emergency flow instead of the overland emergency flow path.

The fourth catchment within the ASP lands is only 5.5 ha, and under a development condition of 90% imperviousness, was found to produce a total volume discharge over the stretch of 55 years continuous modelling that closely matched the existing discharge volume. The purpose of matching the total volume discharge to the north existing wetlands between the ASP lands and the Shepard Slough Complex is to maintain the hydroperiod of those existing wetlands.

East External Upstream Lands Stormwater Management Concept

Under existing conditions, the east external upstream lands have many small wetlands and depressions that hold the runoff. There is an existing catchment that is 134 ha that flows north to the existing wetlands between the MDP lands and the Shepard Slough Complex.

In the proposed stormwater management concept, the east external upstream lands are divided into four main catchments with three SWMFs (4, 5 and 6). Three catchments each have a proposed SWMF, SWMF 4, 5 and 6. Proposed SWMFs 4, 5 and 6 convey flow through pipes to SWMFs 3, 1 and 2, respectively. SWMF 4 has an overland emergency flow route to SWMF 3, SWMF 5 has an overland emergency flow route to SWMF 1, and SWMF 6 has an overland emergency flow route to SWMF 2.

The fourth catchment, 10.1 ha located along the north side of the external upstream lands, was separated from the first three catchments as the fourth catchment drains to the existing wetlands between the MDP lands and the Shepard Slough Complex to the north of the site to maintain the hydroperiod of the existing wetlands.

SWMF Design

A PCSWMM model was created and run for the 1:100 year, 24 hour, single storm event, and a continuous flow (using a statistical analysis) for the MDP study area, and the more conservative values were chosen to size the SWMFs. The SWMFs store and release the stormwater at a controlled Unit Area Release Rate (UARR) of 0.8 L/s/ha. SWMF and pipe sizes are preliminary and will be subject to change during the preparation of the Stage Master Drainage Plan (SMDP).

A summary of the results of the 1:100 year, 24 hour single event and continuous simulation for the interim and ultimate post development condition are shown below in **Table ES 1.**

Table ES 1: Summary of SWMFs proposed in the Prairie Gateway MDP

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
Pond Info	Design HWL Elev (m)	1020.5	1021	1021.5	1025	1024	1024
	HWL Depth (m)	2	2	2	2	2	2
	NWL Elev (m)	1018.5	1019	1019.5	1023	1022	1022
	Bottom Elev (m)	1016.5	1017	1017.5	1021	1020	1020
	HWL Volume (m^3)	394,020	335,580	318,350	200,660	144,110	385,790
	Overland Spill Elev (m)	1020.5	1021	1021.5	1025.0	1024.0	1024.0
	Overland Spill Depth (m)	2	2	2	2	2	2
	Catchment Area (ha)	475.2	643.2	442.1	176.0	130.4	348.4
	Allowable Flow at 0.8 L/s/ha (L/s)[1]	380	515	354	141	104	279
	Orifice Size (mm) [1]	380	450	390	235	194	325
	Top of SWMF Perimeter Elevation (m)	1021.5	1022	1022.5	1026	1025	1025

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
	Overflow Weir Depth at 1 m^3/s	0.44	0.44	0.44	0.44	0.44	0.44
	Freeboard, Overflow Depth to Top of SWMF (m)	0.56	0.56	0.56	0.56	0.56	0.56
100-yr, 24 hr	Max Water Level (m) above NWL	1.43	1.35	1.36	1.39	1.43	1.40
	Max Wat Elev (m)	1019.93	1020.35	1020.86	1024.39	1023.43	1023.40
	% Full (HWL)	71.6%	67.3%	68.1%	69.3%	71.6%	70.2%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.307	0.411	0.269	0.116	0.088	0.228
	Max Outflow (L/s/ha)	0.647	0.638	0.609	0.657	0.671	0.654
	Max Active Volume (m^3)	265,420	221,000	207,050	136,000	100,900	266,800
	Max Active Volume (m3/ha)	559	344	468	773	774	766
Continuous	Max Water Level (m) above NWL	1.93	1.89	1.92	1.90	1.93	1.91
	Max Wat Elev (m)	1020.43	1020.89	1021.42	1024.90	1023.93	1023.91
	% Full (HWL)	96.3%	94.4%	96.0%	94.9%	96.3%	95.7%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.369	0.507	0.345	0.140	0.103	0.273
	Max Outflow (L/s/ha)	0.776	0.788	0.781	0.793	0.790	0.785
	Max Active Volume (m^3)	369,690	313,600	301,300	189,700	138,300	368,500
	Max Active Volume (m^3/ha)	778	488	682	1,078	1,061	1,058
	Freq Analysis 100 yr Water Level (m) above NWL	1.91	1.96	1.93	1.87	1.89	1.99
	Freq Analysis 100 yr Active Volume (m^3)	367,000	325,000	303,000	188,000	136,000	384,000

Next Steps

Advancing the MDP to the SMDP will require additional studies, site visits and further assessments. There is a planned MDP revision due to time constraints on the current version of the MDP and the time of year not allowing for a field program to obtain hydrogeology, geotechnical and survey data. After the site investigations, field programs and assessments of the retrieve data, the results will be compared with the input parameter assumptions for the existing conditions, interim development, and ultimate development models and if the parameters assumed differ from the field data, the model parameters will be updated. The three models will then be rerun and SWMF sizing reviewed. See **Table ES 2** for a detailed list of the requirements for the MDP revision.

Note, if the current landowner does not grant access to the site for the field programs, the nearest data points obtained will be extrapolated to include the land not accessed.

The “Prior to Impacted SMDP” line items in **Table ES 2** are intended to be completed for only the areas that are to be included in that upcoming SMDP. The items are required to gain the additional site-specific information to complete the full SMDP.

Table ES 2: Next Steps to Further the Stormwater Management Concept Design for the MDP Study Lands

Study	Section Reference	Notes	Purpose of Data Obtained
MDP Revision			
Site Investigation	3.2.1, 3.2.10	• Confirm culvert crossings/ boundary conditions within MDP study area, and at boundaries • Culvert data: material, inverts, diameter, condition within MDP study area, and at boundaries	• Update in model if required.
General Hydrogeology Investigation	3.1, 3.2.7	• Initial water levels for surface and groundwater • Hydraulic conductivity testing • Testing for surface and ground water general chemistry • Commence 1 year of monitoring for surface water level of wetlands and ground water level monitoring	• Extrapolate using data gathered to overall MDP to confirm model input parameters. Update in model if required. • Add hydraulic conductivity to existing model
General Geotechnical Investigation	3.2.6.3	• Confirm soil type • Infiltration testing	• Extrapolate using data gathered to overall MDP to confirm model input parameters. Update in model if required. • Revised hydrology model and hydrogeology assessment with updated soil type and infiltration rate.
Wetland Retention Performance Criteria	2.3.1	• Hydroperiod (stage duration curve) for any wetland likely to be retained from within the 17 wetlands that are being reviewed for crown claimability. • General water quality for discharge to a retained wetland inside or outside the MDP.	• Flow, volume, water quality targets • Will not be able to provide any single wetlands specific water quality requirements
Rerun MDP models		• Update soil type, hydraulic conductivity, groundwater and surface water connections	• Update/optimize stormwater management concept including SWMF sizing and location.
Prior to Impacted SMDPs			
Hydrogeology Investigation	3.1, 3.2.7	• Complete 1 year of ground water monitoring well data • Hydraulic conductivity testing • Surface and groundwater sampling and general chemistry testing	• Evaluate changes in groundwater levels and flow patterns over time. • Evaluate chemistry for potential groundwater-surface water interactions
Surface Water Level Monitoring	3.1.3	• Complete 1 year of monitoring for surface water level of wetlands.	• Evaluate interaction between groundwater and surface water • For detailed stormwater modelling in SMDP
Geotechnical Investigation	3.2.6.3	• Confirm SMDP site specific soil type and conditions.	• For detailed stormwater modelling in SMDP • To update infrastructure cost estimate and modify design if required.
Water Body Permanence Assessment Results	2.2	• Receive initial confirmation of which wetlands of the 17 reviewed are Crown claimable	• For wetland retention determination in SMDP.
Bed and Shore Survey	2.2	• Confirms boundary for any Crown wetland's legal boundary	• Use boundary for outline plan and detailed design.

Study	Section Reference	Notes	Purpose of Data Obtained
Capital Infrastructure Design (to be completed by City of Calgary)			
Site Survey	4.4, 5.2.4	• Confirm RR 284 drainage elevations. • Topo elevations along route of trunk to Shepard Ditch tie in. • Shepard Ditch cross sections, existing culvert sizes and inverts near tie in location.	• Use during SMDP to confirm daylight location for storm trunk, and storm trunk cover. • Use for design of daylight location, and ditch upgrades from daylight location to existing Shepard Ditch.
Geotechnical Investigation	3.2.6.3	• Confirm soil type, conditions, groundwater level, bedrock depth	• To use in trunk design and cost estimating.
Assessment of Existing Conditions of Shepard Ditch	5.2.4	• Site visit to assess stability, erosion and seepage concerns related to the tie in.	• Suggest erosion mitigation measures for tie in location.

SMDP's developed for the Prairie Gateway MDP study area are required to include additional items to the standard SMDP due to the site-specific nature of wetlands within the MDP study area. These additional items, listed in **Table ES 3** are to be completed for the SMDP area at the time a developer is interested in pursuing development, as there will likely be many SMDPs with potentially different developers covered by this MDP.

Table ES 3: SMDP Requirements

SMDP Phase	Section Reference	Notes
CoC requirements		• Chapter 11 of the CoC Stormwater Design Manual, and any applicable bulletins or updated CoC Storwmater Design Manuals.
Wetland Confirmation with SMDP Boundary	2.2	• Update stormwater management concept to retain wetlands if wetland decision matrix required retention.
Biophysical Impact Assessment	Appendix A	• To support wetland decision matrix assessments.
• Minimum road and building elevations. • Appropriate horizontal setback horizontally from the major drainage infrastructure • Discharge configuration for flows directed to the wetlands to the north of the ASP lands to mimic the existing flows. The SMDP will also need to consider the water quality of the flow entering the retained wetlands, and the existing wetlands to the north of the ASP study area, between the ASP lands and the Shepard Slough Complex. • SMDP to also determine the requirements of the forebay design or OGS design for SWMFs.		

Acronyms / Abbreviations

AEPA	Alberta Environment and Protected Areas
ASP	Area Structure Plan
BMP	Best Management Practice
CoC	City of Calgary
CPKC	Canadian Pacific Kansas City
DEM	Digital Elevation Model
ECRDS	East Calgary Regional Drainage Study
ECGWM	East Calgary Regional Drainage Study Grassland and Wetland Mapping
EPEA	Environmental Protection and Enhancement Act
ESA	Environmental Site Assessments
ESAR	Alberta Environmental Site Assessment Repository
GIS	Geographic Information System
HGL	Hydraulic Grade Line
HWL	High Water Level
LID	Low Impact Development
LiDAR	Light Detection and Ranging
m BGS	Metres Below Ground Surface
MDP	Master Drainage Plan
NWL	Normal Water Level
OPC	Opinion of Probable Cost
RR	Range Road
ROW	Right of Way
RVC	Rocky View County
SCP	Source Control Best Management Practices
SMDP	Stage Master Drainage Plan
SWMF	Storm Water Management Facility
TOR	Terms of Reference
TWP	Township Road
UARR	Unit Area Release Rate

1 Introduction

The Prairie Gateway is a proposed logistics center that is the result of a joint effort between the City of Calgary (CoC), Shepard Development Corporation, and Rocky View County (RVC). There is an Area Structure Plan (ASP) submission for the Prairie Gateway lands which is a policy document that guides future land use, infrastructure development, and community growth within the development, and this Master Drainage Plan (MDP) has been developed to support the above ASP.

The MDP will guide the ultimate stormwater management strategy for the ASP lands. The document addresses the current and future needs of the ASP lands considering the natural topography, downstream receiving areas, proposed grading and addressing potential flooding issues. The report includes recommendations of size and location of proposed stormwater management facilities (SWMFs), desktop hydrogeological evaluation, desktop wetland and natural drainage course mapping, classification, analysis, and recommendations for future work.

The overall MDP will inform the design of the next stage of stormwater management planning for development. For the CoC the next stage is Stage Master Drainage Plan (SMDP), but RVC does not have this requirement. RVC typically uses a Sub-Catchment Master Drainage Plan (SCMDP) for land use planning and re-designation. RVC has agreed that the CoC design process and methodology for planning will be followed.

The following section describes the Terms of Reference (TOR) developed between the Stantec and the CoC and RVC dated March 2024, defines the MDP study scope and objectives.

1.1 Objective

The objectives of the MDP (also described in the TOR) are listed below:

The MDP will follow section 11.1.3 and checklist #9 of the 2011 City of Calgary Stormwater Management and Design Manual. The primary objectives of this MDP are as follows:

- Lay out the ultimate stormwater drainage plan.
- Establish existing parameters for drainage courses and wetlands in order to assess impacts of development on the environment and existing wetlands.
  - Note, the general water quality for discharge to a retained wetland inside or outside the MDP will be provided in the MDP revision.
- Develop a phasing strategy that most economically utilizes existing infrastructure and sets up subsequent phases for expansion, and by considering neighboring future, existing and ongoing development.
- Assess the existing stormwater management infrastructure and the existing condition flows in the East Calgary regional drainage basin and identify areas for expansion to meet the demands of the anticipated growth.
- Identify any discrepancies or dependencies from the ECRDS Phase 1 and align with work being completed on the ECRDS Phase 2.

- Coordinate boundary conditions and analyze offsite requirements with RVC and CoC and complete any off-site analysis that is required and not already being undertaken within an acceptable timeline by other initiatives, for example the ECRDS Phases 1 or 2.
- Establish design criteria to ensure compliance with all relevant federal, provincial, and municipal (CoC and RVC), and environmental and stormwater regulations, standards and guidelines and identify and reconcile any conflicting drainage standards or standards deviations.
- Analyze the projected development stormwater flows for the lands within the ASP boundary based on proposed land uses and anticipated end users to ensure post development flows do not exceed allowable recommended runoff rates.
- Identify optimal locations for stormwater management facilities and routing of stormwater infrastructure and provide preliminary grading design and planning overland drainage escape routes.
- Explore Low Impact Development Strategies and/or Water Reuse Strategies to minimize downstream impact.
- Outline specific design requirements and prerequisite investigations identified by the MDP and outline their relationship to and timing for resolution with the planning continuum and approval authority.

1.2 Study Area

The subject land is located in Rocky View County on the eastern boundary of the City of Calgary, see **Figure 1-1**Error! Reference source not found.. The study area includes the Prairie Gateway ASP area (903 ha) as well as upstream external areas confirmed to drain towards or through the ASP area (655 ha), see **Figure 1-2** Error! Reference source not found.for a map of the study area boundary. The bounding lands for the ASP area are the Canadian Pacific Kansas City (CPKC) Rail mainline to the south, the abandoned rail (ROW) to the north, and range roads 284/282 to the east and west.

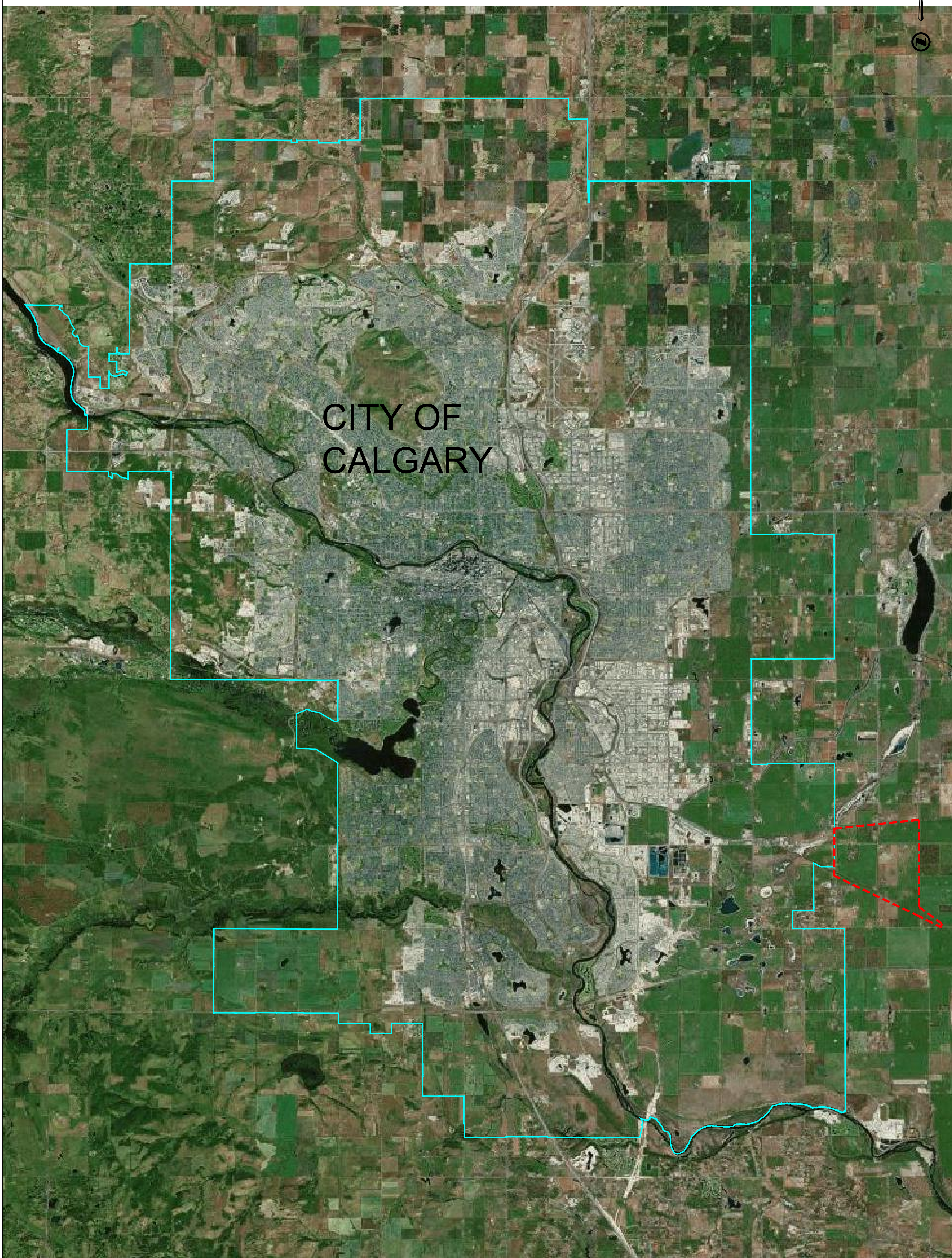
The upstream external areas which extend eastward from the ASP boundary, north of the existing rail line and south of the abandoned rail right of way, were determined based on the existing drainage patterns of the lands. The total of the upstream external land and the ASP study area make up the MDP study extents.

At the request of the CoC and RVC, additional areas adjacent to the ASP study area south, northeast and northwest were included as “adjacent lands” so that their contributions to the downstream storm trunk infrastructure (and any impacts on the ASP and upstream lands) could be assessed. However, this report will not be examining servicing constraints, wetland retention, or any other considerations for these adjacent lands therefore they cannot be considered part of the MDP study area. The report is also not assessing the Shepard Slough Complex or lands upstream of the Shepard Slough Complex (ie. areas north of Glenmore).

Currently, the ASP study area is mostly cultivated land, with a small amount of existing light industrial development. Upstream external areas are mostly undeveloped agricultural land except for some rural large residential lots to the southwest of the site. Amongst the agricultural land to the west of the site is the Shepard Wetland which is a significant wetland feature for the Calgary region as the wetland acts as stormwater storage and treatment for much of East Calgary.

The topography within the ASP study area is relatively flat (approximately 0.2% grade rising from west to east within the study area, see **Figure 3-5** for existing ground topography) with some lower depressions that are seasonally wet and semi permanent wetlands, see **Section 2** for wetland details. Most of the rainfall received by the ASP study area ponds within the lands in these low depressions. There are two locations in which the flow exits the ASP study area to the north across Township Road 232 (TWP); represented by black arrows in **Figure 1-2.**

According to estimates, the soils in the ASP study area are predominantly sandy clay loam based on the Hydrogeological Assessment summarized in **Section 3.1**. To simulate the infiltration process, the model utilized the suggested infiltration parameters from the 2011 City of Calgary Stormwater Management and Design Manual for sandy clay loam soil.



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PRAIRIE GATEWAY ASP AREA

CITY OF CALGARY BOUNDARY

Notes

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SHEPARD DEV. CORPORATION

PRAIRIE GATEWAY
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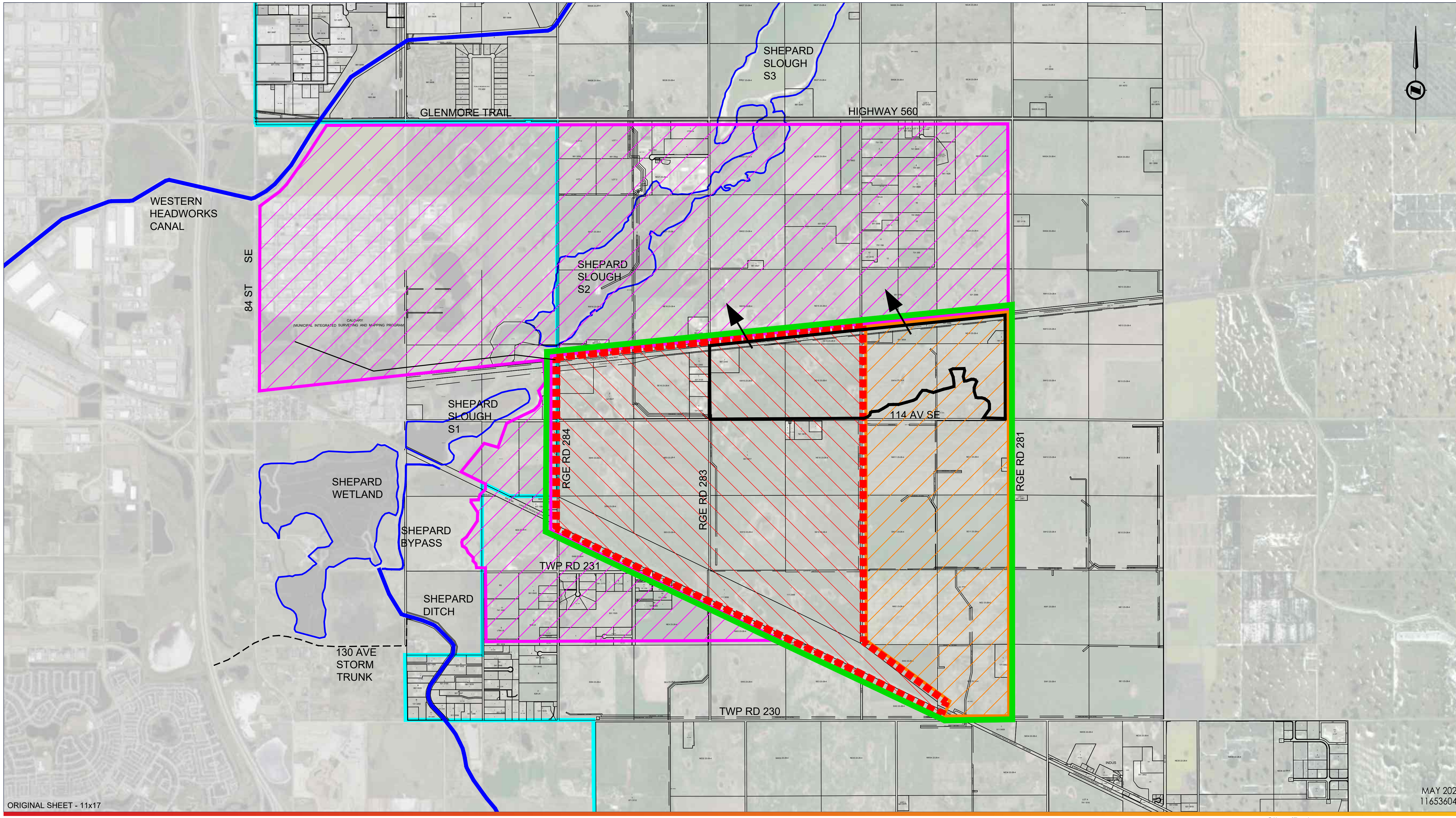
Figure No.

1.0

Title

LOCATION PLAN



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Legend

- PRAIRIE GATEWAY ASP AREA
- CITY OF CALGARY LIMITS
- MDP STUDY AREA
- EXTERNAL UPSTREAM AREA
- ADJACENT LANDS
- EXISTING CONDITIONS DRAINAGE BOUNDARY

Notes

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PRAIRIE GATEWAY
MASTER DRAINAGE PLAN

Figure No.
1.2

Title
STUDY AREA

1.3 Guiding Documents

The below legislation, regulations, policies and other guidelines and plans apply directly to the design, construction, operation and maintenance of drainage infrastructure within the ASP lands.

1.3.1 FEDERAL

- The Canadian Environmental Protection Act, 1999, c. 33 (CEPA).
- Department of the Environment Act, 1985, c. E-10 regards the preservation and enhancement of the quality of the natural environment, including water, air and soil quality.
- Migratory Birds Convention Act, 1994 c.22, prescribes the protection areas for migratory birds and nests which relates to wetland disturbances.
- Canadian Standards Association, W211:21, 2021, is the national stormwater management standard and it includes a list of the components required when creating an MDP.

1.3.2 PROVINCIAL

- Alberta Environment and Protected Areas (AEPA) administers water conservation and protection through the *Environmental Protection and Enhancement Act (EPEA)* and the *Water Act, 2023*. The *Water Act* also sets requirements for MDPs and provides the framework for the Alberta Dam and Canal Safety Directive, 2018.
- The EPEA includes the *Stormwater Management Guidelines for the Province of Alberta,1999*, and *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, 2012*, which provide the planning and design guidelines for storm drainage systems in Alberta and Best Management Practices (BMP) for conveyance of stormwater and flood control.
- The *Public Lands Act, 2022*, states the Government of Alberta owns the naturally occurring bodies of water within the province including wetlands and any activity within the wetlands requires departmental approval.
- The *Alberta Wetland Policy, 2013*, provides guidance on the wetland value and management. Where development is planned, the policy promotes avoiding and minimizing the impacts of development to the wetland, and if impacts cannot be avoided, wetland replacement or advancing wetland science and management may be acceptable.

1.3.3 MUNICIPAL

1.3.3.1 City of Calgary

- City of Calgary Stormwater Management and Design Manual 2011 detailed guidelines for design of major and minor stormwater management systems. The CoC amends the guidelines by issuing bulletins, and a few of the notable stormwater bulletins are listed below, note this is not an exhaustive list.

- City of Calgary Water Resources/Water Services Amendments to the 2011 Stormwater Management & Design Manual, Industry Bulletin, 2013 regarding reducing SWMF sediment accumulation.
- City of Calgary Water Resources/Water Services Interim Runoff Volume Control, Industry Bulletin, 2019 provides an update to the industrial development average annual runoff volume target.
- City of Calgary Stormwater Management Facilities (SWMFs) and Miscellaneous Items, Industry Bulletin 2023, details the options available if it is demonstrated that it is not practical for an overland emergency to accommodate major rain events.

- City of Calgary Climate Projections for Calgary 2022, provides a precipitation forecast for the 1:100-year storm projected to the year 2050 and 2080
- Instruction Manual for ESC Plan Applications 2022, provides the requirements for ESC during construction and the guideline to meet for sediment loss.
- Design Guidelines for Subdivision Servicing 2020 defines stormwater trunks that are CoC funded by size and provides specific storm pipe design criteria.
- City of Calgary Wetland Conservation Plan 2004 sets priorities for the CoC's higher value existing wetlands to be retained and provides mitigations within the development approval process for wetland disturbance. The plan is designed to achieve no net loss of Calgary's wetlands.

1.3.3.2 Rocky View County

- Rocky View County Servicing Standards 2013 detailed guidelines for design of major and minor stormwater management systems.
- Rocky View County has agreed that it is acceptable for the purposes of this MDP, for the design to adhere to the CoC standards and planning to follow the CoC methodology.

1.3.4 STUDIES AND PLANS

1.3.4.1 Prairie Gateway Area Structure Plan

The Prairie Gateway ASP guides the proposed development of the area including land use, transportation and access and site servicing. The MDP supports the ASP by further defining the stormwater management strategy for the ASP development area and accommodates the development of the east external upstream lands within the ASP stormwater management concept.

1.3.4.2 East Calgary Regional Drainage Study Phase 1 (ECRDS)

The ECRDS, prepared by Kerr Wood Leidal (KWL) for the City of Calgary, reviewed the existing drainage conditions and developed preliminary conceptual servicing options for the ultimate development of the study area covering 23,800 ha from the north side of the CoC to the southeast corner of the CoC and into RVC, which includes the MDP study area.

KWL completed site visits in 2021 and confirmed that the lands to the east and south of the Shepard Wetlands have no obvious drainage paths to the Shepard Ditch but is very flat with pothole wetlands and likely groundwater contribution.

Under the post development conditions ECRDS Phase 1 proposed that a majority of the MDP study area ties into Shepard Ditch. The remainder of the post development flow drains north near Shepard Slough S2, and drainage required treatment and control to abide by the *Water Act* and *Public Lands Act*. See **Table 1-1** for a summary of the results of the ECRDS Phase 1 Study.

Concerns for the 1:100-year, 24-hour storm event are:

- Shepard Bypass flows 1:100 year are exceeding the design flow,
- Shepard Bypass culvert end requires rehabilitation.
- Shepard Ditch culverts crossing private access south of TWP 224 are currently undersized. The crossing has a capacity of 16 m^3/s and the design flow is estimated to be greater than 25 m^3/s

The report compiled the unit area release rate (UARR) for the Prairie Gateway Area. The UARR ultimately draining to the ditch was 2.5 L/s/ha and the UARR ultimately draining to the Shepard Bypass was 0.8 L/s/ha.

Based on Memo *Prairie Gateway ASP – Stormwater – Master Drainage Plan – Unit Area Release Rate* (City of Calgary (CoC), 2024) the CoC recommends limiting the UARR to 0.8 L/s/ha for the entire Prairie Gateway Area until an opportunity to increase the rate is fully evaluated by the CoC and RVC

Table 1-1: Summary of ECRDS Phase 1 Model Results

Storm Infrastructure	Location of Reach	Physical Characteristics	Design Flow	Existing Max Flow (1:100 yr, 24 hr)	Ultimate Max Flow (1:100 yr, 24 hr)	Notes
Shepard Slough S2	North of MDP Study Area	• Significant semi-permanent (Class IV wetland) water body • Spill elevation 1015.78 • Discharges to Shepard Slough S1	N/A			• Stormwater treatment and control required prior to entering the slough.
Shepard Bypass	East of Shepard Wetland	• Grassed channel. • 3 m bottom • 3H:1V side slope • Crosses under the abandoned rail ROW in a culvert • Discharges to Shepard Ditch through 1.2 m diameter CSP culvert	2 m^3/s	0.45 m^3/s	2.12 m^3/s	• **Channel capacity exceeded for ultimate condition**, but was still within the culvert capacity. • **CSP culvert end is eroded.**
Shepard Ditch	Shepard Wetland Discharge Bay	• Gravel armour channel • bottom of 8.5 m to 9.5 m • 2.5H:1V side slope	8.5 m^3/s	3.67 m^3/s	7.31 m^3/s	• Only used 86% of it's capacity during the ultimate condition
	HWY 22X	• Same cross section as above	15 m^3/s	4.86 m^3/s	9.08 m^3/s	• Some sedimentation along inside of bends and minor bank erosion was noted
	178 Avenue SE	• Same cross section as above • Private crossing south of TWP 224 currently undersized (16 m^3/s crossing capacity)	23 m^3/s	9.13 m^3/s	16.05 m^3/s	• **Design flow limited by private crossing.**
Outfall B137	Bow River	• Concrete chute • 2 m high x 2.5 m wide • 3H:1V side slope	> 25 m^3/s (estimated)	9.16 m^3/s	16.05 m^3/s	• Only used 64% of it's capacity during the ultimate condition, • Prone to debris accumulation

2 Wetlands

There are two wetland studies that were completed by Stantec to support the ASP submission. An "Environmental Screening Addendum – Prairie Gateway (Shepard Industrial lands) Area Structure Plan", dated May 2024. Subsequently, a "Water Body Permanence Assessment" dated February 2024 was prepared to assess the Crown claimability of the wetlands identified in the Environment Screening Report.

2.1 Environmental Screening Addendum Summary

The Environmental Screening Addendum identified and classified wetlands within the ASP study lands and compares the wetland classification to the WSP Golder report, "East Calgary Regional Drainage Study Grassland and Wetland Mapping" dated July 19, for the Shepard Industrial ASP. In summary the Environmental Screening Addendum identifies:

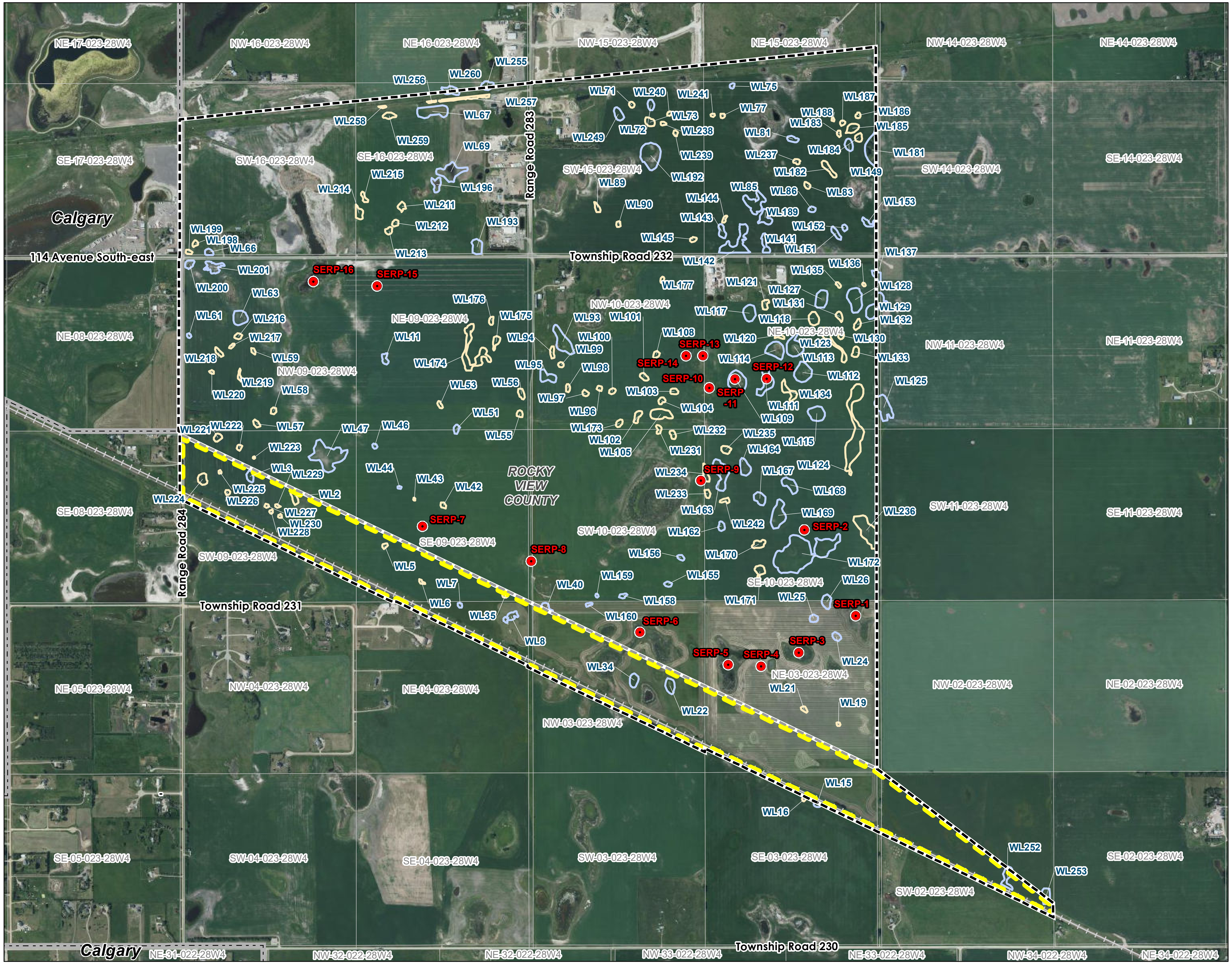
- 287 wetlands within the ASP boundary:
  - 110 ephemeral waterbodies (only brief surface water is present)
  - 79 temporary graminoid marshes (MGII)
  - 82 seasonal graminoid marshes (MGIII)
  - 15 semi-permanent graminoid marshes (MGIV)
  - 1 semi-permanent shallow open water (WAIV)

See **Figure 2-1** and **Figure 2-2** for a map of all of the wetlands within the ASP boundary and their class.

The Environmental Screening addendum concludes that "future decisions around wetland retention will need to be informed by field studies as part of the BIA and the outcome of the Crown claim determination" (Stantec Consulting Ltd., 2024). The report also mentions mitigations that should be considered during the design phase include:

- Locating stormwater management facilities in the approximate location of existing wetlands to maintain existing topography where possible.
- Looking at options to integrate components of wetlands into stormwater management facilities.
- Designing SWMFs as constructed wetlands.
- Considering salvage of wetland soils for use within the proposed SWMF stormwater construction.

The full Environmental Screening Report can be found in **Appendix A Environmental Screening Addendum – Prairie Gateway (Shepard Industrial lands) Area Structure Plan**



Area Structure Plan (ASP) Boundary

Canadian Pacific Kansas City (CPKC) Corridor

Rare Plant Targeted Survey (SERP)

Wetland Class

Ephemeral Waterbody

Graminoid Marsh - Temporary (MGII)

Railway

Municipal Boundary

Quarter Section

N

0 250 500 metres

(At original document size of 11x17)
1:18,500

Notes

1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary

Project Location
SE Calgary
Alberta

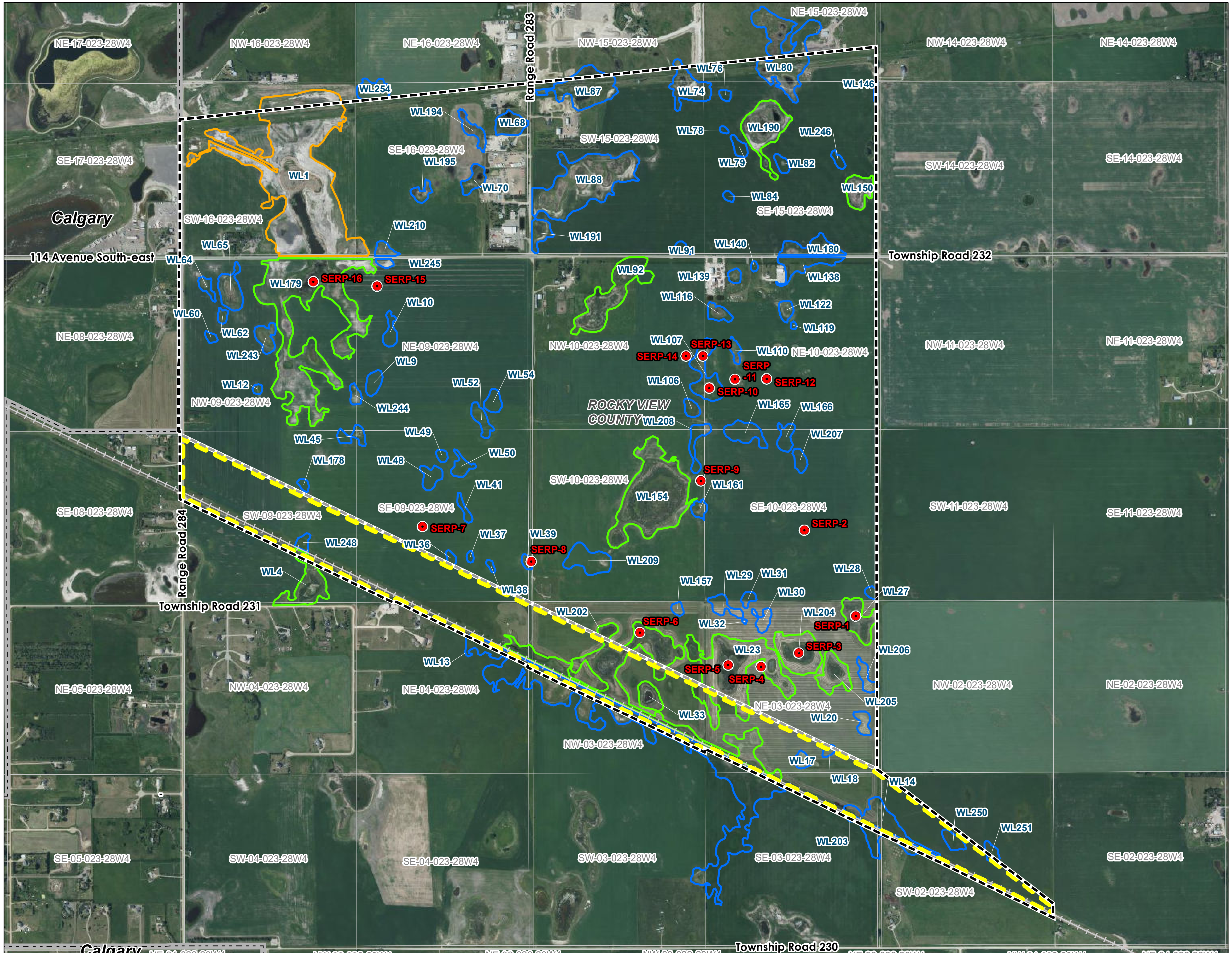
Prepared by DSPRY on 2024-02-07
TR by KFOUQUETTE on 2024-02-07
IR Review by MCHISHOLM on 2024-02-07

Client/Project 116536040_001
Shepherd Development Group
Environmental Screening Addendum
Prairie Gateway (Shepard Industrial Lands)
Area Structure Plan

Figure No.
2-1

Title
Area Structure Plan (ASP) Overview - Ephemeral Waterbodies and Class II Wetlands

W:\Clients\Shepard_Development_Corp\Shepard_Industrial_ASP\Figures\116536040_001_EW_II_Overview.mxd Revised: 2024-03-19 By: dcspry



Stantec

Area Structure Plan (ASP) Boundary
Canadian Pacific Kansas City (CPKC) Corridor
Rare Plant Targeted Survey (SERP)

Wetland Class

Graminoid Marsh - Seasonal (MGIII)
Graminoid Marsh - Semi-permanent (MGIV)
Shallow Open Water - Semi-permanent (WAIV)
Railway
Municipal Boundary
Quarter Section

N

0 250 500 metres

(At original document size of 11x17)
1:18,500

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary

Project Location
SE Calgary
Alberta

Prepared by DSPRY on 2024-02-07
TR by KFOUQUETTE on 2024-02-07
IR Review by MCHISHOLM on 2024-02-07

Client/Project 116536040_002
Shepherd Development Group
Environmental Screening Addendum
Prairie Gateway (Shepard Industrial Lands)
Area Structure Plan

Figure No.
2-2

Title
Area Structure Plan (ASP) Overview - Class III and IV Wetlands

W:\Clients\Shepard_Development_Corp\Shepard_Industrial_ASP\Figures\116536040_002_III_Above_Overview.mxd Revised: 2024-03-19 By: dcspry

2.2 Water Body Permanence Assessment Summary

As a recommendation from the Environmental Screening Addendum, a Water Body Permanence Assessment was completed to assess the Crown claimability of the 287 wetlands classified within the ASP study area, with 17 of those wetlands determined to be potentially Crown claimable. Of the seventeen wetlands:

- 4 were classified as seasonal graminoid marshes (MGIII)
- 12 were classified as semi-permanent graminoid marshes (MGIV)
- 1 was classified as a semi-permanent shallow open water wetland (WAIV)

See **Figure 2-3** for the locations of the classified and assessed wetlands within the ASP study area. The Water Body Permanence Assessment was submitted to the AEPA for an opinion on whether any of the Study area wetlands may be claimed by the Crown. See the full Water Body Permanence Assessment in **Appendix B: Waterbody Permanence Assessment – Prairie Gateway (Shepard Industrial lands) Area Structure Plan.**

Stantec

Area Structure Plan (ASP) Boundary

Wetland Class

- Graminoid Marsh - Seasonal (MGIII)
- Graminoid Marsh - Semi-permanent (MGIV)
- Shallow Open Water - Semi-permanent (WAIV)

Railway

Municipal Boundary

Quarter Section

N

0 250 500 metres

(At original document size of 11x17)
1:18,500

Notes

1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary

Project Location
SE Calgary
Alberta

Prepared by DSPRY on 2024-02-07
TR by KFOUQUETTE on 2024-02-07
IR Review by MCHISHOLM on 2024-02-07

Client/Project 116536040_003
Shepard Development Group
Water Permanence Assessment - Prairie Gateway (Shepard Industrial Lands) Area Structure Plan

Figure No.
2-3

Title
Waterbody Permanence Assessment - Prairie Gateway (Shepard Industrial Lands) Area Structure Plan

W:\Clients\Shepard_Development_Corp\Shepard_Industrial_ASP\Figures\116536040_003_Historical_Overview.mxd Revised: 2024-02-08 By: dcspry

2.3 Post-Development Wetlands Strategy

There have been in depth discussions within the project team and with the CoC and RVC, about the wetlands and level of priority that should be considered for maintaining the wetlands.

For the purposes of sizing the stormwater management infrastructure, it was decided that it would be more conservative to assume that no wetlands would be retained in the ultimate post-development condition. Flexibility was incorporated in the storm servicing concept to allow wetlands to be retained, if the below decision matrix guides the decision to wetland retention.

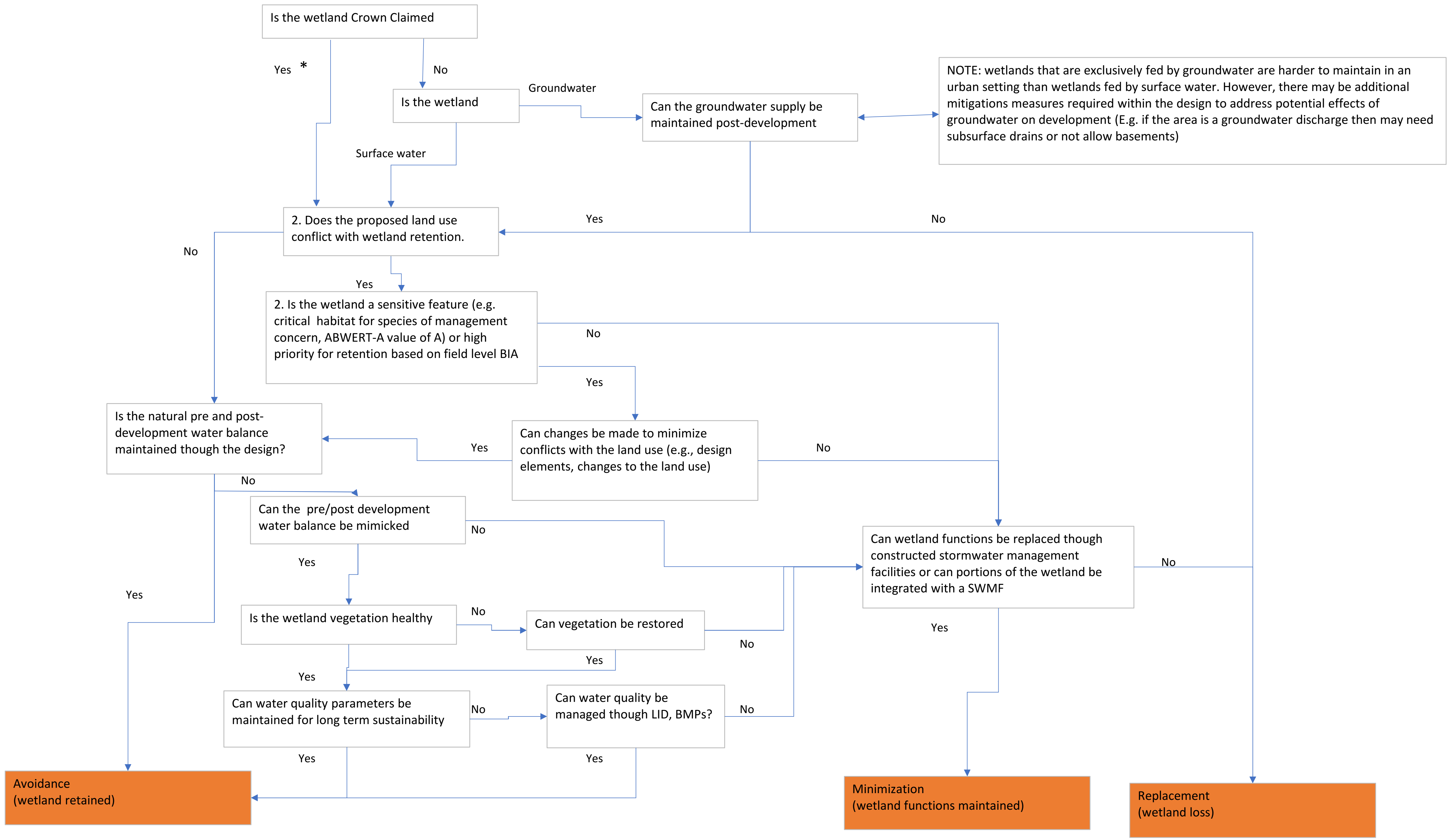
2.3.1 CONSIDERATIONS FOR WETLAND RETENTION

Figure 2-4 is a Wetland Retention Decision Tree that is intended to guide the decision of which specific wetlands should be maintained, removed or if only the wetland functions are to be maintained.

Examples of drainage concept alternatives that could be designed to retain some wetlands under the current concept are listed below:

1. Wetland WL 1, 88,150 and 190 (all north of TWP 232) identified in Figure 2-3 could be considered for retention as most of those wetlands have a high retention value (with semi permanent water presence except for WL 88).
2. With the ASP boundary, portions of Wetland WL 62, 64, 65 and 179 (south of TWP 232, west side of ASP lands) that are adjacent to proposed SWMF 3 could be maintained as the storm trunk was intentionally routed around the wetland to avoid disturbance of the wetland.
3. The development intention of the east external upstream lands of the ASP boundary is currently unknown and wetland retention could be considered in these areas, however, these wetlands have not been classified yet.

Wetland retention performance criteria will be evaluated in an MDP revision to determing the flow, volume and water quality targets for the retained wetlands.



* Note: If crown land cannot be retained there are additional steps that have to be taken for replacement or compensation.

Figure 2-4
Wetland Retention Decision Tree

2.3.2 WETLAND IMPACT OR REMOVAL REQUIREMENTS

Wetlands that would be removed or are otherwise impacted by the proposed developments require approval from:

1. AEPA Public Lands Approval authorities under the *Public Lands Act*, for activities within the bed and shore of any Crown owned wetlands.
2. AEPA under the *Water Act*, which requires compensation for wetlands that aren't Crown claimable, based on the results of a Wetland Assessment Impact Report.
3. AEPA under the *Water Act*, activities which may affect any wetland are subject to the regulatory requirements under the *Water Act*.
4. The CoC in accordance with the City's Wetland Conservation Plan (2004).

3 Existing Conditions Analysis

The pre-development drainage system analysis includes a brief hydrogeological desktop assessment and a subsequent hydrological assessment which uses the hydrogeological and wetland results as inputs to a model to describe the full drainage system within the MDP study area. The pre-development analysis attempts to provide a benchmark to which post-development conditions are compared for the purpose of determining potential impacts and mitigation efforts.

3.1 Hydrogeological Assessment

3.1.1 OBJECTIVES

The objectives of the desktop hydrogeology study are to evaluate the regional and local geologic and hydrogeologic settings of the study area, assess the potential for shallow groundwater flow systems to interact with the project, and identify hydrogeological considerations for the MDP. Due to the limited project timeline, field data collection was not included in the scope of work at this time.

3.1.2 RESULTS

3.1.2.1 Topography and Drainage

The current topography across the study area is relatively flat and the surface morphology is characterized by low relief (<1 m) linear ridges (Alberta Geological Survey (AGS), 2021). KWL completed site visits in 2021 which included the ASP study area, and the study confirmed there is no obvious drainage paths to the Shepard Ditch but is very flat with pothole wetlands and likely groundwater contribution (Kerr Wood Leidal (KWL)., 2023). Several low-lying areas are present within the study area (pre-development condition) as discussed in **Section 1.1** and **Section 2.3**, though it is Stantec's assumption for stormwater facility sizing only, that the wetlands will not be retained post-development at this is the more conservative assumption. Post-development drainage and topography are discussed in **Section 4.3.**

3.1.2.2 Geologic Setting

The surficial geology (**Figure 3-1**) mapped within the study area is Pleistocene age stagnant ice moraine, which is generally composed of glacial tills, though locally stratified glaciolacustrine and/or glaciofluvial sediments may be present (Fenton, et al., 2013). No significant sand and/or gravel deposits were identified within the study area (Hydrogeological Consultants Ltd. (HCL), 2002). The thickness of the surficial sediments is anticipated to be between 5 m and 10 m within the study area, though may be less than 5 m in localized areas (Atkinson, et al., 2020).

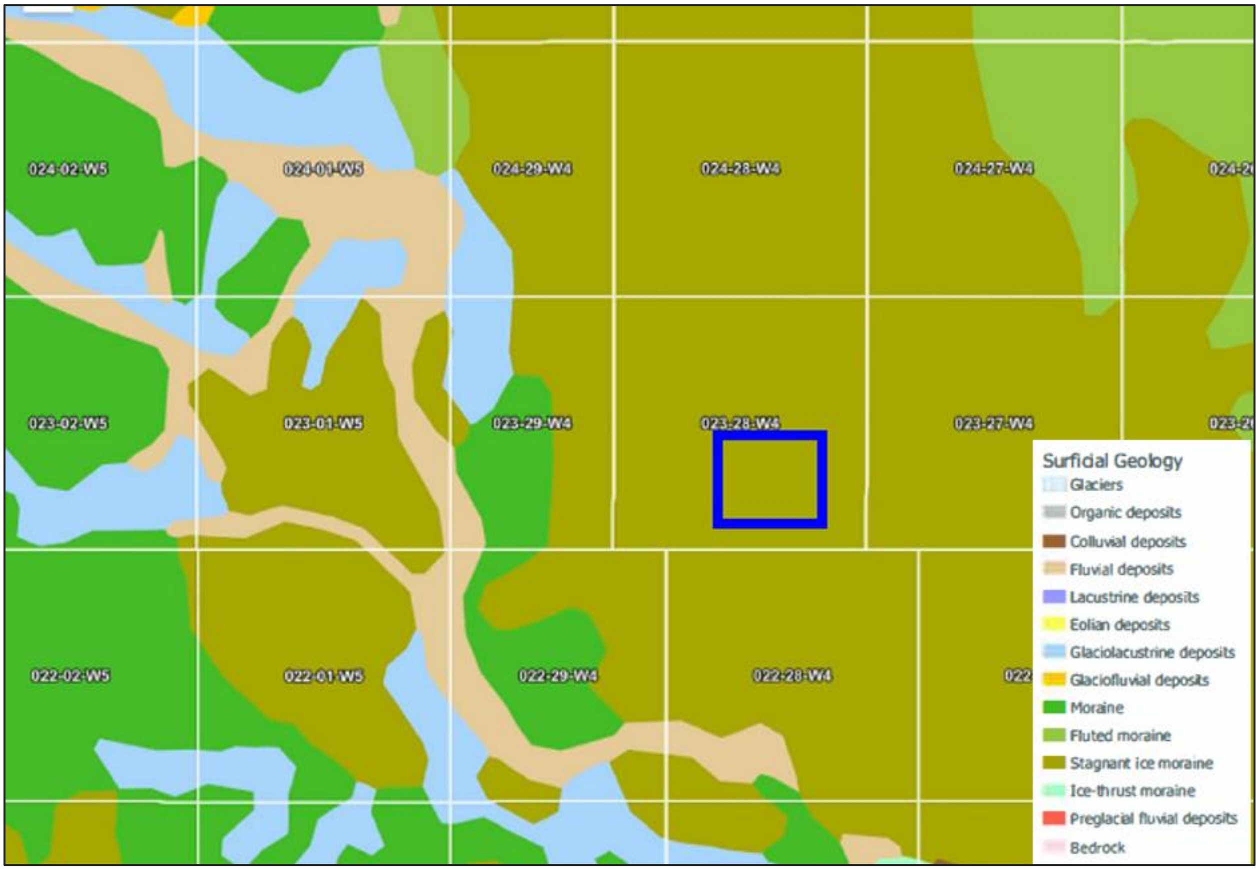


Figure 3-1: Surficial Geology of the Study Area (AER Surficial Geology of Alberta, n.d.)

The bedrock surface (**Figure 3-2**) within the study area is low relief and regionally slopes to the south in the direction of the Buried Calgary Valley (Atkinson, et al., 2017). The uppermost bedrock geology mapped within the study area consists of the Lacombe Member of the Paskapoo Formation. The Paskapoo Formation consists of Paleogene age sandstone, siltstone, and mudstone deposited in an alluvial depositional environment (Prior, et al., 2013)

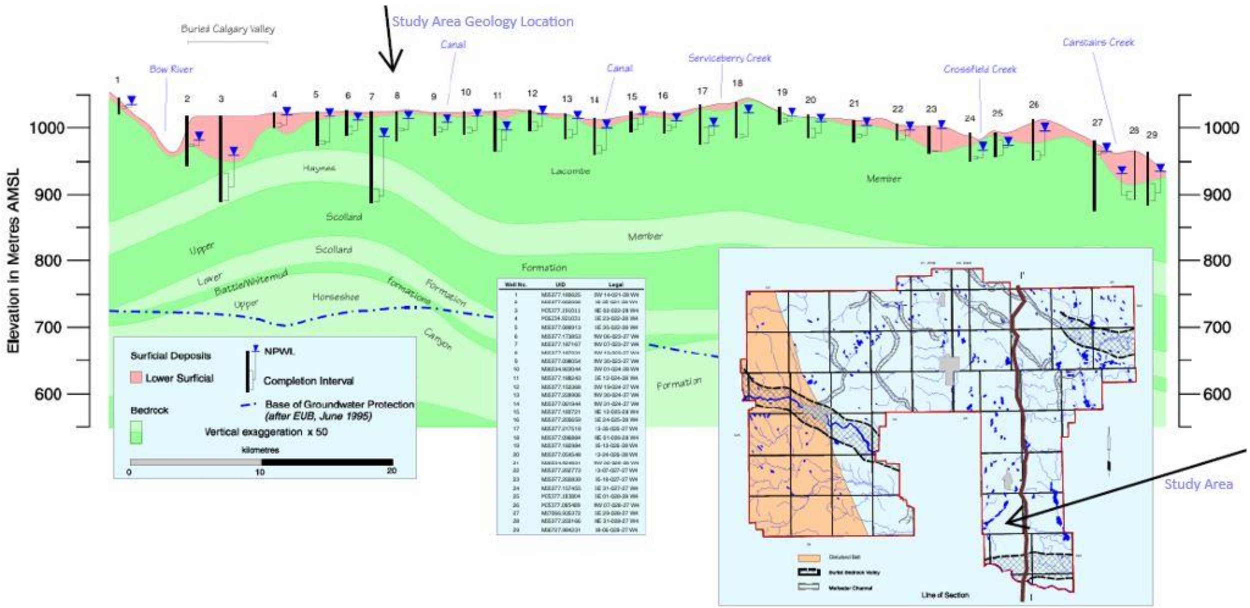


Figure 3-2: Bedrock Surface and Geology of the Study Area (Alberta Geological Survey (AGS), 2021)

The geologic setting at a local scale was developed using water well records available in the AEPA Water Well Information Database (Alberta Environment and Protected Areas (AEPA), 2024). Based on the water well records potentially within the study area, the local surficial deposits consist of sandy clay till with varying silt, sand, and gravel content overlying interbedded sandstone and shale with minor occurrences of siltstone. The depth to bedrock ranges from 2.4 metres below ground surface (m BGS) to 13.4 m BGS. Given the identification of localized areas of thin surficial cover (< 5 m), there is potential shallow bedrock may be encountered during cut/fill activities and/or construction of the stormwater management features.

3.1.2.3 Hydrogeologic Setting

Water use in the vicinity of the study area is primarily from bedrock aquifers nested within the Lacombe Member of the Paskapoo Formation (Alberta Geological Survey (AGS), 2021) and (Hydrogeological Consultants Ltd. (HCL), 2002). The lower surficial aquifer is generally absent/not mapped within the study area. There is potential the lower surficial aquifer may be intersected in the eastern most portion of the study area, though this cannot be accurately predicted at the desktop level. If present, the aquifer is anticipated to be less than 5 m thick with apparent yields generally less than 10 cubic metres per day (m3/day; 1.5 imperial gallons per minute [igpm]). Total dissolved solids (TDS) concentrations within surficial deposits are predicted between 1,000 milligrams per litre (mg/L) and 2,000 mg/L. The apparent yield for wells completed within the upper bedrock aquifer is estimated to range from less than 10 m3/day (1.5 igpm) to 75 m3/day (10.5 igpm). TDS concentrations within the upper bedrock aquifer are generally between 1,000 mg/L and 2,000 mg/L (Hydrogeological Consultants Ltd. (HCL), 2002).

A search of the AEPA Water Well Information Database was completed in February 2024 and identified eighteen (18) water-well records potentially within the study area (Alberta Environment and Protected Areas (AEPA), 2024). Water use was reported as domestic (14 records), domestic and stock (2 records), commercial (1 record), and industrial (1 record). The water well records reported total depths ranging from 29.3 m BGS to 106.7 m BGS and based on the available completion and lithology data, all the identified records utilize(d) the underlying bedrock aquifer. The groundwater source mapping (**Figure 3-3**) in the study area depicts that 91-100% of the water supply wells are completed in the bedrock. The targeted screen interval was generally located between approximately 30 m BGS and 60 m BGS within water-bearing sandstone. Excluding the decommissioned record completed much deeper within the bedrock aquifer (GIC 147296), test rates for the aquifer ranged from 9.1 liters per minute (L/min) to 181.8 L/min and reported static water levels ranged from near surface (<1 m BGS) to 14.8 m BGS.

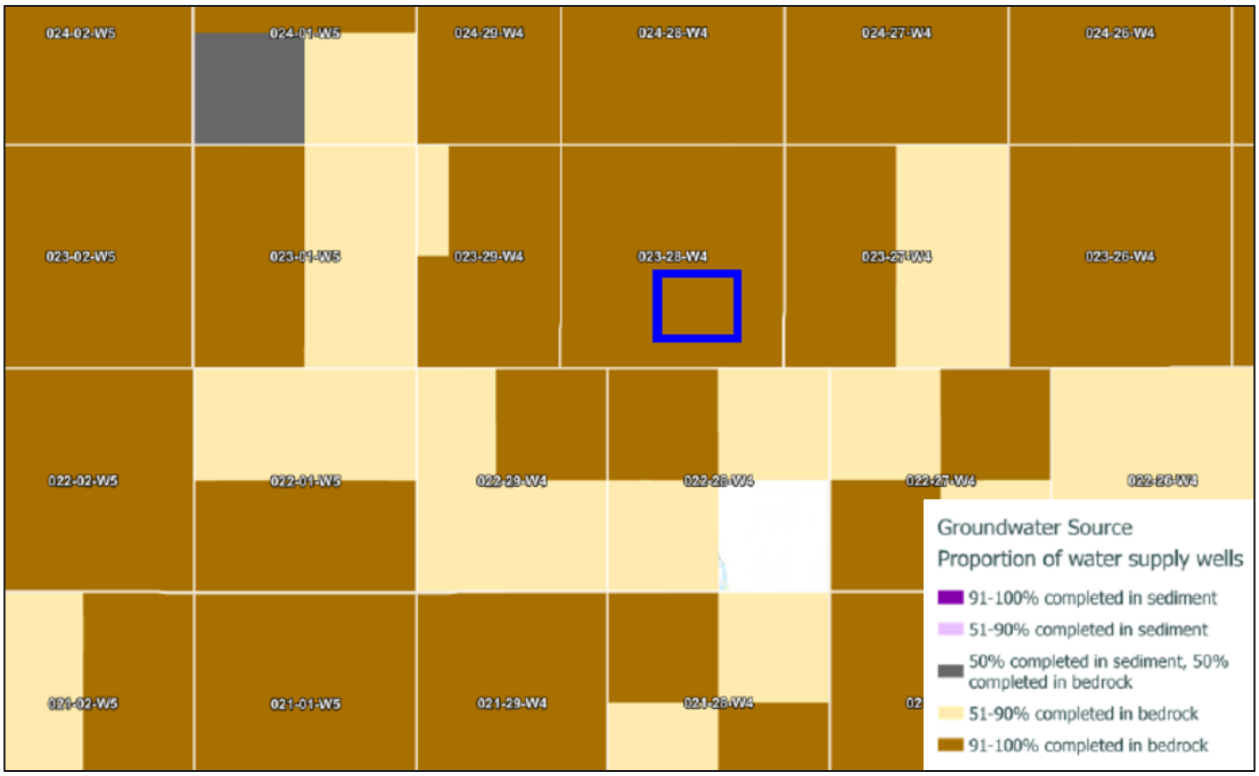


Figure 3-3: Groundwater Source Map of the Study Area (Hydrogeological Consultants Ltd. (HCL), 2002)

Figure 3-4 depicts the Alberta Water Well Information Database Map of the water wells in the project area. The groundwater drilling reports for these wells were reviewed to have an estimate on the groundwater levels. The reports had data extending from 1966 – 2021, and the associated static water levels varying between 3.1 – 14.8 m measured from ground level.

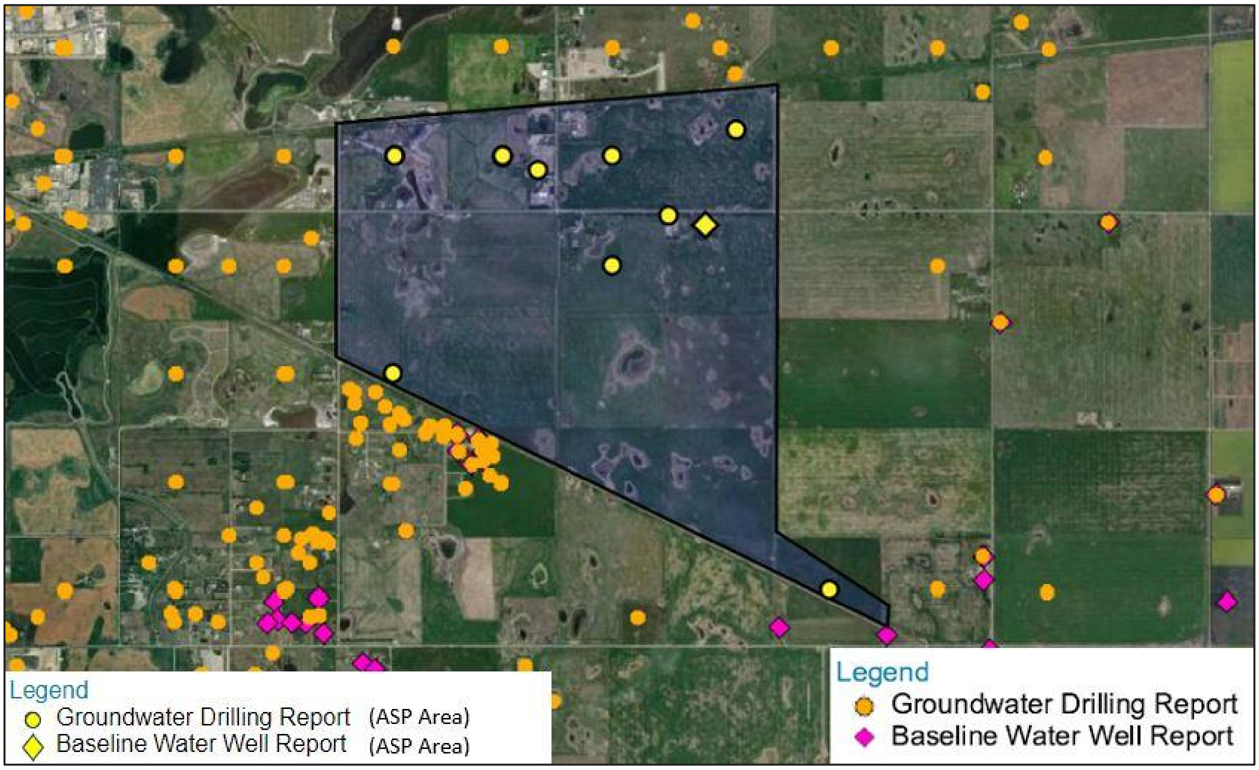


Figure 3-4: Alberta Water Well Information Database Map (Alberta Environment and Protected Areas (AEPA), 2024)

A search of the Alberta Environmental Site Assessment Repository (ESAR) was completed in February 2024 to identify potential Phase II Environmental Site Assessments (ESA) within one section of the study area that may be used to inform the local hydrogeologic setting (Government of Alberta (GOA), 2024). One ESA was identified for the property located at 11500 114 Avenue S.E., Calgary, Alberta, approximately 15 m west of the study area. Three (3) monitoring wells were installed within the shallow surficial materials (<4.2 m BGS). Depth to groundwater ranged from 0.72 m to 1.6 m and the inferred direction of shallow groundwater flow was to the northwest (Biophilia Inc (Biophilia), 2012). Hydraulic conductivity testing was not completed as part of the Phase II ESA. Based on the identification of shallow groundwater within the surficial deposits of the adjacent property and the wetlands present within the study area, there is the potential shallow groundwater will be encountered during cut/fill activities and/or construction of the stormwater management features.

Given the thin surficial cover, groundwater flow systems within the surficial deposits are anticipated to be local, driven by surface topography, and perched. Local groundwater flow patterns and the connectivity between the wetlands and shallow groundwater flow systems cannot be determined at the desktop level without site-specific assessment, though given the dry climate of the study area (Alberta Geological Survey (AGS), 2021) and that the wetlands are present year-round, it is presumed there is some baseflow (groundwater) contribution to the wetlands. Changes to the study area topography as part of site development are anticipated to influence local flow systems. Removal or compaction of surficial cover decreases the infiltration capacity of soils and may increase the amount of overland flow expected during storm events. Addition of cover or infilling of natural drainage/low lying areas may increase the infiltration capacity of soils and/or decrease the amount of surface water/overland flow present within the catchment. Flow within the aquifers of the Paskapoo Formation supporting the majority of local water wells is anticipated to be regional and towards the southeast (Atkinson, et al., 2017) and is unlikely to be significantly impacted by changes to topography and surface drainage.

3.1.3 RECOMMENDATIONS

Based on the results of the desktop assessment, there is potential for shallow groundwater to interact with the project. The permeability and hydraulic conductivity of shallow surficial sediments cannot be estimated at the desktop level, though there is potential that zones of coarser grained/ higher permeability deposits may be encountered. It is Stantec's understanding that the development will primarily consist of slab-on-grade industrial buildings with stormwater management features and that the wetlands will be assessed in the future to confirm their retention or removal. The primary concerns from a shallow groundwater perspective include groundwater infiltration into unlined stormwater management features if they extend below the water table and the effects of cut/fill activities on local groundwater flow regimes. Removal of surficial cover in areas with near surface groundwater could increase overland flow during storm events due to reduced infiltration capacity of the soils.

It is recommended that a site-specific hydrogeology investigation be completed to further develop the conceptual site model. This investigation should consist of the installation of shallow and deeper nested groundwater monitoring wells in the vicinity of the existing wetlands and proposed stormwater management features, seasonal and inter-annual monitoring to evaluate changes in groundwater levels and flow patterns over time, and hydraulic conductivity testing. Further, surface water and groundwater sampling for general chemistry should be completed to evaluate potential groundwater-surface water interactions in the vicinity of the existing wetlands.

The site-specific hydrogeology investigation should be prepared to supplement the SMDP and monitoring wells should be in place for 1 year.

3.2 Hydrological Assessment

A pre-development hydrologic analysis was performed to provide an estimation of the volume of stormwater runoff that collects in the existing wetlands within the MDP study area and that exits the MDP study area and flows to existing wetlands that are between the MDP study area and the Shepard Slough Complex.

3.2.1 REVIEW OF BACKGROUND DATA

To develop the pre-development model, the below data was collected and reviewed:

- 2020 Digital Elevation Model (DEM / LiDAR)
- City of Calgary and Rocky View County Municipal Infrastructure Data (GIS)
- Shepard Industrial SMDP 2002

- Shepard Business Park, Phase 3 Storm Ponds, As-built drawings 2009
- Shepard Stormwater Diversion Project, Phase 4, Wetland Construction, As-built drawings 2011 (including Shepard Ditch upstream of 100th St).
- Calgary Airport precipitation and temperature data set (CoC dataset from 1960 to 2014) including both rainfall and snowfall.
- Alberta Ground Water Well Reconnaissance
- ECRDS Phase 1 Model (Kerr Wood Leidal (KWL)., 2023)

The ECRDS model was reviewed, however, Stantec determined that creating a new model for the existing condition was valuable as in the ECRDS model, pervious areas are represented using Low Impact Development (LID) controls in subcatchments and the MDP stormwater analysis required increased granularity.

There were no critical gaps identified during the review of existing background data that required a site inspection or field survey to complete the MDP level analysis. However there is a planned MDP revision to follow the MDP submission that will include a site investigation and topographic survey of drainage features to confirm the drainage pathways (especially any culverts at road crossings or under the rail corridor).

3.2.2 PRECIPITATION- RUNOFF ANALYSIS

The hydrologic analysis involved the quantification of runoff resulting from precipitation. The model was run for the below list of design precipitation events:

- 1:100 year 24 hour storm event
- City of Calgary standard continuous simulation period, 1960-2014

The ECRDS Phase 1 model that was received included the design precipitation events.

3.2.3 HYDRAULIC AND HYDROLOGIC MODEL

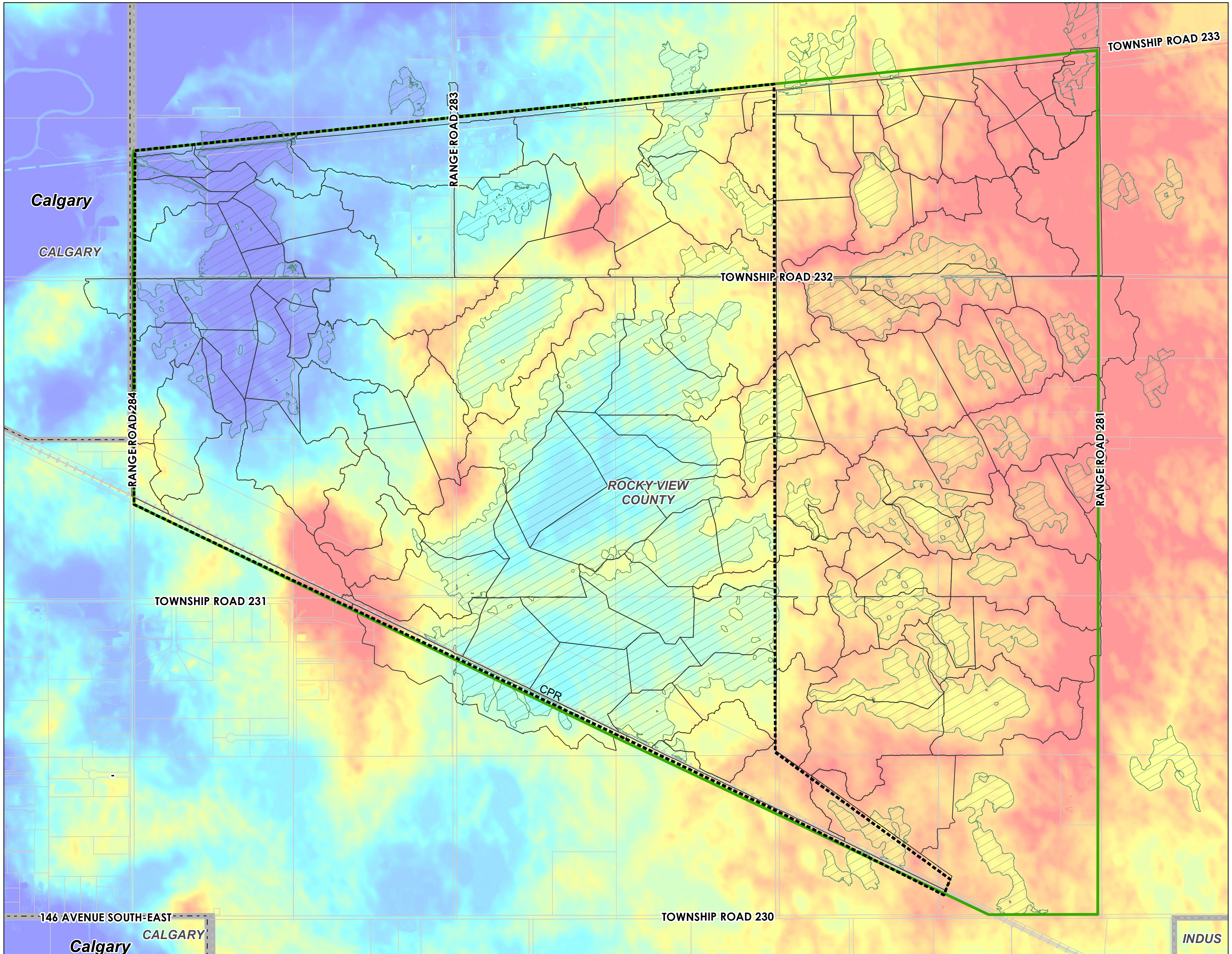
A PCSWMM computer model was used for this analysis. The rainfall-runoff simulation model was used to complete the above single event and continuous simulations to gather the runoff flows and quantities for each simulation.

The runoff component of the model simulates the storm event occurring on the subcatchment areas resulting in the subcatchments generating runoff. The pre-development subcatchment areas and wetland areas were delineated by PCSWMM using the 2020 DEM data. The subcatchment analysis had a target discretization level of 10 ha and the model was then further refined using historical aerial wetland photos. The analysis resulted in 71 subcatchments and 5 main wetlands within the ASP study area. The east external upstream lands resulted in a total of 57 subcatchments which were also included in the existing model. **Figure 3-5** illustrates the pre-development model and subcatchments with topography represented as a background heat map (higher elevations as hotter colours).

The wetlands were determined using PCSWMM to create storage polygons (wetlands) with a minimum depth of 0.3 m, see **Figure 3-6** for the wetland locations and boundaries. Note, these wetland boundaries will not exactly match the wetlands identified in **Section 2.2** as this methodology of delineating the wetlands is not the same as the Water Body Permanence Assessment.

The routing portion of the model transports this runoff through a system of channels and storage locations. The model tracks the quantity of runoff generated within each subcatchment, the flow rate and flow depth in each channel during the simulation period. **Figure 3-7** shows the contours, background aerial photo and overall existing flow paths within the model. Most of the runoff is contained inside the MDP study area. There are two locations within the MDP study area that flows north to the existing wetlands between the ASP lands and the Shepard Slough Complex under 1:100 year storm event and the continuous simulation, see **Section 3.3.1** for the full discussion.

The specific existing conditions model parameters can be found in **Appendix C - Existing Model Parameters.**



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Pre-Development Subcatchments
- Modelled Wetland

Elevation (m)
High : 1030
Low : 1018

N

0 250 500 metres
(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Project Location
SE Calgary
Alberta

Prepared by KDB on 2024-02-02
TR by NF on 2024-02-02

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
3.5

Title
Existing Conditions Model Subcatchments

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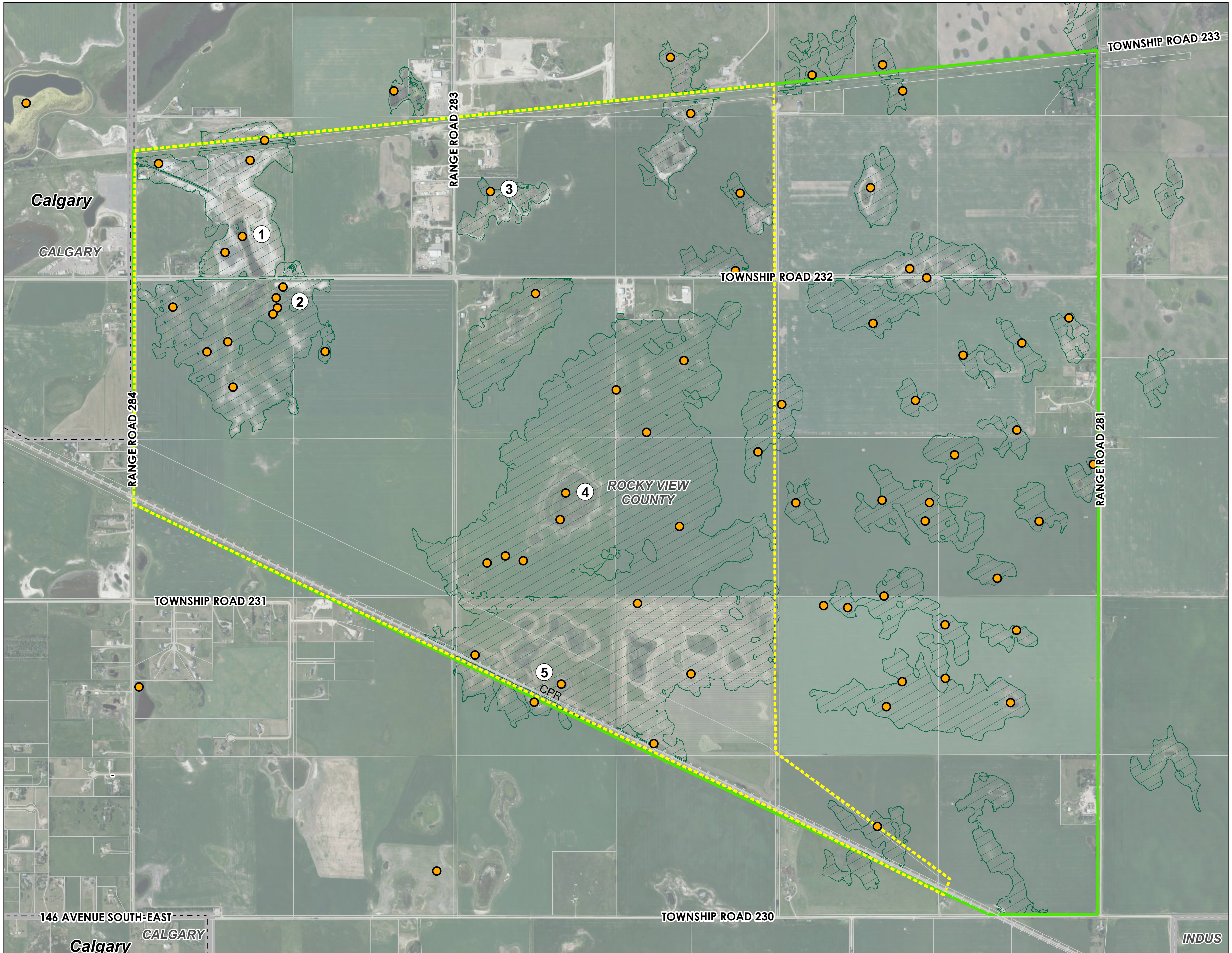

Stantec

ASP Boundary
MDP Boundary
Railway
Municipal Boundary
Model Storage Node
Calibration Node
Modelled Wetland

N

0 250 500 metres
(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
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The City of Calgary

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Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
3.6

Title
Wetland Delineation for Model Calibration

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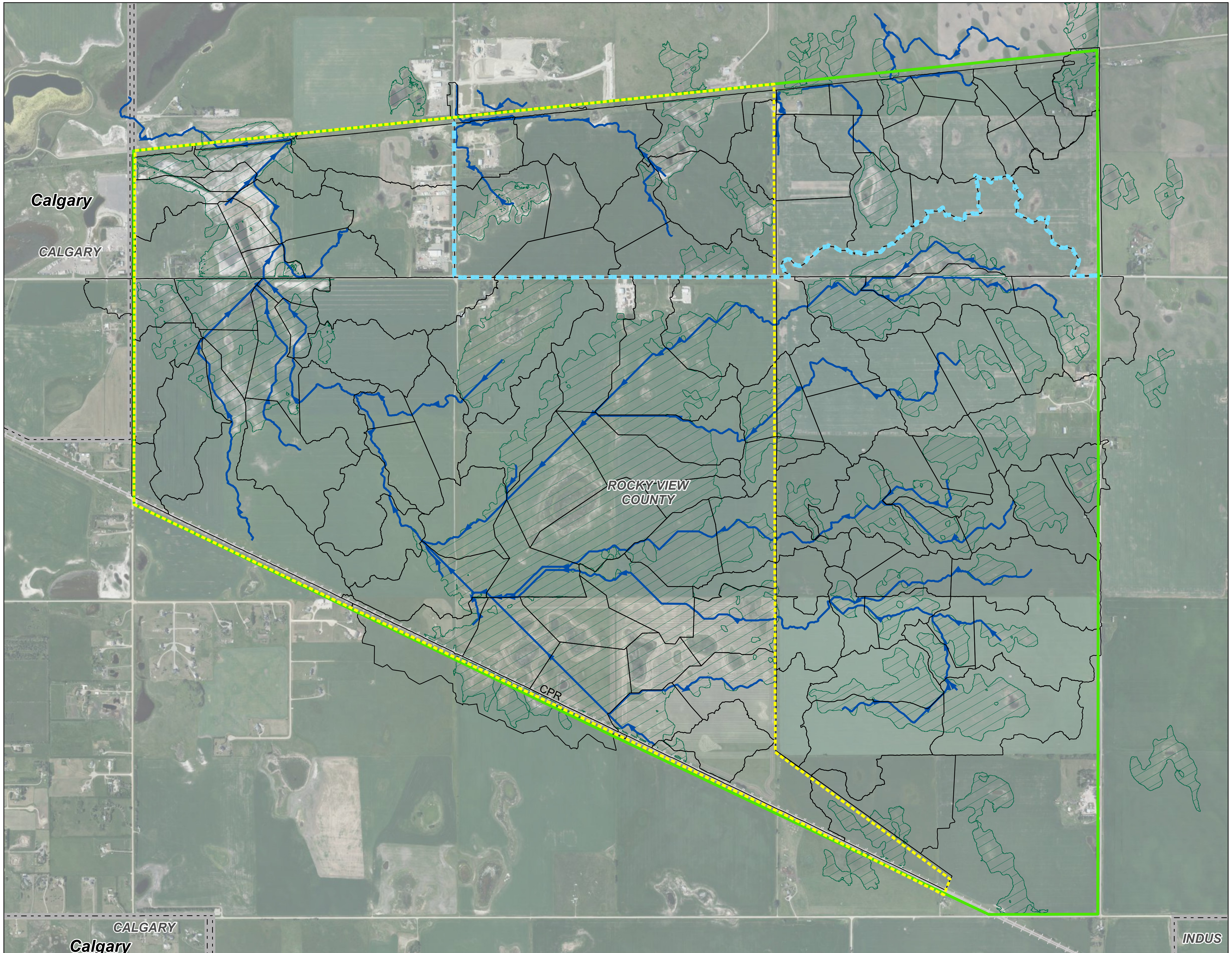

Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Continuous Overland Drainage Route
- Drainage Division
- Pre-Development Subcatchment
- Modelled Wetland

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary

Project Location
SE Calgary
Alberta

Prepared by KDB on 2024-02-02
TR by NF on 2024-02-02

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
3.7

Title
Existing Conditions Overland Flow Paths

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3.2.4 CLIMATE PARAMETERS

For the pre-development assessment, a continuous simulation approach was developed. This approach uses hourly rainfall precipitation data from January 1, 1960 to December 31, 2014, obtained from CoC's precipitation and temperature. The simulation generates runoff conditions based on the 55 years of hourly data. The obtained water level results were used to calibrate the model, while the flow results were used to estimate the flow spills from the ASP area. It is worth noting that the 55-year record includes both wet and dry years, with the sampled wet years being 1966, 1974, 1979, 2005, 2006, 2013, and 2014.

3.2.5 SNOWMELT

PCSWMM also has the capability to simulate snowmelt using a Snowpack routine along with temperature, evaporation and wind data. Snowmelt was incorporated in the pre-development analysis using maximum and minimum temperature data that was provided by the CoC. Snowmelt parameters from ECRDS Phase 1 model were adopted in this model.

3.2.6 RUNOFF COMPUTATION

Computation of runoff in the model is based on several physical parameters which includes catchment area, length/width, slope, imperviousness, Manning’s ‘n’ roughnesses, depression storage and infiltration. Summaries of the parameter values that were used are provided in **Appendix C - Existing Model Parameters**. The following is a description of how the values were determined for imperviousness, length and slope, and infiltration.

3.2.6.1 Imperviousness

According to aerial photos, the amount of impervious surface coverage under natural or pre-development conditions is almost zero. However, as there are some roads and a few developed lots, an assumption of in general 5% of each subcatchment is an impervious area (roads and permanent water bodies) was chosen. All subcatchments were modelled then with a remaining area of 95% pervious with the soil type as sandy clay loam. While performing calibration, Manning’s values, 0.013 for impervious areas and 0.15 for pervious areas which represent agricultural zone were used in the model.

To confirm that the above assumptions were not affecting the model results, three sensitivity analyzes were completed. The first sensitivity analysis was performed on the aquifer coefficients (A1, B1, A2, B2). The simulated water level in the wetlands was found to be sensitive to these coefficients and so the coefficients used in the ECRDS model resulted in a better match.

A second sensitivity analysis was performed on Manning's n values in subcatchments for the previous area. The simulated water level in wetlands was found to be sensitive to Manning's n, and the use of 0.15 in the ECRDS model resulted in a better match.

The third sensitivity analysis was performed on the evaporation factor in storage nodes. The simulated water level in wetlands was found to be sensitive to the evaporation factor and using 0.8 in the ECRDS model resulted in a better match.

3.2.6.2 Length and Slope

Catchment length reflects the distance from the outer edge of the catchment to the flow path within that catchment. Catchment slope is the slope along that same length from the side of the catchment to that flow path.

3.2.6.3 Infiltration

The Green Ampt method was used for calculation of catchment infiltration by the PCSWMM model. The minimally available soils mapping and geotechnical information lead to an estimation of sandy clay loam soils for all catchments. The Green Ampt parameters were selected based on **Table 3-12** from the City of Calgary Design Manual, 2011 and are summarized in **Table 3-1** as shown below. There is an opportunity to refine the soil type estimation after a geotechnical investigation is completed for the SMDP level analysis.

Table 3-1: Infiltration Parameters for Catchments and Storage Nodes

Parameter	Value
Soil Type	Sandy Clay Loam
Infiltration Method	Green-Ampt Infiltration
Suction Head (mm)	220
Conductivity (mm/hr)	1.534
Initial Deficit (fraction)	0.361

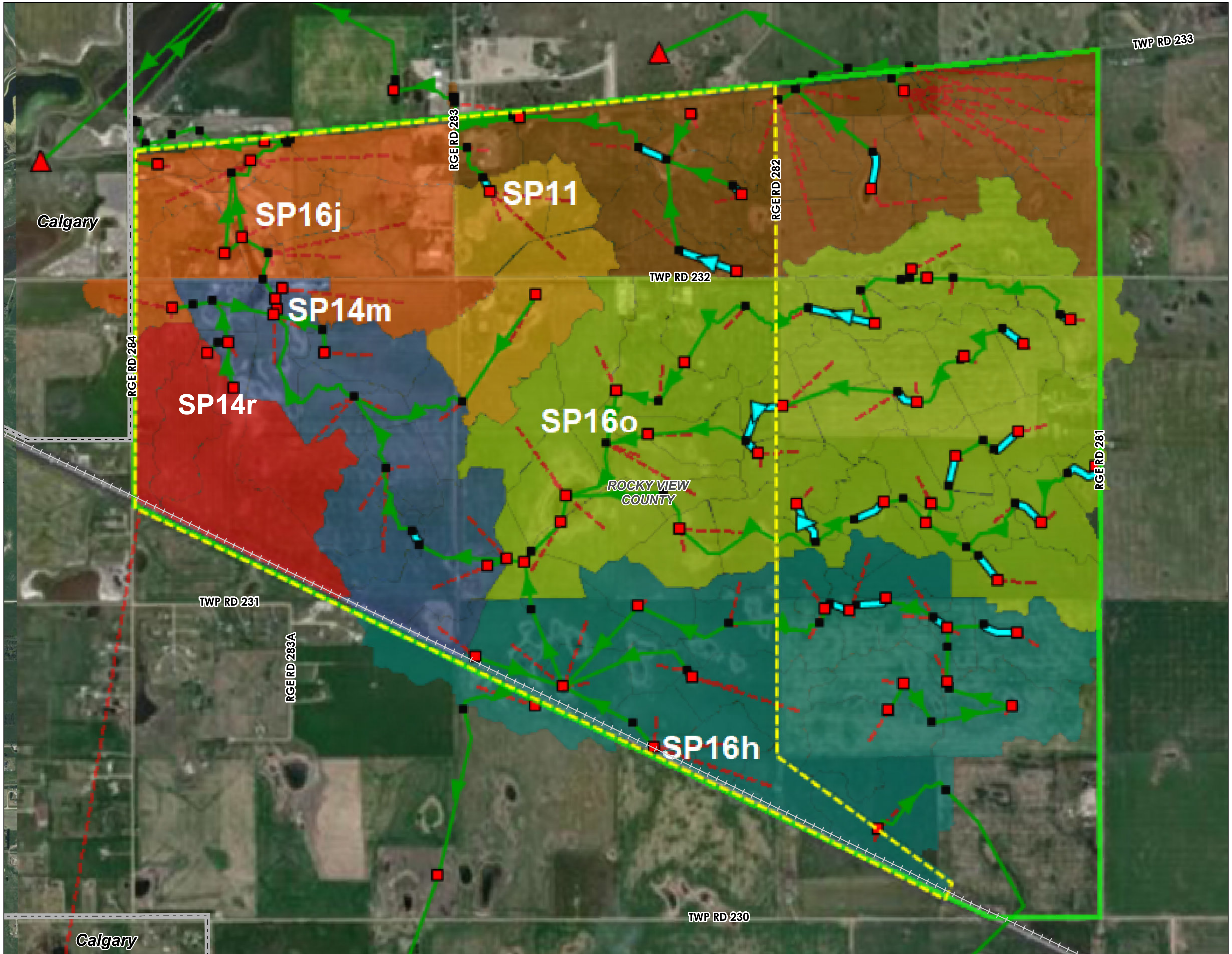
3.2.6.4 Depression Storage

Depression storage represents water that is stored within small depressions on the ground surface which is lost through infiltration and evaporation. In the context of this MDP study depression storage is not meant to include storage within large natural low areas and wetlands. Values of 1.6 mm for impervious areas and 3.2 mm for pervious area were used in the model as recommended in the City of Calgary Design Manual 2011.

3.2.7 GROUNDWATER CONDITIONS

The Groundwater Module in the model was used to simulate the interaction of shallow groundwater with wetlands. To represent the unsaturated and saturated zones, the model uses a simple two-zone groundwater routine, which is separated by the groundwater table's elevation. Flow from the unsaturated to the saturated zone is governed by a percolation equation that uses calibrated parameters, such as A1, B1, A2, B2, and A3. The unsaturated zone receives water from infiltration and can lose moisture through evapotranspiration. When the groundwater table rises to the surface, infiltration stops. Losses and outflow from the saturated zone consist of deep percolation, saturated zone evapotranspiration, and lateral groundwater flow.

Stantec has discretized aquifers for this MDP by using tributary areas to the five primary on-site wetlands within the MDP study area (see **Figure 3-8**) and to the existing wetlands to the north of the MDP study between the MDP study area and the Shepard Slough Complex. Please see **Section 3.2.12** for further details on calibration of the existing conditions model.



Stantec

- ASP Boundary
- MDP Boundary
- Storage Node
- Overland Node
- Overland Flow
- Weir

Aquifer

- Aquifer_SP6j
- Aquifer_SP11
- Aquifer_SP14m
- Aquifer_SP14r
- Aquifer_SP16h
- Aquifer_SP16o
- Aquifer2 discharge to North

N

0 250 500 metres

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Notes

1. Coordinate System: NAD 1983 3TM 114
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The City of Calgary

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Alberta

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Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
3-8

Title
Existing Aquifers and Associated Subcatchments

3.2.8 EVAPORATION LOSSES

The PCSWMM model computes evaporation losses from two sources; depression storage on the catchment surface and the water surface in storage locations. A historical evaporation timeseries from the ECRDS Phase 1 model was used in the subject model.

The PCSWMM model output reports evaporation that is computed from catchment depression storage as well as infiltration of water into the soil. PCSWMM does not compute evapotranspiration (ET) of water that has infiltrated into the soil unless the groundwater routine is used. The results of infiltration and evaporation as computed by the PCSWMM models are to be interpreted as being general in nature for the purpose of this report and should not be taken as being final approved results for all cases. This will need to be verified in subsequent studies using field geotechnical testing on soil characteristics and infiltration capacity.

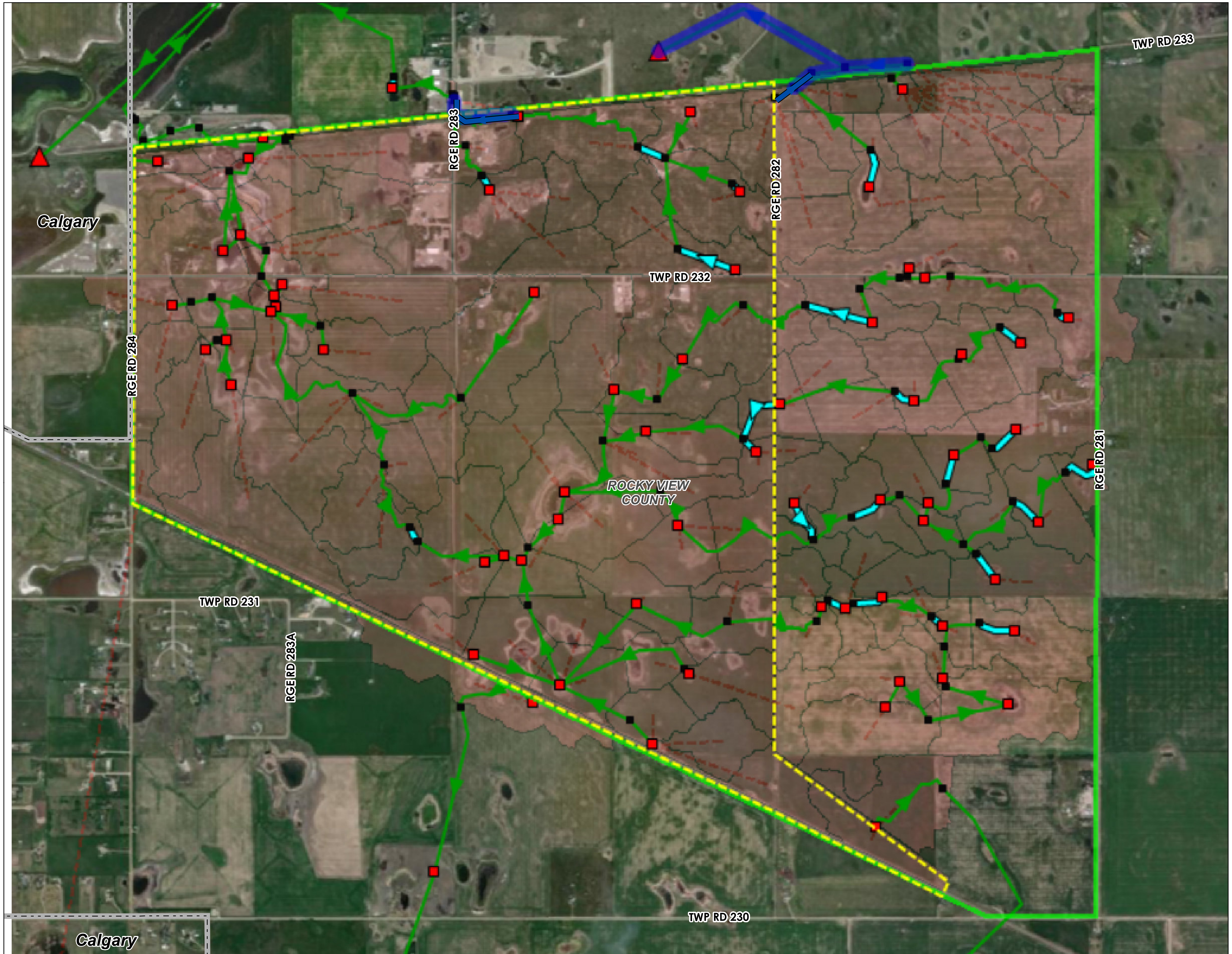
3.2.9 STORAGE ROUTING

Storage routing was performed to simulate the natural depression and low areas in the ASP study area and east external upstream. These storages are the wetlands shown in **Figure 3-6,** and are represented by a depth-area relationship based on an analysis of LiDAR data from 2020. The LiDAR data was used to determine storage locations with a minimum depth of 0.3 m and the depth area relationship for each storage location was created. Outlet inverts were defined based on LiDAR data and wetland boundaries.

The storage nodes also have evaporation with an evaporation factor of 0.8, which was determined as a calibration parameter. The seepage functionality in PCSWM was used to represent the infiltration that is allowed at the storage nodes.

The initial water level in the storages was set based on the 2-year design storm water level. To achieve this, the model was run under a 2-year design storm condition, and the peak results were used as the starting point (hot start) for both the 100-year and continuous models.

See **Figure 3-9** for the existing model storage locations (Red Nodes). Note, the storage nodes and the overland node differ in that the volume of stored water in the overland nodes is zero as the overland nodes are only responsible for connecting ditches.



Stantec

- ASP Boundary
- MDP Boundary
- Storage Node
- Overland Node
- Spill Location
- Overland Flow
- Weir
- Subcatchment

N

0 250 500 metres

(At original document size of 11x17)
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Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
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Project Location
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TR by NF on 2024-03-06

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Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
3-9

Title
Existing Conditions PCSWMM Model

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3.2.10 CONVEYANCE ROUTING

Within the PCSWMM model, storage nodes were connected using overland flow paths with a typical trapezoidal cross-section that was sized to prevent the flow from overtopping the channel. The assumed geometric dimensions of the flow path are below:

- 2.0 m bottom width;
- 5H:1V side slopes; and
- 5.0 m depth.

Note, there are no existing culverts along the abandoned rail ROW or CPKC Rail mainline based on record reviews of the ASP study area. This will be confirmed as part of the MDP revision as part of the site investigation.

Initial water depths in storage nodes are calculated based on water levels from the 2-year event simulation, while initial water depths in conduits are assumed to be zero.

3.2.11 EXISTING BOUNDARY CONDITIONS

The existing model does not have boundary conditions to the Shepard Ditch or Bypass as it does not spill to either under the 1:100-year single event or continuous simulation. The are only two spill locations that exit the ASP lands, one flow path within the ASP lands and one within the east upstream external lands. Both of these flow paths flow overland to the north to existing wetlands between the ASP lands and the Shepard Slough Complex. See **Figure 3-9** and **Figure 3-10** for these spill locations.

Section 3.3.1.2 and **3.3.1.3** describes the peak flow and volume at both of these outlet locations.

3.2.12 EXISTING MODEL CALIBRATION RESULTS

The continuous simulation model for the ASP area was calibrated based on the water levels of the five major wetland calibration nodes shown in **Figure 3-6**.

After the continuous simulation model was set up, the sampled dates with normal to high water levels and available aerial photography were used to calibrate the catchments. Drought months were not chosen as the calibration nodes would be dry and the water level would be zero, and not provide feedback. Iterations of the model were made to identify the sensitivity of selected parameters to be adjusted (within reasonable limits); such that, simulated wetland conditions reasonably match observations within a level of confidence appropriate for this study.

To estimate the wetland's water levels in the selected aerial photos, we compared the shoreline of the wetlands in the photos with the 2020 LiDAR data. However, in some cases, the shoreline in the photos appeared to be within the water body of the LiDAR data. In such cases, the water level of the shorelines in the aerial photos was estimated by extrapolating the topography data around the water body in the LiDAR data.

The intention was to confirm the "aerial" line area is approximately the same as the aerial image surface water area for display purposes. The focus was placed on matching the higher end of elevation spectrum (larger events) in roughly equal areas flooded between the aerial photos and the model results.

The existing model was run for each calibration event, and the yellow outline is the model result.

Catchment Manning's values, Green-Ampt infiltration and groundwater parameters were adjusted to calibrate the model. Calibration figures of each of the calibration events per wetlands and 1:100 year single event and continuous model flood inundation can be found in **Appendix C.2 Existing Condition Results.** Given the uncertainty in the measurement error alone, a 0.33 m difference between the model and the aerial image is considered good.

Table 3-2**Table 3-2** presents the water level results. The calibration results are deemed reasonable, considering the number of assumptions that were required for the wetland bathymetry and water level estimates derived from the aerial photography and 2020 LiDAR data. The largest difference in observed data is for Wetland #4 for in 2006. The Wetland #4 difference could be due to could be partly attributed to the water level estimating using extrapolated LiDAR data. Given the uncertainty in the measurement error alone, a 0.33 m difference between the model and the aerial image is considered good.

Table 3-2: Calibration Results for the Prairie Gateway ASP Study Area

Calibration Events								
	Date	**Aug 1966**	**Jun 1974**	**Jun 1979**	**Sep 2005**	**Sep 2006**	**Sep 2013**	**Oct 2014**
	Precipitation Analysis (PDSI)*	Very Wet (3.61)	Slightly Wet (1.34)	Slightly Wet (0.57)	Slightly Wet (1.72)	Mild Drought (-1.16)	Very Wet (3.34)	Moderately Wet (2.22)
Wetland #	**Source**	**Corresponding Water Level (m)**						
1	Aerial Image	1017.7	1017.67	1017.62	1017.64	1017.69	1017.67	1017.65
	Model	1017.69	1017.66	1017.69	1017.76	1017.71	1017.7	1017.63
	Difference	**-0.01**	**-0.01**	**0.07**	**0.12**	**0.02**	**0.03**	**-0.02**
2	Aerial Image	1018.25	1017.84	1018.04	1017.81	1017.86	1017.92	1017.79
	Model	1018.03	1017.92	1018.06	1017.78	1018.1	1018.06	1017.87
	Difference	**-0.22**	**0.08**	**0.02**	**-0.03**	**0.24**	**0.14**	**0.08**
3	Aerial Image	1022.12	1022.1	1022.11	1022.05	1022.04	1022.1	1022.08
	Model	1022.08	1022.05	1022.1	1022.08	1022.07	1022.13	1022.05
	Difference	**-0.04**	**-0.05**	**-0.01**	**0.03**	**0.03**	**0.03**	**-0.03**
4	Aerial Image	1021.34	1021.31	1021.37	1021.28	1021.31	1021.29	1021.29
	Model	1021.58	1021.48	1021.57	1021.36	1021.64	1021.55	1021.41
	Difference	**0.24**	**0.17**	**0.2**	**0.08**	**0.33**	**0.26**	**0.12**
5	Aerial Image	1022.3	1022.18	1022.13	1022.22	1022.19	1022.13	1022.15
	Model	1022.23	1022.2	1022.26	1022.34	1022.3	1022.26	1022.14
	Difference	**-0.07**	**0.02**	**0.13**	**0.12**	**0.11**	**0.13**	**-0.01**

Calibration Events								
Date		**Aug 1966**	**Jun 1974**	**Jun 1979**	**Sep 2005**	**Sep 2006**	**Sep 2013**	**Oct 2014**
Precipitation Analysis (PDSI)*		Very Wet (3.61)	Slightly Wet (1.34)	Slightly Wet (0.57)	Slightly Wet (1.72)	Mild Drought (-1.16)	Very Wet (3.34)	Moderately Wet (2.22)
Wetland #	**Source**	**Corresponding Water Level (m)**						
* Source Palmer Drought Severity Index (PDSI) for Calgary International Climate Station 3031094								

A final check of the model calibration was completed by considering a mild drought year based on the PDSI (October 2003 was chosen), confirming that the wetlands were dry using an historical aerial photograph, and then running the calibrated model and verifying the storage nodes were dry (water depth was zero).

3.3 Analysis of Existing Conditions Results

From the final PCSWMM model continuous simulation, 1,308 hectares of land modelled has runoff water stored in the low areas and wetlands and does not spill. A 186 hectare catchment from the MDP study area (includes any partial outflows from the subcatchments) overflows to the existing wetlands between the ASP lands and the Shepard Slough Complex, outside the MDP study area.

3.3.1 RUNOFF VOLUMES AND PEAK FLOWS

3.3.1.1 Wetland Water Balance

The wetland water balance is a comparison of the total inflowing water to the wetland and the total outgoing water. The total inflow is the sum of the surface runoff and groundwater flowing into the wetland from the upstream catchments that spill over into the wetland. The depth of water at the wetland is determined by applying that volume of water over the respective active watersheds.

The total outgoing water from the wetlands is a compilation of the evaporation, infiltration and outflow. The evaporation was calculated by multiplying the total inflow volume by the percentage of evaporation extracted from the model. Similarly, the infiltration volume was calculated by multiplying the total inflow volume by the percentage of infiltration extracted from the model. The outflow volume is a model result.

The flow error volumes are calculated as the difference between total inflow volume and the sum of outflow, evaporation and infiltration at each wetland. See **Table 3-3** for the wetland water balance results from the continuous model.

Table 3-3: Water Balance (Volume) Analysis in SWMFs During the Existing Condition

Wetland	Total Inflow		Evaporation		Outflow		Infiltration		Flow Error	
	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)
1	218	100%	22	10.3%	0	0%	199	91.2%	-3.3	-1.5%
2	170	100%	16	9.6%	0	0%	151	88.9%	2.5	1.5%
3	195	100%	20	10.2%	0	0%	178	91%	-3.2	-1.6%

Wetland	Total Inflow		Evaporation		Outflow		Infiltration		Flow Error	
	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)	(mm/yr)	(%)
4	335	100%	33	9.8%	0	0%	301	90%	1.6	0.5%
5	210	100%	21	10.2%	0	0%	191	91%	-3.0	-1.4%

According to **Table 3-3**, about 10% of the total inflow losses are caused by evaporation, while approximately 90% of the total inflow losses are due to infiltration. The maximum loss due to remaining water in the wetland, and other factors such as flow errors is at most 1.6%, considered acceptable. None of the wetlands selected for calibration experienced any flow spills during the continuous model (55 years).

Appendix C.2 Existing Condition Results show the storage volume, water level, and maximum flow for storage nodes and flow paths under both the 100-year event and continuous conditions.

3.3.1.2 Outflow from ASP Study Area to North

The total spill volume to the lands north of the ASP study area is 880,093 m^3. The peak discharge rate was computed to be 0.532 m^3/s for the 141 ha of catchments shown on **Figure 3-10.**

Figure 3-10: Existing Conditions ASP Study Area Outflow Catchments

Table 3-4 presents details for the flow spills from ASP to the north to the existing wetlands between the MDP study area and the Shepard Slough Complex; the volume of spill flow is 880,093m^3, and the majority of the outflow is trapped in the wetlands north of the ASP lands. The location of the spill is along RR 283 north of the abandoned rail ROW represented in blue in **Figure 3-10.** The flow path leaving the northeast side of this catchment (C103) flows through the MDP lands and then exits the MDP lands to the north.

Table 3-4 Existing Peak Flow and Volumes from the ASP Study Area to North

Event	Peak Flow (m^3/s)	Peak Flow (L/s/ha)	Total Volume (m^3)	Depth (mm/yr)
100-year	2.042	14.5	23,199	-
Continuous (55-year)	0.532	3.8	880,093	11.3

Figure 3-11 provides a spill flow duration curve from the ASP area. The curve can be interpreted as 1% of the time, the daily outflow leaving the ASP area is more than 6 L/s.

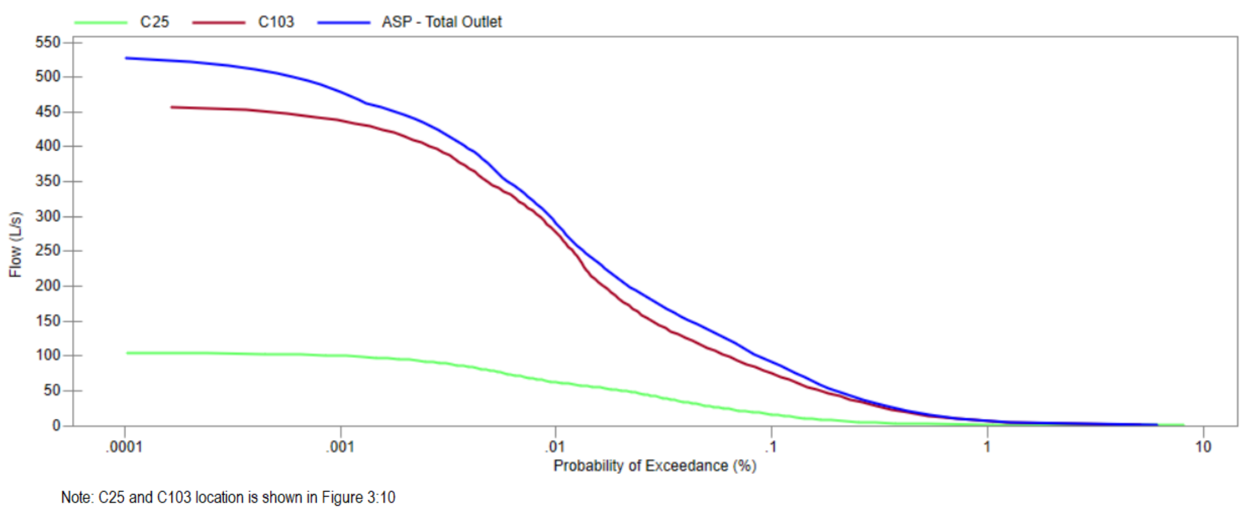

Figure 3-11: Flow Duration Curve at ASP Outlet (Continuous Model)

3.3.1.3 Outflow from MDP Study Area to North

The MDP area (the ASP plus the east external upstream lands) also has a catchment that spills to the wetlands north of the MDP area, see **Table 3-5.** The east upstream external lands spill to the north into quarter section NW14-23-28-4 as shown in **Figure 3-12**. The total spill volume to the lands north of the entire MDP study area, 2,463,510 m^3. The peak discharge rate was computed to be 1.324 m^3/s for the 275 ha catchment.

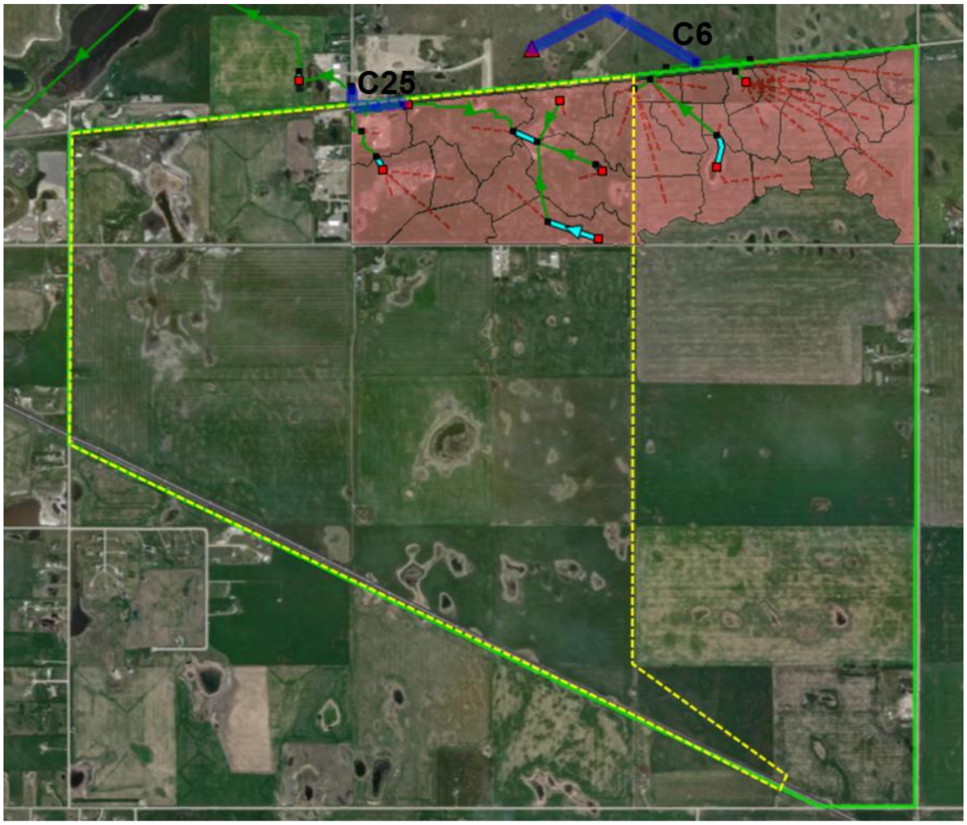

Figure 3-12: Existing Conditions MDP Study Area Outflow Catchments

There are two flow paths that leave the MDP study area from the east upstream external lands that were combined into one flow path (C6) as for the purposes of this MDP the total flow exiting the MDP lands is the quantity of interest. The flow path from the northeast corner of the existing ASP catchment drains through the east upstream external lands and exits using that same combined flow path (C6).

Table 3-5 Existing Peak Flow and Volumes from the MDP Study Area to North

Event	Peak Flow (m^3/s)	Peak Flow (L/s/ha)	Total Volume (m^3)	Depth (mm/yr)
100-year	2.855	10.4	70,990	-
Continuous (55-year)	1.324	4.8	2,463,510	16.3

Figure 3-13 provides a spill flow duration curve from the MDP area. The curve can be interpreted as 1% of the time the daily outflow leaving the ASP area is more than 18 L/s.

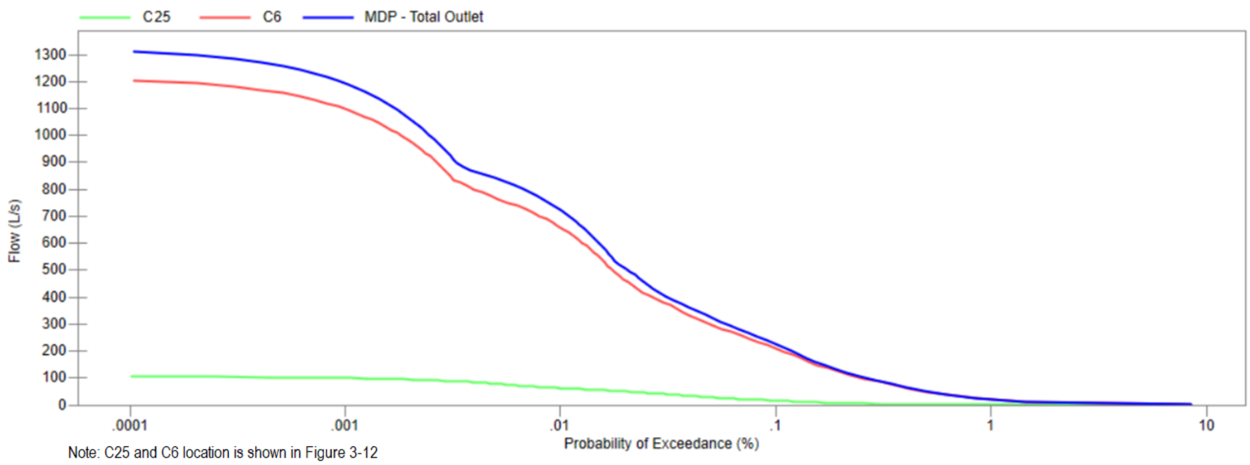

Figure 3-13: Flow Duration Curve at MDP Outlet (Continuous Model)

4 Stormwater Management Concept

This MDP report presents a stormwater management servicing concept for the ultimate servicing of the lands presented in the study area that will be serviced by the Shepard Ditch.

4.1 Design Objective

The master drainage plan concept is adhering to the following objectives:

- UARR of 0.8 L/s/ha discharge for pipe sizing downstream of the ponds and outflows
- Pond sizing – establish preliminary storage requirements based on the statistical 1:100-year return period annual maximum volume (by analyzing the continuous flow annual maximum volume for each of the 55 years of data for the MDP study areas).
- Pond active depth – maximum of 2.0 m between NWL and HWL
- Matching the total volume of runoff (in the continuous model) directed to the existing wetlands (between the ASP lands and the Shepard Slough Complex) between the existing conditions and the interim/ ultimate post-development conditions.

At the request of the CoC and RVC, the UARR for the entire MDP study area was assumed to be 0.8 L/s/ha of discharge to the Shepard Ditch. It is anticipated that the ECRDS Phase 2 modelling will confirm the remaining capacity of the Shepard Ditch the UARR for the Prairie Gateway Area.

4.2 Servicing Concept

The objective of the stormwater servicing concept is to provide onsite storage and a gravity draining system to a single downstream discharge point at the upstream end of the Shepard Ditch, while accounting for the east external upstream lands. The proposed single downstream trunk also needs to accommodate the north, west and south adjacent lands.

The servicing concept must also accommodate the interim development condition, with a fully developed ASP study area and the east external upstream lands remain in the predevelopment condition and the ultimate development condition where both the ASP lands and the east external upstream lands are developed.

The topography of the study area is generally quite flat (approximately 0.2% grade rising from west to east within the study area). The storm ponds are proposed to be in a long, linear orientation to help keep the high-water level of the ponds lower to achieve lower finished design grades of the ASP lands.

The servicing concept for the study area has been presented as three different options, with differing contributing areas in the ultimate condition.

4.2.1 ULTIMATE SERVICING OPTION 1 – AREA 1-11

Figure 4-1 Error! Reference source not found. shows the servicing concept for Option 1, which services all areas 1 – 11. The existing Shepard Business Park Ponds A, B and C were included in the analysis as the outlet elevation of Pond C is the limiting factor in setting the trunk elevation (see **Figure 4-2**). All of the downstream pipes from the ponds have been sized via the rational method based on maximum allowable discharge of 0.8 L/s/ha.

Currently the SWMF and invert elevations are set to be slightly conservative but feasible. It is anticipated that the SWMF's could be lowered at the SMDP stage once the cut, fill and grading design is more detailed, while still being serviceable with any of the three options. Lowering the ponds, however, may result in losing the ability to have an overland emergency drainage route, thus a comparison will need to be made at SMDP time between the fill volume required versus designing the trunks for an additional 1.0 m3/s of flow and a discussion with the CoC and RVC would be required.

For the purpose of this MDP, we are assuming this Option 1 is proceeding. We do not anticipate that Option 2 or 3 would impact the ability to service the ASP lands, but the flexibility of the grading could be adjusted if Option 3 were to proceed.

4.2.1.1 Discharge Location

The discharge point into the Shepard Ditch has been analyzed at a few locations to determine if the RR 284 trunk slope can be increased. Locations reviewed were:

- Tie into the Shepard Ditch at the outlet of the Shepard Wetland (approximately TWP 231): The proposed trunk is approximately 3.3 km long at a slope of 0.05 %, and then the trunk outlets to a ditch, approximately 370 m west of RR 284A, which will connect to the Shepard Ditch.
- Tie into the Shepard Ditch one quarter section south of TWP 231: The trunk is approximately 4 km long at a slope of 0.054 %. While this option gains slightly higher slope, there may be difficulties with gaining easements along RR 284.
- Tie into the Shepard Ditch at TWP 230: The trunk is approximately 4.9 km long at a slope of 0.051 %.

As directing the trunk further downstream does not significantly increase the slope of the trunk because the relatively flat slope of the existing Shepard Ditch, it is recommended to tie in at the outlet of the Shepard Wetland i.e. 3.3 km 0.05 % sloped trunk, with a ditch that outlets to the Shepard Ditch. This also benefits infrastructure costs by reducing the trunk length. The exact location and structure details of the transition point between pipe and ditch will be determined at detailed design.

It is important to note, this slope is half of the minimum standard design slope for pipes (0.10 %) and will likely present construction difficulties and have a higher likelihood of ponding locations in the pipe, which will increase the maintenance requirements for the trunk. Other options that may be considered are pumping area 9-11 flows to an upstream manhole of the proposed storm trunk (the intersection of RR284 and TWP 232, which would allow a trunk slope of 0.10 %).

An alternative discharge through the Shepard Sloughs S1 and S2 has not been considered as per the discussion with the CoC, it is unclear if the Province will allow or require changes to stormwater entering the Shepard Slough Complex.

4.2.2 ULTIMATE SERVICING OPTION 2 – AREA 1-3, 7-10

Figure 4-3 shows the servicing concept for Option 2, which services area 1-3, and 7-10, while areas 4, 5, 6 and 11 are left at pre-development. Similar to Option 1, the outlet elevation of Pond C is the limiting factor in setting the trunk elevation and the SWMF and invert elevations are also slightly conservative but feasible with a n opportunity to be refined (and possibly lowered) at the SMDP stage.

The slope of the storm trunk on TWP 231 and RR284 is still at 0.05% in this option, but the reduced contributing areas, slightly reduces the storm trunk sizing.

4.2.3 ULTIMATE SERVICING OPTION 3 – AREA 1-8

Figure 4-4 shows the servicing concept for Option 3, which services areas 1-8.

The slope of the storm trunk on TWP 231 and RR284 has been increased to 0.10%, as such the required trunk sizes are smaller due to the higher slope and less contributing area. The elevations of the SWMF's and inverts within the ASP area are high enough that this option is serviceable, however the invert at the north end of RR 284 would be too high to service area 9 and 10 by gravity.

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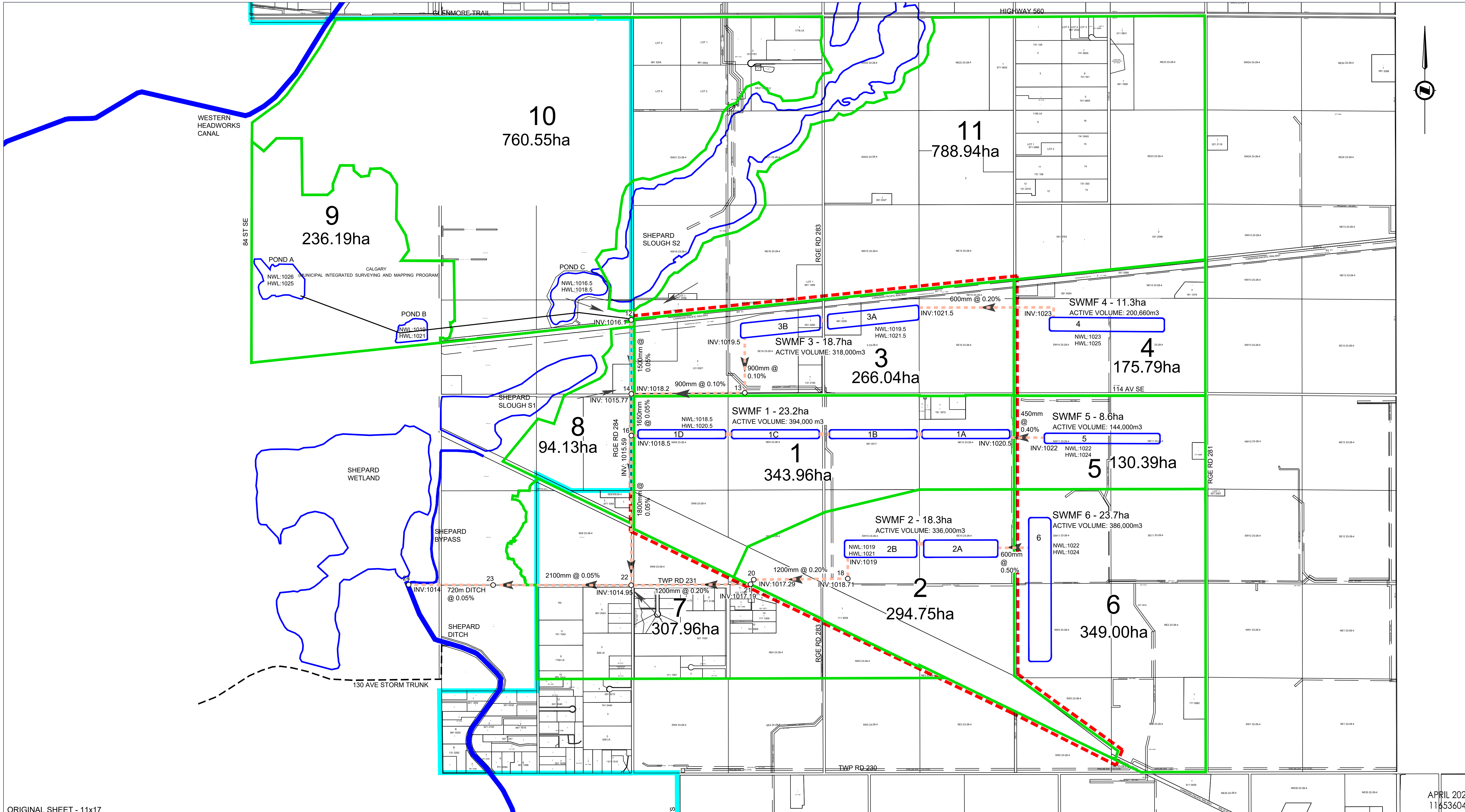

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Notes OPTION 1 INCLUDES AREA 1-11

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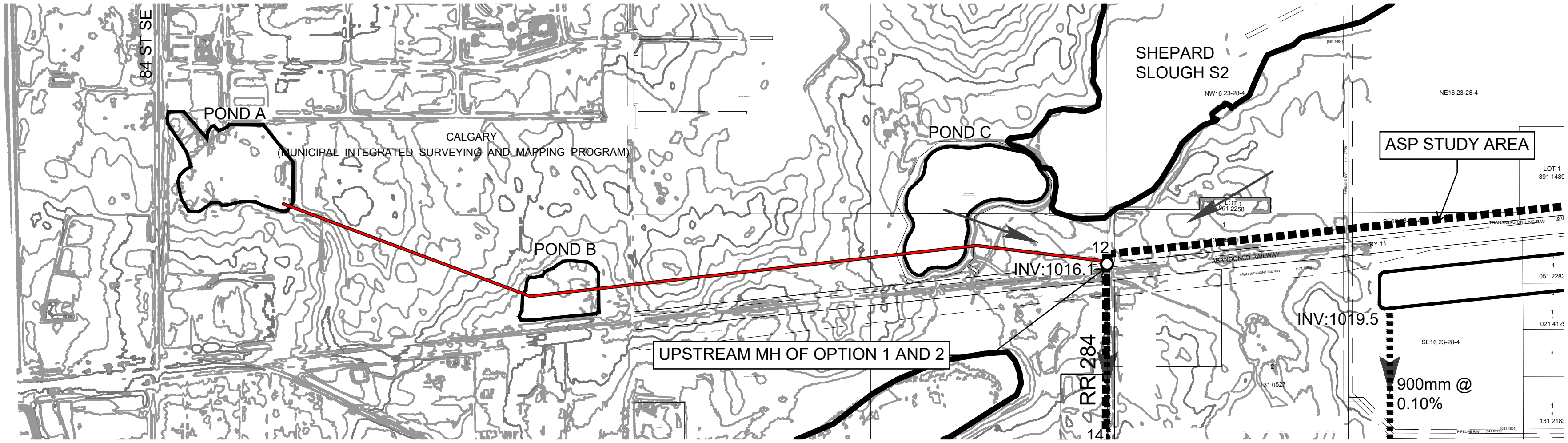
Figure No.

4.1

Title

SERVICING CONCEPT
OPTION 1



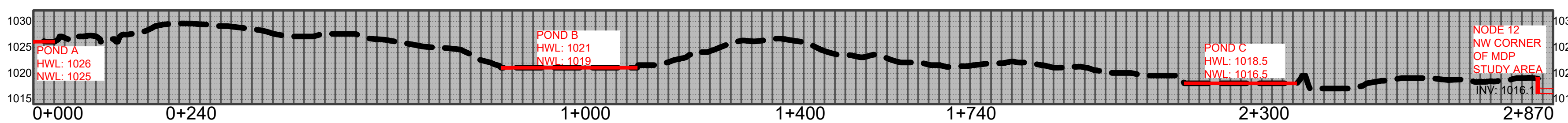


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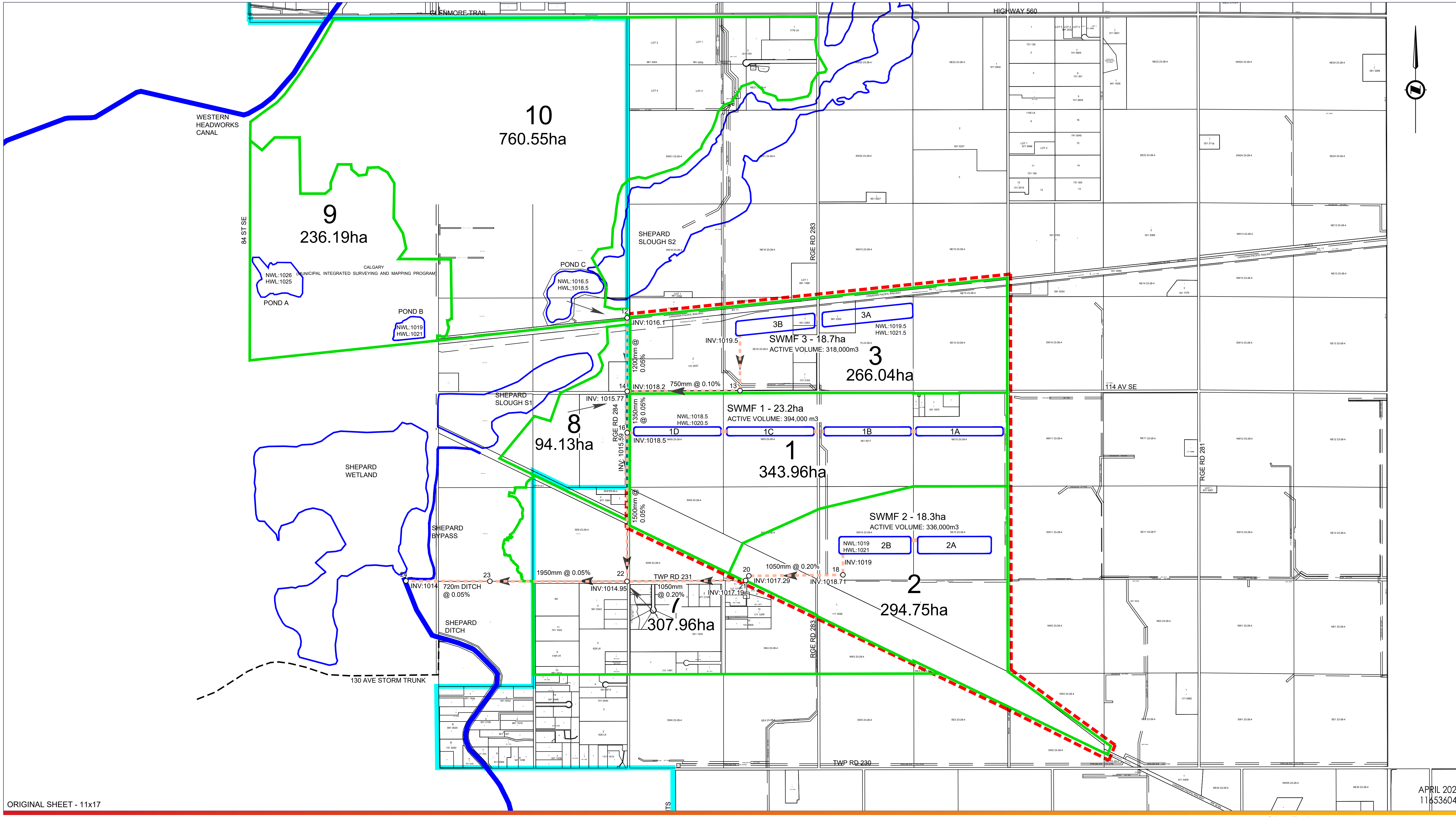
Figure No.
4.2

Title
POND A-B-C PROFILE



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- PRAIRIE GATEWAY ASP AREA
- CITY OF CALGARY LIMITS
- STORM CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- PROPOSED SWMF
- CONTRIBUTING AREA

Notes

OPTION 2 INCLUDES AREA 1-3, 7-10

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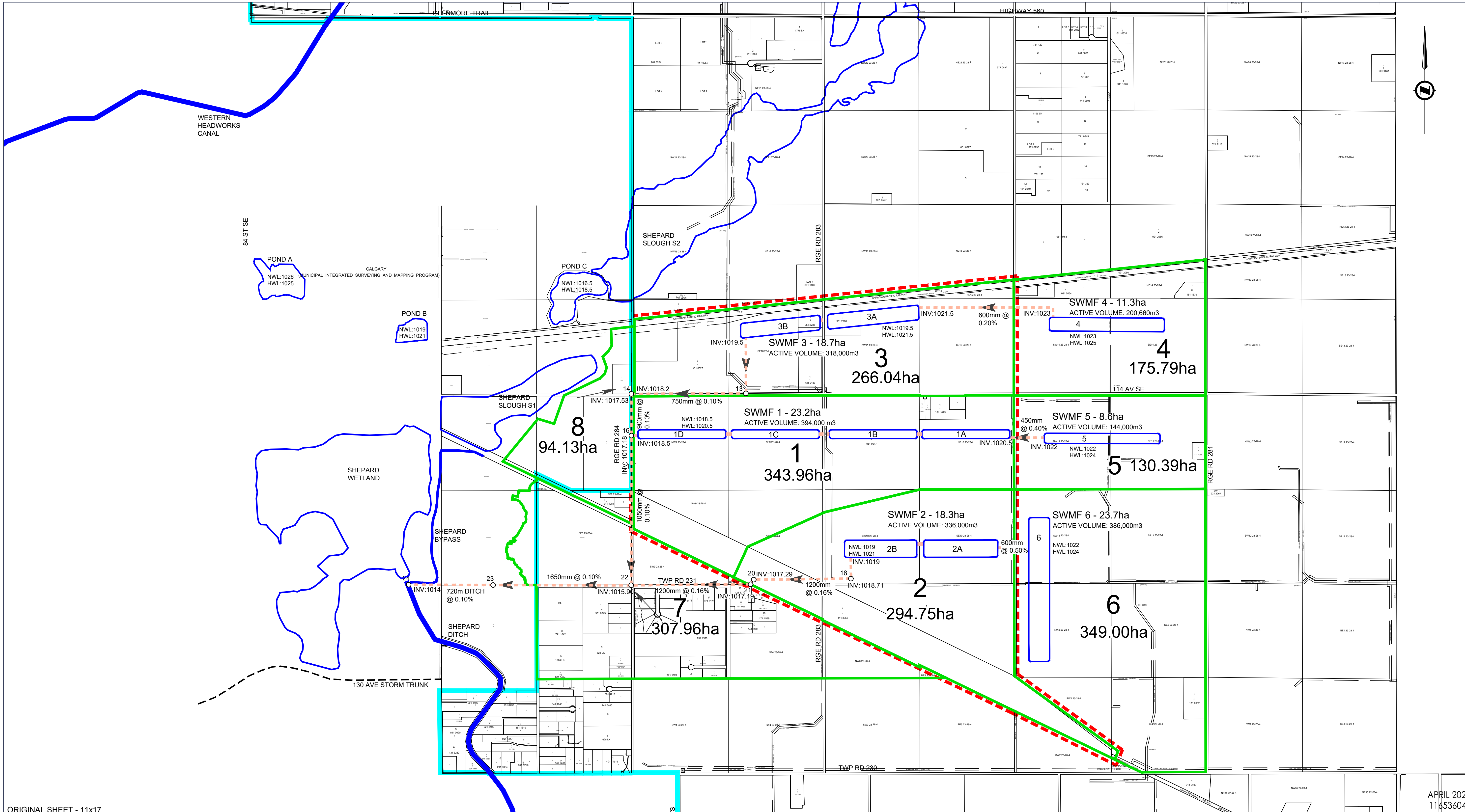
MASTER DRAINAGE PLAN

Figure No.
4.3

Title
SERVICING CONCEPT OPTION 2



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- PRAIRIE GATEWAY ASP AREA
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- STORM CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- PROPOSED SWMF
- CONTRIBUTING AREA

Notes

OPTION 3 INCLUDES AREA 1-8

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Figure No.

4.4

Title

SERVICING CONCEPT OPTION 3

4.2.4 STAGING

Staging is generally anticipated to run from south to north, west to east, with each stage being approximately 32 ha in size (on average 2 stages per quarter section and 1 stage constructed per year). The staging scheme lends well to the linear pond cells as the ponds can be expanded easterly as stages develop. Note, that the SWMF cells shown on the figures are still conceptual in nature and subject to change. Each cell will be further separated into sub cells using isolation structures to allow for maintenance.

The SWMF locations have also been strategically chosen to be at the low spots in the subcatchment areas and the phasing of each SWMF starts in the lowest area (west cell). This is intentional to allow the undeveloped stages within the quarter section of a SWMF, to naturally drain to the SWMF. There are a few instances where some minor grading would be required to divert the flows towards the SWMF, i.e. when SWMF 3_b and SWMF 1_d would be constructed.

While the above staging is understood to be the intention at this time, it is still possible for the staging to proceed differently, using temporary ditching to interconnect ponds cells or connect to trunk outlets, on a temporary basis.

It would also be a requirement of the SMDP that the drainage of the existing lands surrounding the new construction stages be accommodated as the temporary grading required will be highly dependant on the phasing.

The conceptual staging is shown on **Figure 4-5.**

4.2.4.1 Year 1

Year 1 requires a significant amount of drainage infrastructure to service the first stage of development. SWMF 1, as well as all downstream trunk infrastructure to the outlet at the Shepard Ditch is likely necessary. The proposed trunk spans approximately 2,450 m from the SWMF 1 west cell to the outlet along TWP 231. Then from the outlet there is 720 m of ditch to convey the flow to the Shepard Ditch.

The major overland path from SWMF 1 tips over to the north and eventually to the wetlands north of the ASP lands between the ASP lands and the Shepard Slough Complex. Grading outside the development stages is anticipated to be limited to the overland flow path from SWMF 1, with 2 culvert crossings required for the drainage to reach the existing wetlands to the north. This is discussed in detail in **Section 4.3** as well as an alternative overland flow path.

4.2.4.2 Year 5

The Year 5 buildout will likely include the second and third cells of SWMF 1 to continue development with no additional trunk infrastructure required until area 2 and/or 3 is developed. The major overland flow path for Year 5 will not change from Year 1.

The approximate 990 m of storm trunk section to service Area 9, 10 and 11, from the northwest corner of the ASP lands, along RR 284, down to the connection point where SWMF 1 meets the RR284 storm trunk, could be constructed at anytime, depending on the development timing of the north and west lands.

4.2.4.3 Year 20

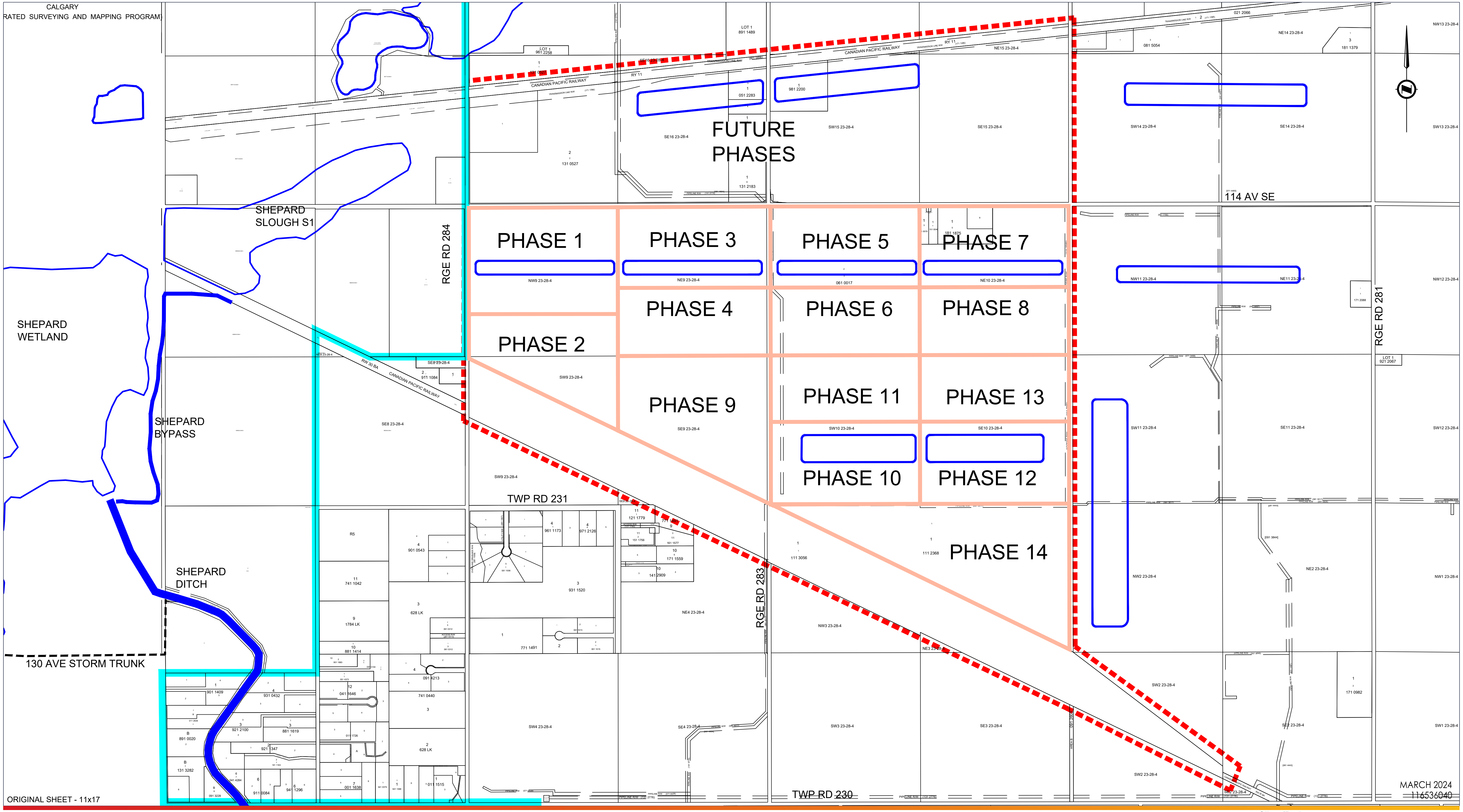
The Year 20 development horizon (at 32 ha of land per year) will likely require the construction of the remaining cell of SWMF 1 and both cells of SWMF 2 and the approximate 1,920 m of downstream storm pipes that connect SWMF 2 to the tie in location to the trunk constructed in Year 1 (at the intersection of RR 284 and TWP RD 231).

Major overland flow from SWMF 2 is accommodated as an additional 1 m^3/s of capacity added to the downstream pipes. See Error! Reference source not found. for details.

4.2.4.4 Maintenance Considerations

For construction or maintenance purposes, sluice gates or isolation structures are required between cells to isolate the cells for maintenance or spills. A maximum volume between isolation structures shall be 25,000 m^3 (volume of SWMF at the HWL) per isolation section, i.e. approximately four isolation sections per cell shown in **Figure 4-5.** Each isolation chamber shall be located above HWL with an access route to the chamber that is also above the HWL.

These sluice gates or isolation chambers are intended to have minimal head differences between the cells on either side of the isolation. To achieve isolation, the operator would close the sluice gates, and dewatering the cell by pumping. The SWMFs cannot be dewatered by gravity from NWL to the bottom.



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- PRAIRIE GATEWAY ASP AREA
- CITY OF CALGARY LIMITS
- STAGING BOUNDARY
- PROPOSED SWMF

Notes

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MASTER DRAINAGE PLAN

Figure No.
4.5

Title
STAGING PLAN

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4.2.5 EXTERNAL AND ADJACENT AREAS SERVICING

The areas adjacent to the ASP boundary have been analyzed to see the implications of the development of the Prairie Gateway area and evaluate servicing opportunities for these lands. The discharged flow in each of the below sections was included in the 1:100 year single event, and continuous simulation of the ultimate development condition.

Please read this section in conjunction with **Figure 1-1, Figure 4-1,** and **Figure 4-3**.

4.2.5.1 Upstream External Area - East of ASP

The area directly east of the ASP study area currently drains through the ASP area, so the servicing analysis has included this area in the ultimate servicing concept (area 4, 5 and 6). In the interim condition flows will drain overland per the existing conditions and some grading work may be required to direct the flows toward the interim SWMFs. This will need to be evaluated at the SMDP level. In the ultimate condition, stormwater from these catchments would be stored and discharged at 0.8 L/s/ha and conveyed through the Prairie Gateway proposed SWMF's.

4.2.5.2 Adjacent - Northeast of the Study Area

The area north and northeast of the ASP study area (area 11) was reviewed only for trunk sizing purposes (as the area is proposed to be serviced by the storm trunk on RR 284). The proposed discharge from this area is 0.631 m^3/s (based on a maximum UARR of 0.8 L/s/ha). The discharge is assumed to be entering the storm trunk at the furthest northwest proposed manhole (approximately where the abandoned rail ROW crosses RR 284) at a constant flow rate.

4.2.5.3 Adjacent - Northwest of the Study Area

The existing Shepard Business Park area northwest of the site (area 9 and 10) has only been reviewed to assess the potential to accommodate flows through the proposed storm trunk on RR 284. Existing Shepard Business Park Ponds A, B and C were included in the analysis and based on the outlet elevation of Pond C as discussed in **Section 4.2.1.1.** The proposed discharge to the storm trunk from this area is 0.797 m^3/s (based on 0.8 L/s/ha) and the discharge is assumed to be entering the storm trunk at the same proposed manhole where the abandoned rail ROW crosses RR 284, at a constant flow rate.

4.2.5.4 Adjacent - West of the Study Area

Catchment 8 is a small area to the west of the ASP study area that is anticipated to contribute a constant flow of 0.075 m^3/s (based on 0.8 L/s/ha) to the proposed RR284 trunk into a manhole at the intersection of RR284 and TWP 232, under the ultimate post development condition.

4.2.5.5 Adjacent - South of the Study Area

Catchment 7 is located south of the ASP study area and is estimated to contribute a constant flow of 0.246 m^3/s (based on 0.8 L/s/ha) to the RR284 storm trunk into a manhole at the intersection of RR284 and TWP 231, under the ultimate post development condition.

4.2.6 RAIL AND ROAD CROSSINGS

Culvert crossings will be required for crossing of new rail lines running in a north-south direction throughout the ASP area, roughly at the quarter section lines. With the SWMF's being split into connected cells at the quarter section lines, this allows for the rail or road crossings at those locations on the berms separating the cells. There should be no infrastructure parallel to the rail lines, only crossings.

Culverts will be sized at the SMDP level for flow paths crossing the roads to accommodate the flow without an increase in head. The culverts are proposed to be multiple barrels to ensure cover and appropriate capacity and would be installed between pond cells flat or with very little slope. These culverts will also be locations of sluice gates, isolation chambers (required per ever 25,000 m^3 of SWMF).

Minimum road and building elevations will be set vertically above freeboard to the overland drainage, and at least at a minimum slope to allow for drainage of runoff to the SWMF. At this stage, there is no road network outline or building locations, therefore it is not possible to set the exact minimum elevations. The SMDP will need to consider the minimum allowable slopes for drainage to set the minimum road and building elevations.

An appropriate horizontal setback will also be required from the major drainage infrastructure to roads, property lines and buildings. This will also need to be reviewed at the SMDP.

4.2.7 INTEGRATION WITH SANITARY AND WATER SERVICING CONCEPTS

Coordination with Stantec on sanitary and water servicing concepts is ongoing. Currently, the stormwater management trunks are placed along the quarter section lines as commonly those would be transportation corridors and then stormwater pipe alignment would be proposed under the roads. Future review of inverts and obverts is required to address any conflicts with sanitary pipes. Water pipes have a pressurized flow, and as such, they can be raised above the larger storm trunks and to avoid conflicts at crossing locations.

4.3 Major Drainage System

The design standards for the City of Calgary require a major system that can safely convey runoff resulting from a storm event up to the 1:100, 24 hour event or continuous simulation (whichever is greater), without flooding causing damage to property, and if there is not emergency drainage route, an additional 1 m^3/s of pipe capacity is required. Error! Reference source not found. represents the proposed major drainage schematic and shows the overland emergency escape route with existing and proposed elevations. Generally, the ASP area is split by a drainage divide with Areas 1 and 3 on the north and Area 2 on the south of the divide. Areas 1 and 3 are able to have an emergency overland drainage route to the existing wetlands north of the MDP area between the MDP area and the Shepard Slough Complex.

The overland route from SWMF 1 and SWMF 3 has two options:

- Direct overland flows north through the existing wetland in the northwest corner of the ASP area and then via culvert crossing towards Shepard Slough S2.

- Direct overland flows from SWMF 1 west towards Shepard Slough S1 and direct overland flows from SWMF 3 towards the existing wetland as per Option 1, or across RR 284 to Shepard Slough S1.

Due to the existing track elevations and surrounding topography, Area 2 in the south of the ASP study area is not recommended to have an emergency overland drainage route, therefore the outlet pipes from SWMF 2 have been sized to accommodate an additional 1.0 m^3/s. Overland flows from Area 6 would be directed towards SWMF 2.

4.3.1 ULTIMATE OVERLAND OPTION 1

Figure 4-6 illustrates the schematic locations of the major overland drainage route options. The intent is that the flow paths are revised during the planning process and solidified in the SMDP.

SWMF 3 has a higher HWL than SWMF 1 which allows there to be a combined overland emergency escape route internal to the ASP that SWMFs 1 and 3 would both tie into and be directed north towards Shepard Slough S2. A culvert would need to be installed crossing the abandoned rail ROW and some ditch excavation and grading would need to be completed to maintain grade towards Slough S2. This option avoids the need for easements into the lands west of RR284.

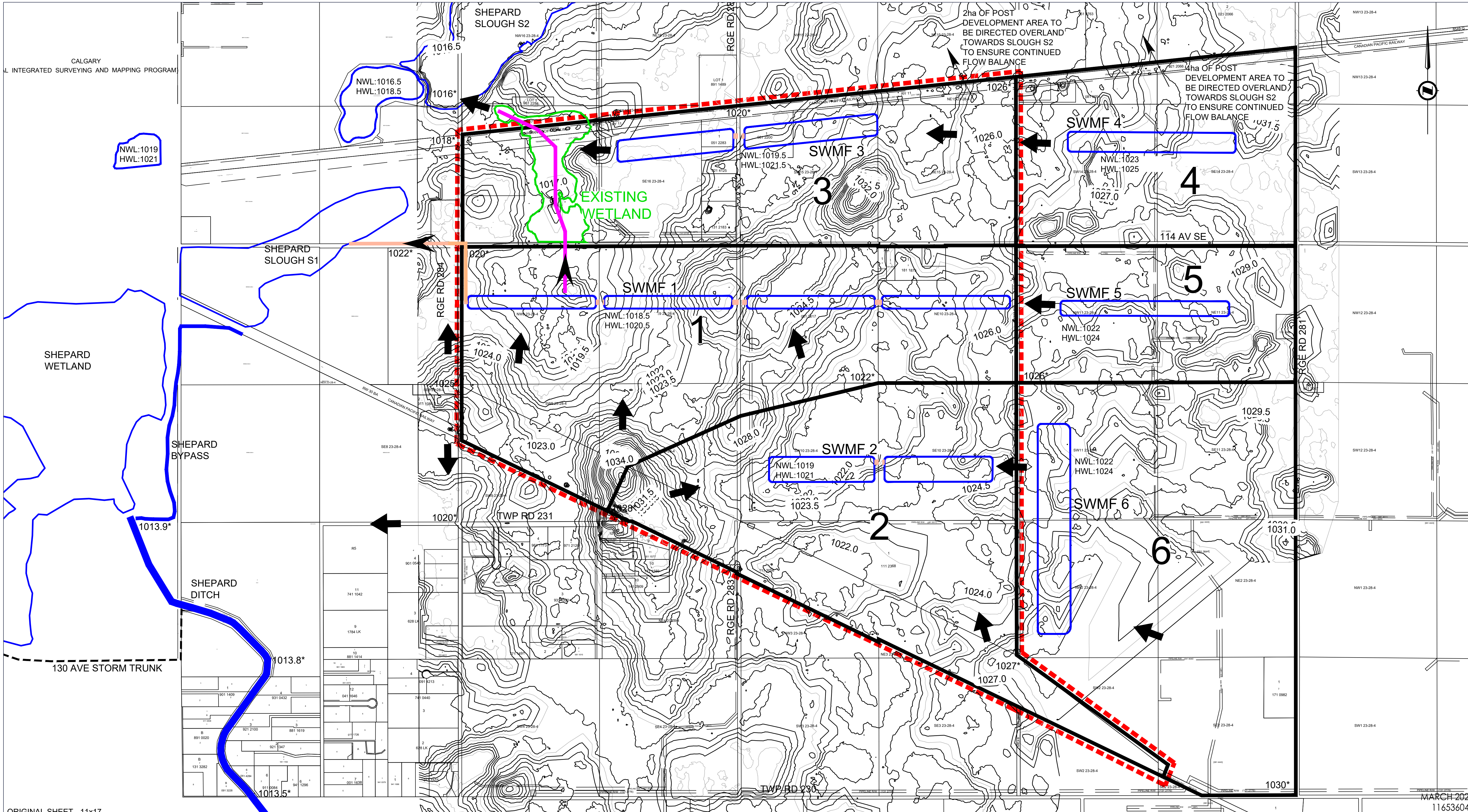
In both Options 1 and 2, SWMF 4 would have an overland flow route to SWMF 3, SWMF 5 would have an overland flow route to SWMF 1, and SWMF 6 would have an overland flow route to SWMF 2.

4.3.2 ULTIMATE OVERLAND OPTION 2

As an alternative, the overland flows from SWMF 1 could be directed to the western boundary of the ASP area and a culvert crossing RR284, instead of directing north to Shepard Slough S2 which requires ditching work, the route could be directed west towards Shepard Slough S1. This alternative requires less offsite upgrades but may require easements within the lands west of RR 284.

Overland flows from SWMF 3 could still be directed towards the existing wetland as per Option 1 or depending on retention of the existing wetland in the northwest corner of the ASP lands, could also be directed west and cross RR 284 to be directed towards Shepard Slough S1.

The SWMF overland spill elevations can be found in **Table 5-2** and **Table 6-2.**



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- STORM CATCHMENT
- PRAIRIE GATEWAY ASP AREA
- OVERLAND FLOW OPTION 1
- OVERLAND FLOW OPTION 2
- MAJOR OVERLAND FLOW DIRECTION
- 1020* EXISTING ELEVATION
- 1017 EXISTING CONTOURS

Notes

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MASTER DRAINAGE PLAN

Figure No.
4.6

Title
MAJOR DRAINAGE

4.3.3 SWMF 2 OVERLAND EMERGENCY ESCAPE ROUTE

It was determined that an overland emergency escape route was not practical for SWMF 2 for the below reasons:

1. The potential overland flow path southward, through the CPKC rail crossing, is narrow and there is no eventual outlet beyond the wetland south of the railway crossing which would lead to a potential flooding issue, based on the LiDAR analysis.
2. The land south of the ASP area has private landowners, and they would likely have concerns related to the flows being directed to their property.
3. There is a concern of potential raising of the grade downstream in the future on private lands if development occurs for the lands to the south, leading to a future interruption of the overland escape route.
4. The proposed rail yard would be developed and filled in order to bring the grade up (anticipated to be one of the first areas modified) and there would be no overland conveyance route available to discharge the flows southerly to the existing grassland area; a culvert or other closed conduit under the rail line would be needed, for several hundred metres.

Figure 4-7 depicts a plan & profile view of the ground profile if the flows were to be sent along the same path as the proposed pipe alignment. As can be seen from the profile there are multiple low spots where the overland flow would be stored and not drain south due to gravity and, if in the future, the area is developed, there would be no location to accommodate the overland flows. This is not a viable option.

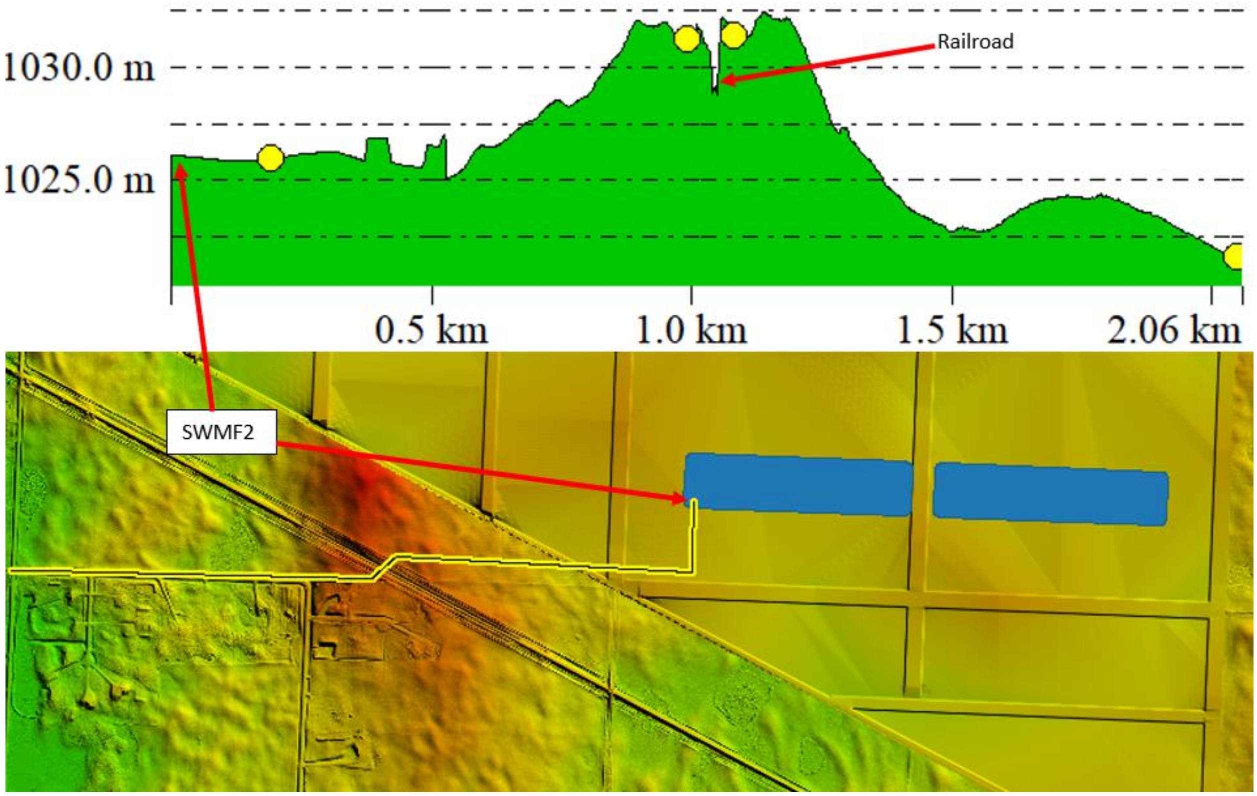


Figure 4-7: Proposed Pipe Emergency Route

Figure 4-8 illustrates the emergency escape route in the scenario if overland flows were drained southerly across the rail corridor. As observed from the LiDAR, there are some high elevations in the overland conveyance route which would cause obstruction and possible ponding of water at the low spots. Moreover, as noted earlier, if the downstream area gets eventually developed in the future with the low elevation locations filled, there would be no pathway for the flows to leave the site and hence, would backflow to the site causing a possible flooding concern.

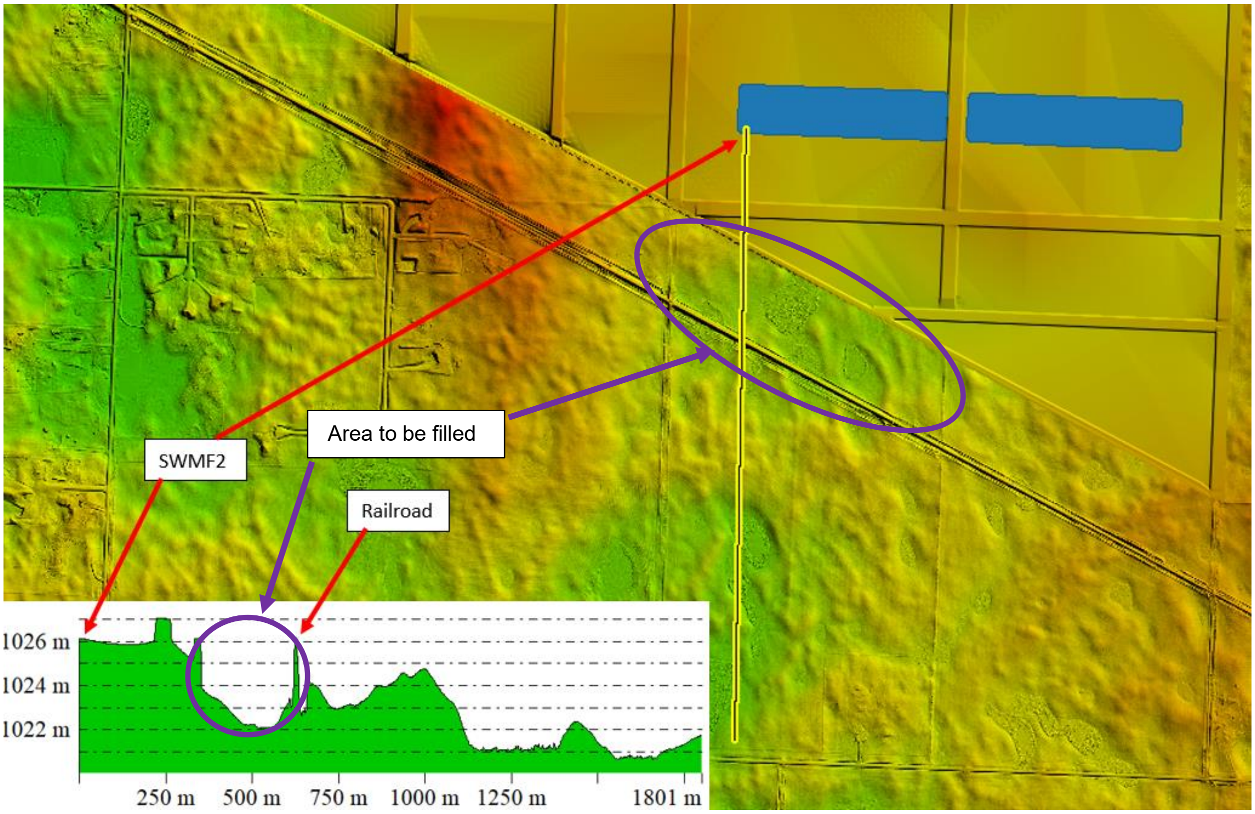


Figure 4-8: Emergency Escape Spill Route (topography is an overlay of preliminary road grading within ASP lands and existing LiDAR to the south)

The preferred path forward is to provide a pipe emergency escape route with additional pipe capacity of 1 m^3/s and maintain the freeboard requirement for the SWMF to 0.5 m (City of Calgary (CoC), 2011). The proposed pipe emergency route is to the west to the proposed storm trunk on RR 284 as shown on **Figure 4-1, Figure 4-3,** and **Figure 4-4.**

4.3.4 SWMF SIZING

Stormwater management facilities are essential components of the stormwater management system to control rates and volumes of discharge to the receiving storm system and Bow River, as well as provide treatment of stormwater to minimize discharge of sediments.

Six SWMFs (wet ponds) are proposed and were designed for the MDP study area. Due to the conceptual locations and shapes, the SWMFs have been sized conservatively at the MDP level so maximum volume and depth are not exceeded in the continuous and single event models. The required storage was calculated by taking the maximum of the statistical analysis of the continuous model results to determine a theoretical 100-year storm event, and the single 1:100 year, 24 hour storm event for both the interim and ultimate condition. This sizing leads to zero spill volume in SWMFs 1 through 6 during the continuous simulation.

The area of the SWMF is determined based on the maximum storage with a maximum 2 m depth of active storage.

At this stage there is no road network outlined or proposed cross section, therefore it is not possible to include street trap low storage to reduce pond sizing, so none has been assumed. The assumption of no trap low storage leads to conservative pond sizing. At the SMDP level, it is expected that the SWMF sizing will be refined and optimized based on a more detailed site layout and grading design. Future SMDP reports and SWMF designs shall conform to the most current version or amendment to the City of Calgary guidelines at the time as well as industry bulletins issued by the Water Resources department.

The SWMFs were segmented into cells at the quarter section lines to allow for road and rail to pass across the water bodies. The figures in this MDP schematically show them as rectangles however, the shape can be determined at the SMDP level with additional grading details and aesthetics in mind. The current stormwater management concept does not involve pumping stormwater.

SWMF details can be found in **Section 5.2.1** and **Section 6.2.1**.

4.3.5 DAM SAFETY ASSESSMENT

The *Water Ministerial Regulation*, Section 27, defines a dam as a water body designed to retain or store water that meets at least one of the below criteria:

1. That provides a live storage capacity of 30,000 m^3 or more and is 2.5 m or more in height when measured vertically to the top of the barrier, OR
2. That is classified as being a significant, high, very high or extreme consequence structure in the Safety Directive, OR
3. That exists for the purpose of storing flowable tailings.

It is important to recognize in this situation live storage is referring to the volume of water that is stored above the surrounding ground level (i.e., the volume that would be released if there was a dam breach).

The proposed SWMFs are anticipated to be excavated with all water storage occurring below the ground with a low consequence of failure (no risk to human life, minimum short-term losses including environmental losses, and low economic losses). Therefore, based on the MDP design, the SWMFs are not considered dams at this time, however, it is recommended to review the classification again at the detailed design level when the cross section for each SWMF and associated berms are finalized.

4.4 Minor Drainage System

The minor system described in this section is referring to the storm system upstream of the SWMFs and connecting the SWMF cells. The outlet pipes from SWMF 1 and 3 are sized to accommodate the minor drainage from SWMF 5 and 4, respectively, and the emergency flow for SWMF 2 and 6 (due to the difficulty in creating an overland emergency flow route).

Although the criteria required for sizing the minor system is outlined in this MDP, determining the minor system components upstream of the SMWFs are outside the scope of this study. A scenario of minor system pipes was created to assess the cover of the pipes and required slopes to allow the stormwater from the future properties to drain to the proposed SWMFs. The example system conveys stormwater from the furthermost corner of each quarter section to the nearest SWMF.

Figure 4-9 illustrates the minor pipe system model created for this scenario.

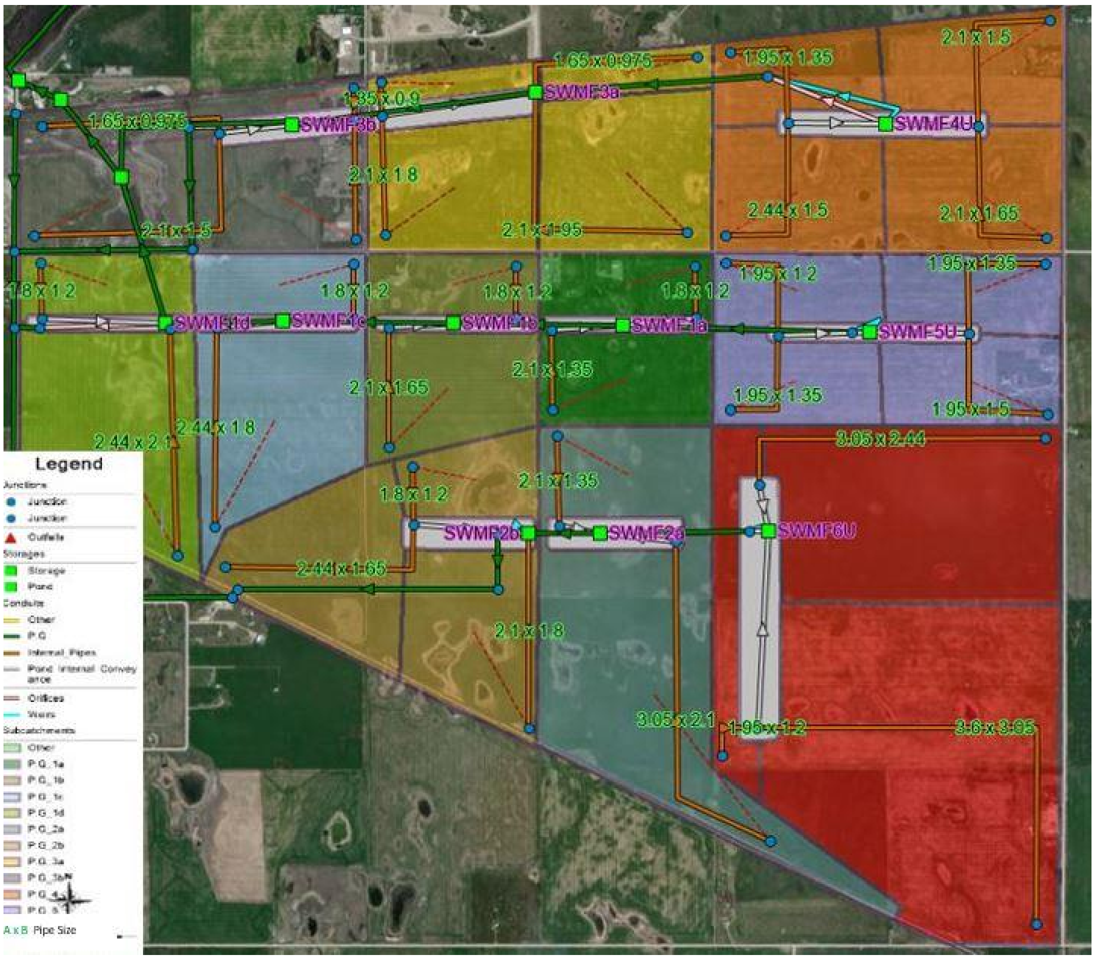


Figure 4-9: SWMF Outlet Pipes and Covers (Layout Overview)

4.4.1 STORM SEWER COVER

As part of the overall ASP design efforts, a conceptual grading design was reviewed in conjunction with the proposed stormwater pipes and their inverts. The proposed minor system pipes have been designed to accommodate a discharge flow of 115 L/s/ha as recommended in the design guidelines.

As illustrated in **Figure 4-10, Figure 4-11, Figure 4-12** & **Figure 4-13**, all the storm trunks which connect SWMFs have sufficient cover without daylighting. Modifications to this design will be required at certain locations and could include additional fill to raise the grade in the areas above the hydraulic grade level

(HGL). Each junction information includes the rim elevation which corresponds to the proposed grade, HGL level at the junction based on the SWMF HWL and the pipe cover from grade.

HGL represents the water level in the pipe in a scenario of the 100-year design storm event. Therefore, the HGL level numbers denoted in the above figures represents the scenario when the 100-year design storm event is occurring and the associated HGL levels at the respective subcatchment locations at the manhole rim elevations. In the case of the HGL being higher than the rim elevation, the stormwater will flow out of the manhole lid and likely cause a flooding concern if the area is not raised while construction.

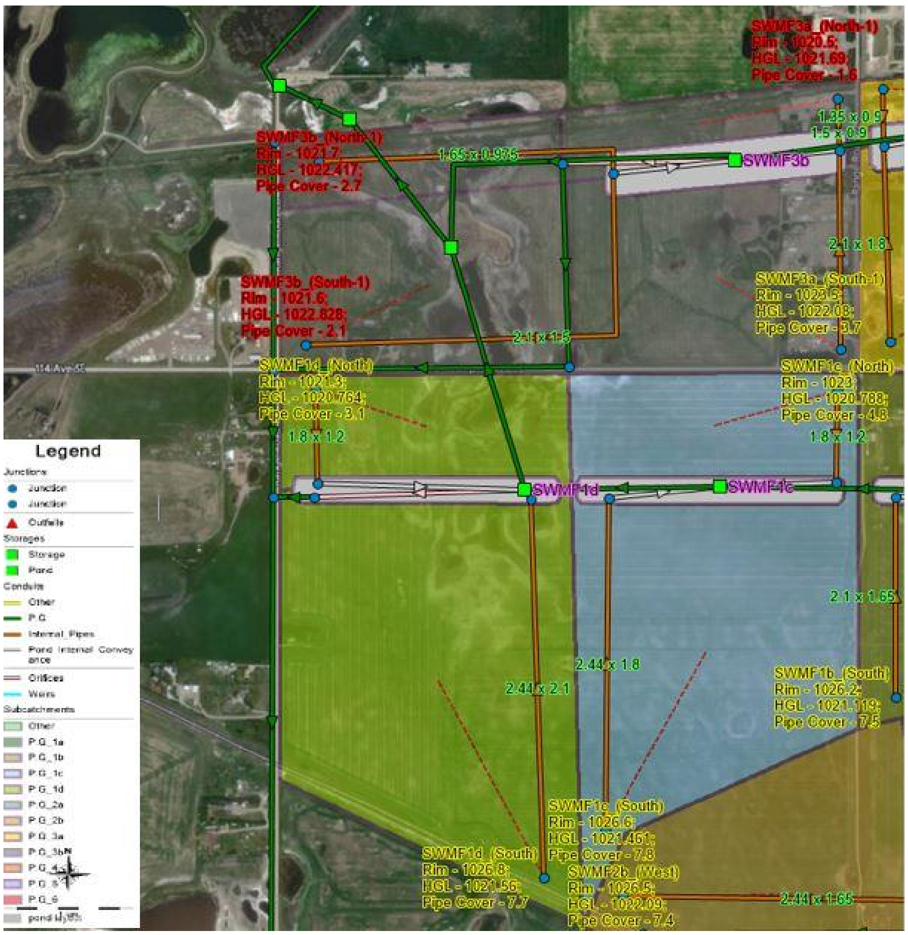


Figure 4-10: SWMF Outlet Pipes and Associated Ground Cover (Layout Section-1)

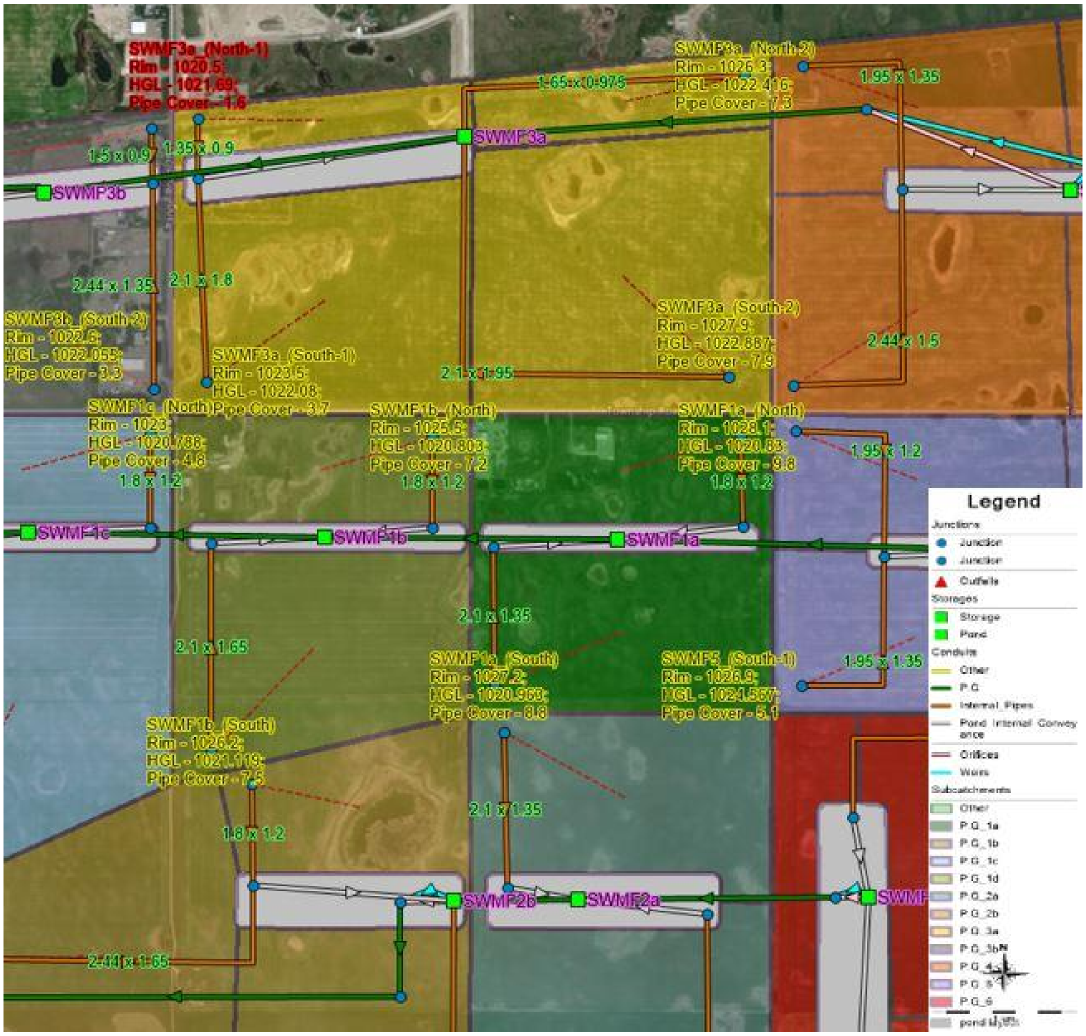


Figure 4-11: SWMF Outlet Pipes and Associated Ground Cover (Layout Section-2)

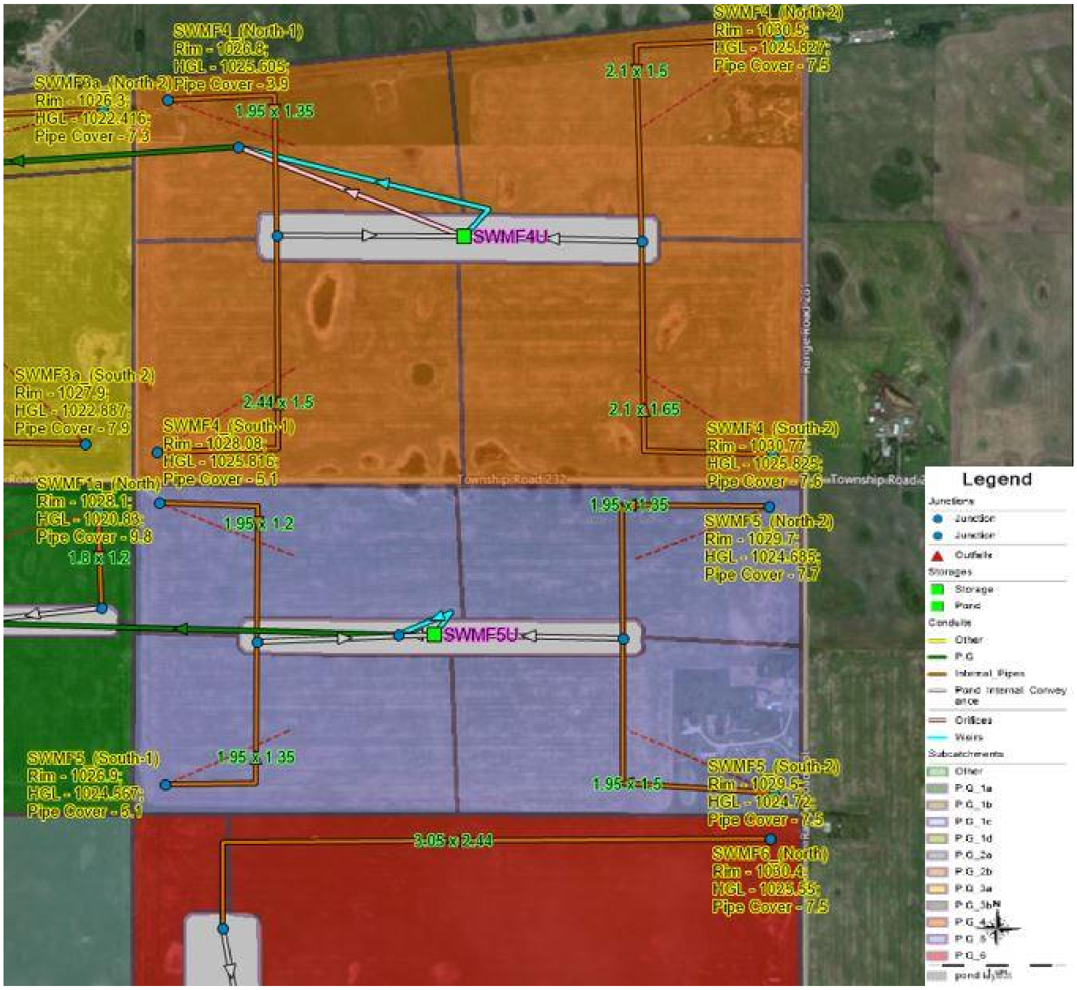


Figure 4-12: SWMF Outlet Pipes and Associated Ground Cover (Layout Section-3)

Figure 4-13: SWMF Outlet Pipes and Associated Ground Cover (Layout Section-4)

To assess impacts of cover to onsite storm sewers, a preliminary storm calculation sheet (**Appendix D Minor Storm System Sizing Calculation Sheet)** was created to determine the maximum size of the outlet pipe which would be required for individual subcatchments draining to the associated SWMF. Based on the conceptual grading plan, the available pipe cover is calculated. Inletting trunks are assumed to be submerged with inverts being 1.5 m below the NWL of the SWMF. The pipes have been sized based on an assumed capture rate of 115 L/s/ha.

The above figures illustrate the maximum pipe sizes to each SWMF within a subcatchment. The trunks are assumed to be a twin pipe system with another pipe of the same size running parallel. The reasoning for using a twin pipe system is to lower the height of the pipe to maintian cover, as a double pipe can be designed to carry the equivalent flow of a single pipe but spreads that flow between two pipes allowing those pipes to be smaller diameter.

4.5 Design Recommendations

The City of Calgary's Stormwater Management Guidelines, dated December 2011, require that the following are to be met relative to the major drainage system:

- Depths and velocities of flows shall be within the acceptable limits as provided in the guidelines;
- Depths of flow are not to exceed 0.3 m;

- Depths of standing (ponding) water are not to exceed 0.5 m.
- Freeboard between water level at the 1:100 year event (plus freeboard of 0.3 m minimum) and the invert of the overland spill weir for SWMF 1 and 3, as both SWMF's have an overland emergency drainage route.
- Freeboard between water level at the 1:100 year event (plus freeboard of 0.5 m minimum) and the invert of the overland spill weir for SWMF 2, as there was no overland emergency drainage escape route that was practical for the design. Outlet pipe and downstream storm pipes are also required to be upsized to accommodate an additional 1 m^3/s as the primary escape route (City of Calgary (CoC), 2023)
- Vertically HWL separation and pipe cover will govern recommended grading minimum elevations, since all expected buildings will be slab-on-grade industrial or commercial construction. The preliminary SMWF sizing accounts for some additional space between HWL to surrounding property grade, and once site grading is further along these can be confirmed.
- Horizontally, the appropriate setback will also be required from the major drainage infrastructure to accommodate future access to that infrastructure.

Additional details of the major and minor drainage systems are not presented further in this Master Drainage Plan. These details will be prepared at the time of detailed designs for each phase of development.

4.5.1 SOURCE CONTROL PRACTICES

Source control best management practices (SCP) are measures that can be used to provide both quantity and quality control of stormwater from urban developments. Within the context of this MDP, SCPs are necessary towards decreasing the runoff volume that would discharge to the Bow River. Such measures can also be used in combination with low impact development (LID) techniques which themselves are development practices that reduce overall environmental impacts.

Both the City of Calgary guidelines (2022) and Alberta Environment's guidelines (January 1999) describe BMP techniques that can be implemented to control the quantity/rate and improve the quality of stormwater discharges to receiving watercourses. Water Resources has developed a Stormwater Source Control Practices Handbook (November 2007) as an initial guide for application of some specific measures. They are currently developing more comprehensive guidelines, standards and specifications for SCPs in the CoC.

The following SCPs could be considered for this industrial development:

- Bio-swale areas can be used to enhance the amount of water retention for plant consumption. Vegetation along street right of ways are a form of bio-retention that are specifically designed to treat the stormwater from roadways and sidewalks.
- Increased topsoil (300 mm or greater) for landscaped areas on private lots and road rights-of-way will increase stormwater retention and provide opportunities for enhanced landscaping.

- Directing drainage from impervious surfaces (roofs, driveways, parking lots, etc.) to landscaped areas will promote additional infiltration of water into the soils.
- Directing overland drainage to open space (park) areas will reduce the amount of water that gets into the stormwater management system.
- Reduction of runoff volumes will occur as incidental benefits arising from evaporation and evapotranspiration losses associated with large SWMF surface areas.
- Stormwater capture and reuse may be possible for high water users for industrial purposes. This may require small onsite water treatment systems and storage tanks within those properties, but it would lessen their draw on the potable water system for processes that don't require potable water.
- Stormwater use for irrigation for the pond PUL fringe areas above the HWL. The stormwater may also be used to irrigate landscaped areas on private sites with an appropriate agreement with the CoC, however, care needs to be taken to ensure that AEPA guidelines for stormwater irrigation are not exceeded.
- Exfiltration ponds have cells within long linear wetlands to exfiltrate water. Some cells may be lined and some not lined with lined cells potentially drying out over time. This SCP is highly dependent on the geology and hydrogeology of the area. Site investigations would be required prior to considering exfiltration ponds.
- Perforated pipes can be installed below and parallel to the conventional storm pipes. Flows are directed to the perforated pipe at the nearest downstream manhole and can exfiltrate into the surrounding gravel filled trench and surrounding ground. Higher flows can still overflow into the conventional storm pipes. This approach has been used in Toronto for 20+ years.
- Educational material can be provided to property owners to inform them of the Drainage Bylaw requirements and encourage additional measures that can be implemented onsite, such as absorbent landscaping and stormwater reuse.

As the road network and typical cross sections have not been determined, the SCPs for the runoff from the impermeable road surface is not yet known. In addition to these stormwater BMPs, LID practices will be proposed at the time of the SMDP.

4.5.2 WATER QUALITY

While the onsite SCPs listed in **Section 4.5.1** can minimize the quantity of pollutants that leave the development areas, the SWMFs will be the primary water quality treatment mechanisms as most stormwater flow reaches a SWMF before leaving the MDP lands. The inlet location for the flows to the SWMFs are also required to direct flow through a forebay for pre-treatment before the flow reaches the main cell of the SWMF. An Oil and Grit Separator unit may be an acceptable alternative to the sediment forebay as determined in the Master Service Agreement.

The target for the offsite discharge is for a minimum 85% removal of TSS for particle sizes greater than, or equal to 50 μm (City of Calgary (CoC), 2011). Modelling for sediment transport has not been completed for this study but shall be completed with future SMDPs prior to detailed design of the SWMFs. If the sediment transport modelling shows that the ponds do not meet the TSS removal requirements additional water treatment, such as an OGS, will be required. As this in an industrial area, other treatment and containment of other contaminants will also need to be considered during detailed design.

For bio-retention areas and bio-swales, estimates shall be provided for the amount of sediment that can be accommodated by these features at the time of full build-out of the contributing catchment area (i.e., fully landscaped) to ensure proper operation of these features. These estimates shall be provided at the time of subdivision design with the affected stormwater management report or Development Site Servicing Plan submission. Final acceptance protocols will be determined in the Master Service Agreement.

In addition to the above quality control for ultimate development conditions, it is equally important to practice temporary sediment and erosion controls during construction of the new developments. Erosion control measures will be defined in the ESC Plan which is required at the detailed design phase. In particular, sediment loadings shall be less than 2 tonnes/ha/year to avoid concerns during construction (City of Calgary (CoC), 2022). Greater amounts of sediments than this loading are required to be removed at the cost of the developer.

5 Post Development Analysis - Interim Condition

The interim condition post development model was created by updating the predevelopment model to reflect a fully developed ASP study area. The interim condition model results were then compared to the pre-development condition results.

5.1 Modelling Approach

5.1.1 PRECIPITATION – RUNOFF ANALYSIS

The interim condition hydrologic analysis includes quantifying the volume of runoff resulting from precipitation falling on the MDP study area. The interim model was run for the below list of design precipitation events:

- 1:100 year, 24-hour storm event (Chicago distribution)
- 55-years continuous simulation (1960-2014)

The 2050 and 2080 projected storm events were not considered for the interim condition as it is anticipated that the MDP study area will be fully developed at that time, and thus in the ultimate development condition. See **Section 6.1.1** for the ultimate condition precipitation runoff analysis.

5.1.2 HYDRAULIC AND HYDROLOGIC MODEL

The interim condition drainage system was reflected in the model with updated subcatchment, conveyance routes and SWMFs.

Within the ASP study area, the 75 pervious existing subcatchments were replaced with 8 impervious subcatchments and 8 storage nodes that represent the 3 SWMFs with 8 cells total. The 3 SWMFs were split into cells to accommodate multiple crossing locations for both road and rail to service the development. The SWMF cells were connected by conduits and the cells on either side of the berms have the same water levels.

- SWMF 1 has 4 cells
- SWMF 2 has 2 cells
- SWMF 3 has 2 cells

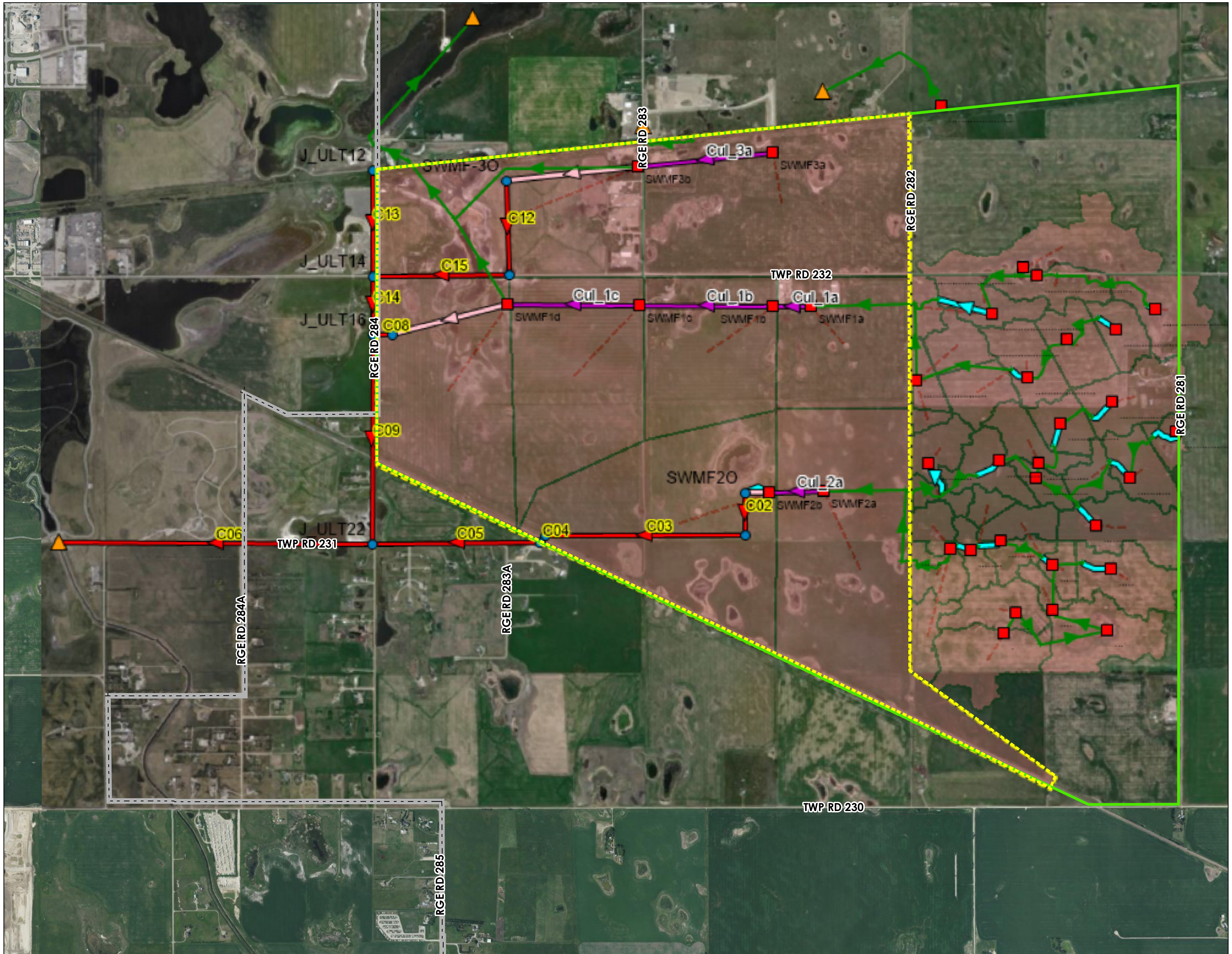
Conduits (representing pipes) were added to connect the SWMF downstream outlets to the conduit representing the storm trunk on RR 284. Under the interim development condition wetlands were removed within the ASP boundary as a conservative assumption.

The east external upstream lands remain as the existing condition, however the subcatchments that were draining into the ASP lands, now drain to proposed SWMFs 1 and 2 by overland routes. Under the interim development condition wetlands in the upstream external lands are maintained.

The remaining MDP study area lands do not runoff to the ASP study area under the existing condition and were not considered in this model. The adjacent lands (areas 7-11) can be connected to the proposed storm trunk along RR 284 and TWP 231 without impacting the proposed servicing concept.

The interim development condition catchments are shown on **Figure 5-1.**

The specific interim conditions model parameters can be found in **Appendix E.1 Interim Condition Input Parameters.**



Stantec

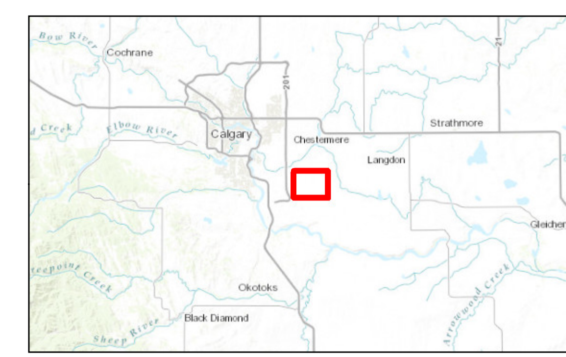
- ASP Boundary
- MDP Boundary
- Storage Node
- Junction
- Outfall
- Overland Flow
- Storm Sewer
- Culvert
- Orifice
- Weir
- Subcatchment

N

0 250 500 metres

(At original document size of 11x17)
1:24,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary



Project Location
SE Calgary
Alberta

Prepared by KDB on 2024-03-25
TR by NF on 2024-03-26

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
5-1

Title
Interim Development Condition
PCSWMM Model

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_Fig5-1_Interim.mxd Revised: 2024-04-19 By: kebuchanan

5.1.3 RUNOFF COMPUTATION

As the existing conditions model was also used for the interim conditions model, the same snowmelt, depression storage and evaporation losses inputs were used. The below parameters were updated from the existing condition to reflect the interim condition.

5.1.3.1 Imperviousness

The land surface within the ASP study area under the interim condition is assumed to be 90% impervious. The east external upstream lands to the ASP study area are assumed to remain undeveloped and the overall drainage pattern matches the existing condition.

See **Appendix E.1 Interim Condition Input Parameters.**

5.1.3.2 Length and Slope

Within the ASP study area, the catchment length is measured from the edge of subcatchment to the SWMF storage node. The slope of these catchment flow paths is assumed to be 0.5%. This assumption represents a conservative overall average slope after final grading.

East external upstream lands, again match the existing condition.

5.1.3.3 Infiltration

The Green-Ampt method, as used in the existing condition model, was also used for the interim catchment infiltration calculation with an assumption that the soil is again generalized as a sandy clay loam. This infiltration assumption was not used for the SWMF storage nodes as the SWMFs will be lined and not have groundwater infiltration.

The soil type should be confirmed by a geotechnical investigation at the time of the SMDP.

5.1.4 GROUNDWATER CONDITIONS

The groundwater within the ASP lands now discharges to the wetlands outside of the ASP study area, as the wetlands within the ASP were removed. SWMFs 1, 2 and 3 do not have infiltration as they are proposed to be lined. The groundwater under the east external upstream lands uses the same aquifer parameters as the existing model except that groundwater either ponds, or discharges to the outside of the ASP study area.

5.1.5 STORAGE ROUTING

5.1.5.1 Storage Rating Relationship

Each of the SWMFs is represented by a depth - area relationship which was determined based on allowable active water depths (maximum active storage depth of 2.0 m) in the SWMFs and containing the 100-year storage volume. The inactive storage, from NWL to bottom of the cell has not been modelled and the initial depth of the storage nodes was set to be at the NWL.

The storage curves for the SWMFs within the ASP study area are presented in **Appendix E.2 Interim Condition Results.**

The storage nodes were modelled to not allow any seepage or infiltration to occur, evaporation is the only type of water loss at the nodes and an evaporation factor of 0.8 from the existing conditions model was kept. Under the interim condition, the east external upstream lands have the same wetland ponding nodes as the existing condition.

See the **Section 4.3.4** on pond sizing for more details.

5.1.5.2 Discharge Relationship

The controlled discharges from the SWMFs were represented in the PCSWMM models as circular orifices. The vertical height of the orifice represents the diameter, which was set to pass the continuous model 100:year return period discharge with the water level at the HWL.

The effects of low driving head on the outlet control structures were incorporated as part of the dynamic modelling and orifice sizing. Outfall structure sizing and design will be determined at detailed design.

The various orifice sizes used in the post-development models are provided in **Table 5-2.**

5.1.6 CONVEYANCE ROUTING

Conveyance of flows for the interim development condition within the ASP study area, (i.e. for SWMF 1, 2 and 3) each have a piped discharge outlet to the proposed trunk on RR 284 which outlets to the Shepard Ditch, see **Figure 5-1.** Pipe sizing can be found in **Appendix E.2 Interim Condition Results.**

The east external upstream lands drainage system follows the existing system flow paths to the east border of the ASP study area, where the flow is intercepted with a conduit and directed to SWMF 1 or 2 as an overland ditch with a 2 m bottom width and 5H:1V side slope.

The storm trunk along RR 284 has been extended beyond the SWMF 1 and 3 connection point to accommodate servicing areas 9-11. If the CoC does not require servicing area 9 to 11, then that section of trunk is not required, and updates to the pipe elevations can be reviewed. See **Section 6.3.3** for details.

5.1.7 INTERIM BOUNDARY CONDITIONS

The model outlets to the Shepard Ditch at a location that is south of the Shepard Wetland. As-built Drawings for the Shepard Stormwater Diversion Project, include the top and bottom of ditch elevation at this location and the previous ECRDS Phase 1 model modelled flows for the Chicago 1:100-year, 24 hour, single event. See **Table 5-1** for a summary of the elevations.

Table 5-1: Existing Condition Elevations at Model Outlet

Source	Location	Elevation (m)
As-Built Drawings	Bottom of ditch	1014.01
ECRDS Phase 1 Existing Model	Bottom of ditch	1013.90
ECRDS Phase 1 Existing Model	1:100-year, 24-hour single event	1014.95
ECRDS Phase 1 Existing Model	Top of ditch	1017.90
As-Built Drawings	Top of ditch	1018.00

Stantec selected the highlighted elevations to consider as the tie in location details for the storm trunk as they are the more conservative assumption.

5.1.8 WATER VOLUME CONTROL PRACTICES

5.1.8.1 General Industrial LID

LID measures will need to be assessed on a site-specific basis with future SMDP reports in consultation with a geotechnical engineer. LID measures need to be properly designed for the soil and groundwater conditions to be effective. Currently the assumption that 10% of the developed ASP study area remains pervious is a conservative estimate and impervious areas can be drained to pervious areas.

5.1.8.2 Potential Stormwater Reuse for High Water Demand Industrial User

There have been discussions between Stantec, and Shepard Industrial of a potential high water demand industrial property to be constructed in the ASP study area. The water demand discussed was an approximate 10,000 m^3/ day average demand required by the property. The processes involved or timing of the demand are not understood at this time, but there is a potential for this property to draw stormwater from the SWMFs for their industrial uses.

All modelling presented in this MDP is to determine the required active stormwater storage for the SWMFs to capture runoff of storm events and store it away from properties and buildings. If a high-water demand property were to be constructed in the MDP study lands and that property were to use stormwater from the SWMFs for their processes, the amount of active storage in the SWMFs cannot be decreased as SWMFs need to function with or without that property's draw.

5.2 Analysis of Interim Model Results

5.2.1 STORMWATER MANAGEMENT FACILITIES

The following assumptions were made to determine the optimal size of ponds:

- SWMF outlet inverts are assumed to be at NWL.
- SWMF HWL is a max of 2.0 m higher than NWL.
- Maximum water elevation for the water in the SWMF is based on the statistical 1:100 year event after a frequency analysis of the continuous model results.

- Initial water elevation in SWMF nodes is assumed to be at NWL.
- Initial water levels of remaining wetlands are set to the 2-year event peak water level

The proposed interim model was run for the 100-year and continuous event (55 years), and a frequency analysis was completed for the continuous model results. The findings are summarized in **Table 5-2** which shows that water depths remained less than the maximum of 2.0 m above the NWL.

There is no overland flow from SWMFs 1, 2 or 3 to discharge to Shepard Ditch under the 100-year or continuous event for the interim development condition.

Table 5-2: Interim Development Model Results Summary

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3
Pond Info	Design HWL Elev (m)	1020.5	1021	1021.5
	HWL Depth (m) above NWL	2	2	2
	NWL Elev (m)	1018.5	1019	1019.5
	Bottom Elev (m)	1016.5	1017	1017.5
	HWL Volume (m^3)	394,020	335,580	318,350
	Overland Spill Elev (m)	1020.5	1021	1021.5
	Overland Spill Depth (m)	2	2	2
	Catchment Area (ha)	507	571	266
	Allowable Flow at 0.8 L/s/ha (L/s)[1]	317	457	213
	Orifice Size (mm)[1]	380	450	390
	Top of SWMF Perimeter Elevation (m)	1021.5	1022	1022.5
	Overflow Weir Depth at 1 m^3/s	0.44	0.44	0.44
	Freeboard, Overflow Depth to Top of SWMF (m)	0.56	0.56	0.56
100-yr, 24 hr	Max Water Level (m) above NWL	1.34	1.29	1.29
	Max Wat Elev (m)	1019.84	1020.29	1020.79
	% Full (HWL)	66.8%	64.5%	64.6%
	Overland Spill Flow (m^3/s)	0	0	0
	Max Outflow (including overland spill m^3/s)	0.295	0.399	0.258
	Max Outflow (L/s/ha)	0.581	0.700	0.971
	Max Active Volume (m^3)	245,990	211,200	195,440
	Max Active Volume (m^3/ha)	485	370	736
Continuous	Max Water Level (m) above NWL	1.72	1.56	1.69
	Max Wat Elev (m)	1020.22	1020.56	1021.19

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3
	% Full (HWL)	86.2%	77.8%	84.4%
	Overland Spill Flow (m^3/s)	0	0	0
	Max Outflow (including overland spill m^3/s)	0.345	0.450	0.315
	Max Outflow (L/s/ha)	0.681	0.788	1.185
	Max Active Volume (m^3)	326,210	256,600	261,400
	Max Active Volume (m^3/ha)	643	450	983
	Freq Analysis 100 yr Water Level (m) above NWL	1.74	1.70	1.73
	Freq Analysis 100 yr Active Volume (m^3)	343,000	281,000	275,000

Notes:
[1] Parameter was sized for the ultimate development condition.

Using the continuous model results, **Table 5-3** summarizes the annual volume of offsite discharge runoff from SWMFs 1 to 3 for the interim development condition.

Table 5-3: Interim Development SWMF Characteristics and Outflow Summary (Continuous Event)

SWMF	Total 55-year Outflow Volume (m^3)	Upstream Catchment Area (ha)	Annualized Outflow Volume (mm/yr)
1	42,788,500	507	153
2	37,317,700	571	119
3	32,517,400	266	222

The frequency analysis included determining the maximum total active volume of storage required for each year of the 55-year continuous simulation. These 55 data points were plotted on a graph and fitted to a Normal, Log-Normal, Pearson III, Log-Pearson III, Gumbel and Weibull distributions The curve with the best fit was determined using the DFASCC Tool and the Hyfran program. Once the best fit distribution was chosen a 1:100 year active volume was determined.

Table 5-2 shows the 1:100-year single event total active volume, the continuous model maximum active volume, and the statistical 1:100 year maximum active volume.

In addition to the SWMF sizing, a modeling exercise was completed to check the pipe capacity for the design storm sewers, and under the 100-year single event and continuous simulation, the pipes operate within their allowable capacity. See **Appendix E.2 Interim Condition Results** for the results.

5.2.2 RUNOFF VOLUMES

5.2.2.1 Interim ASP Study Area Draining to Shepard Ditch

Seepage activity at the SWMFs has been deactivated under interim conditions as it is assumed there is no interaction between water flow through the SWMFs and the surrounding aquifer, so the water loss will only occur through evaporation. The simulation results indicated no computational errors in storage nodes. Thus, the evaporation volume was calculated as the difference between the total inflow volume and the sum of outflow and stored water in each pond. See **Table 5-4** for the SWMF water balance results.

Table 5-4: Water Balance Volume Analysis in SWMFs During the Interim Condition

SWMF	Inflow		Outflow		Evaporation	
	(mm/yr)[1]	(%)	(mm/yr)[1]	(%)	(mm/yr)[1]	(%)
1	185	100.0%	146	82.7%	276	17.3%
2	153	100.0%	119	81.6%	222	18.4%
3	32	100.0%	27	80.6%	54	19.4%

Notes:
[1] Divided by upstream catchment area

5.2.2.2 ASP Study Area Draining to North

To ensure that developing the ASP lands would not remove hydrologic contributions to the wetlands to the existing wetlands between the ASP lands and the Shepard Slough Complex, a trimmed version of the continuous model was created to quantify volumes, peak flow and flow duration curves for a single catchment and iterations of the model were run to determine the area that produces roughly the same volume as the existing model.

An area of 5.5 ha (assumed 90% impervious), producing a total volume discharge of 879,507m^3 over the stretch of 55 years, closely matched the existing volume that was originally draining to the wetland in that 55-year span. For the time being, this area can maintain the current spill path along RR 283 north across the abandoned rail ROW.

Table 5-5 presents details for the comparison of the flow that spills from the ASP area to the north with the interim drainage area.

Table 5-5: Peak Flow and Volumes Comparison from the ASP Lands (Existing and Interim) to North

Event	Existing Model		Interim Model	
	Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)
100-year	2.481	35,383	1.083	4,750
Continuous (55-year)	0.532	880,093	0.226	879,507

Figure 5-2 provides spill flow duration curve from the future ASP area.

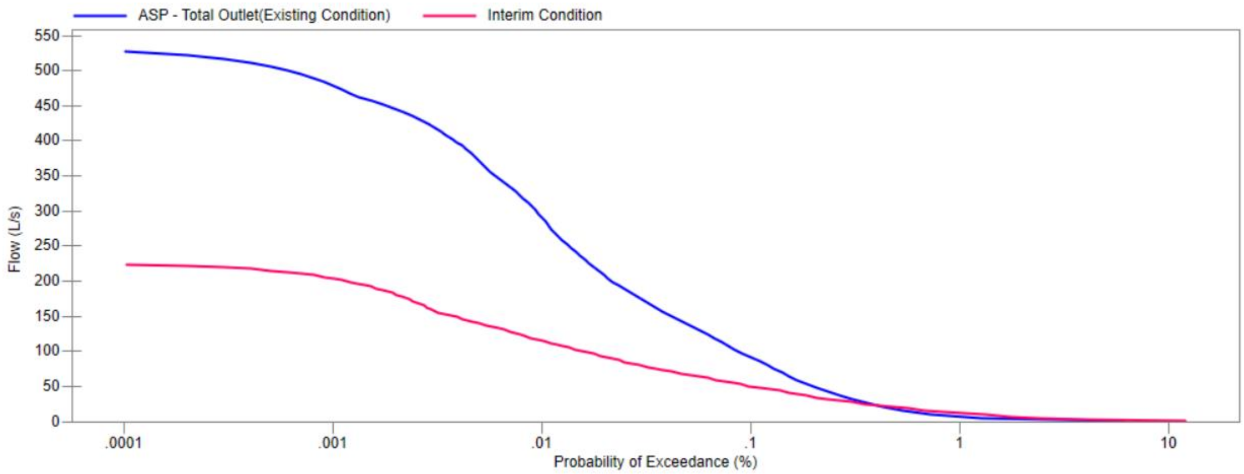


Figure 5-2 Flow Duration Curve at Interim ASP Area Outlet (continuous model)

In the next phase of development design (e.g. SMDP under the CoC planning process), the actual discharge configuration can be managed to achieve peak flows at various return periods to mimic the existing flows. This can be done by having certain parts of the 5.5 ha area drain overland, while other parts may contribute via underground conduits with orifice, weir and/or storage. The SMDP will also need to consider the water quality of the flow entering the wetlands and forebay design.

5.2.3 GROUNDWATER IMPACTS

The proposed SWMFs will be lined therefore there will be no interaction with the groundwater. But if wetlands are retained, they would receive groundwater.

The amount of groundwater flow is unknown at this time and will be further reviewed in the supplementary Hydrogeology Assessment as additional data and field visits are required to complete the analysis. Following the results of the supplementary Hydrogeology Assessment, the SMDP will evaluate the impacts to the groundwater.

5.2.4 IMPACTS TO DRAINAGE COURSES

The tie in location for the proposed RR 284/ TWP 231 storm trunk to the existing CoC storm system is proposed along TWP 231, where the storm trunk will outlet to a proposed ditch-widening which would convey the flow a short distance to the upstream end of the Shepard Ditch. The storm trunk outlet is anticipated to include an outfall with a headwall and erosion protection, and would require widening and upgrades to the TWP231 roadside ditch to convey the flow to the Shepard Ditch. The location of the outlet is approximately 370 m west of the intersection of TWP 231 and RR 284A. The exact location will be determined during the SMDP, after the existing ditch survey has been obtained. As well, erosion protection and energy dissipation requirements need to be reviewed during the design phase of the outlet.

The post-development discharges from the developed ASP study area are not anticipated to have an adverse impact on the downstream drainage courses. This statement is based on meeting the allowable

UARR (to which the Shepard Ditch has been designed) and maintaining the same total volume of flow (from the continuous model) to the north from the MDP lands. Note, the Shepard Slough Complex was not modelled within the MDP model.

Table 5-6 compares the peak flows at key locations for interim post-development and pre-development conditions.

Table 5-6: Interim Condition Peak Flows in Downstream Drainage Courses (Continuous Model) Compared to the Existing Model

Receiving Drainage Course	Existing Area	ECRDS Ph 1 Existing Flow (m^3/s)	ECRDS Ph1 Ultimate Flow 100 yr (m^3/s)	MDP Interim Flow (m^3/s)	Net Change in Peak Flow (m^3/s)[1]
ASP lands draining to North	ASP Area (141 ha)	0.532 [2]	-	0.226 (5.5 ha)	- 0.306
Shepard Ditch (at connection point)	ASP Area (324 ha @ UARR 2.5 L/s/ha)	0.81	0.81	0.26	- 0.55
	ASP Area (450 ha @ UARR 0.8 L/s/ha)	0.36	0.36	0.36	0
	East External Upstream Lands (655 ha)	0.52	0.52	0.35	-0.17

[1] Negative net change is a decrease in MDP flow compared to the ECRDS Phase 1 Ultimate Flow to MDP Interim Flow

[2] Flow from existing MDP model, as existing and ultimate ECRDS Ph 1 model did not include.

6 Post Development Analysis - Ultimate Condition

A post-development hydrologic analysis was performed to examine the proposed development stormwater flows for the MDP study area. The interim PCSWMM model was updated to reflect ultimate post-development conditions. The ultimate post-development models were run using the applicable single storm events and continuous simulation to provide the runoff volumes and storage requirements and compare them to the pre-development benchmark.

6.1 Modelling Approach

The ultimate development condition assumes the entire MDP study area is fully developed.

6.1.1 PRECIPITATION – RUNOFF ANALYSIS

The ultimate condition hydrologic analysis includes quantifying the volume of runoff resulting from precipitation falling on the MDP study area. The ultimate model was run for the below list of design precipitation events:

- 1:100-year 24-hour storm event
- 1:100-year 24-hour storm event 2050 projection
- 1:100-year 24-hour storm event 2080 projection
- a continuous simulation

The 2050 and 2080 projections of the 1:100-year 24-hour storm event were based on the ECRDS Phase 1 model.

6.1.2 HYDRAULIC AND HYDROLOGIC MODEL

The ultimate condition drainage system was reflected in the model with updated subcatchment, conveyance routes and SWMFs. The ultimate analysis uses 11 catchments and assumes no retained wetlands within the MDP study area.

The ASP study area subcatchments and SWMFs remain the same as the interim condition, however there are additional conduit connections (pipes) between the existing SWMFs and the three new SWMFs in the external upstream lands to the east.

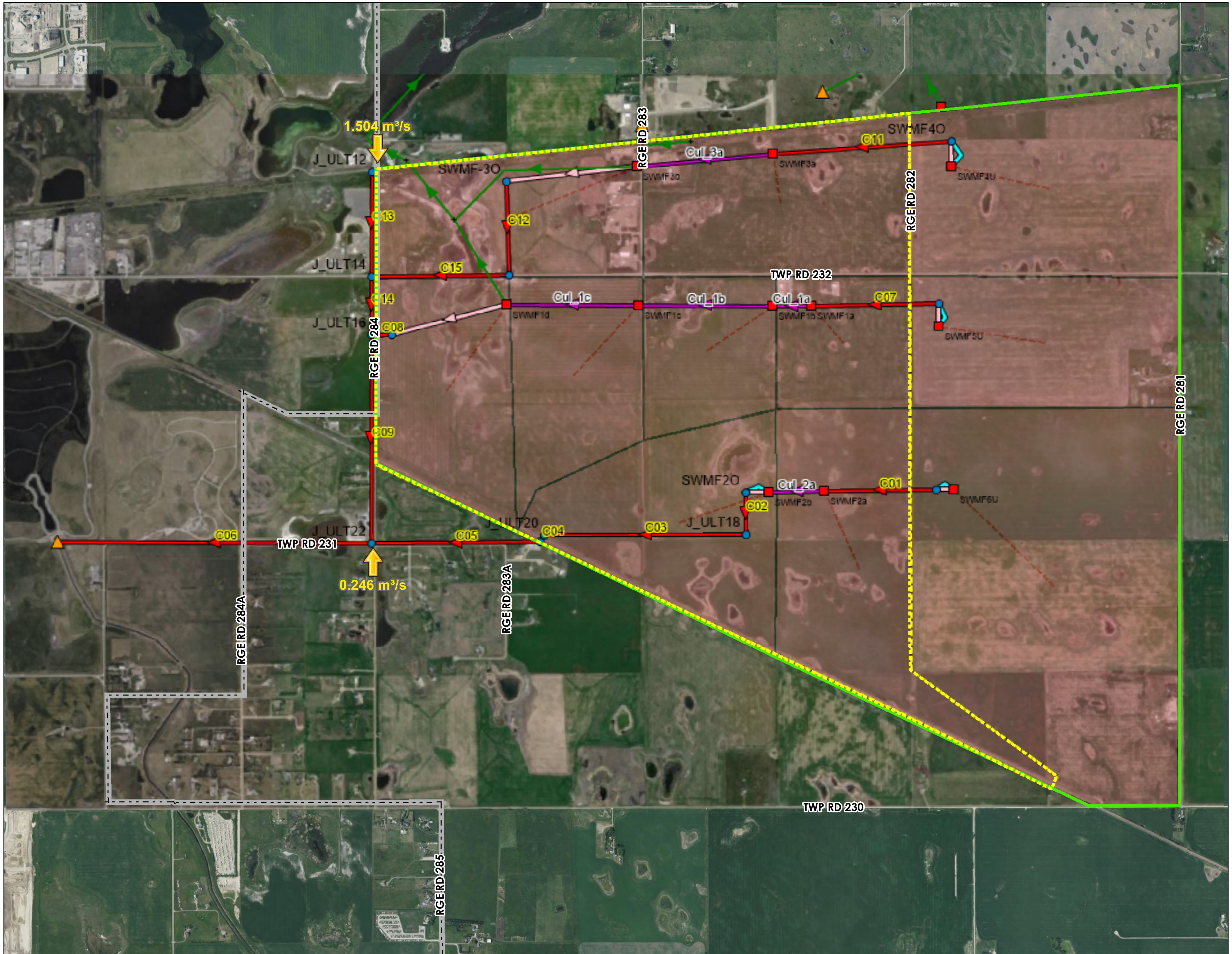
The adjacent lands to the north, west and south of the ASP study area are included in the model as a constant inflow for trunk sizing purposes only (see **Table 6-1**). See **Section 4.2.5** for the full breakdown of the catchments.

Table 6-1: Flows from Adjacent Lands Added to Ultimate Post-Development Model

Pipe	Catchment IDs	Total Area (ha)	UARR (L/s/ha)	Flow (m^3/s)	Tie in Location
C13	8, 9, 10, 11	1879.8	0.8	1.50	Intersection of the abandoned rail ROW and RR 284 (Node 12)
C06	7	308.0	0.8	0.25	Intersection of TWP RD 231 and RR 284 (Node 22)

Under the ultimate condition, the wetlands within the full MDP study area were considered to be fully removed, as this case creates the largest runoff for the stormwater management system to accommodate. The ultimate development condition catchments are shown on **Figure 6-1.**

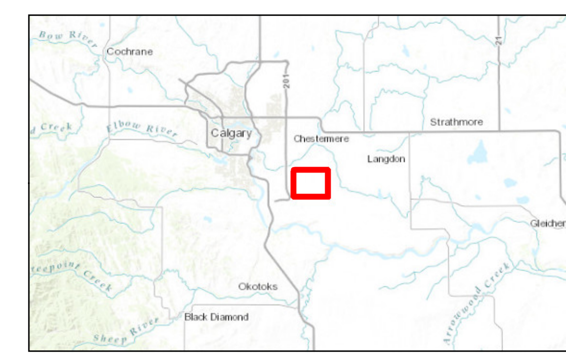
The specific ultimate conditions model parameters can be found in **Appendix F.1 Ultimate Condition Model Parameter.**



Stantec

- ASP Boundary
- MDP Boundary
- Storage Node
- Junction
- Outfall
- Overland Flow
- Storm Sewer
- Culvert
- Orifice
- Weir
- External Flow (m³/s)
- Subcatchment

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary



Project Location
SE Calgary
Alberta

Prepared by KDB on 2024-03-28
TR by NF on 2024-03-28

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
5-2

Title
Ultimate Development Condition PCSWMM Model

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_Fig5-2_Ultimate.mxd Revised: 2024-04-19 By: kebuchanan

6.1.3 RUNOFF COMPUTATION

As the existing conditions model was also used for the ultimate condition model, the same infiltration, snowmelt, depression storage, evaporation losses and groundwater condition inputs were used. The below parameters were updated from the existing condition to reflect the ultimate condition.

6.1.3.1 Imperviousness

All catchments are fully developed with an assumed 90% imperviousness.

6.1.3.2 Length and Slope

Within the MDP study area (area 1-6) the catchment length is measured from the edge of subcatchment to the SWMF storage node and the slope of these catchment flow paths is assumed to be 0.5%.

6.1.4 GROUNDWATER CONDITIONS

SWMF 4,5 and 6 are proposed to be lined, as were SMWF 1, 2 and 3, therefore there is no infiltration or seepage at the SWMF nodes in the model. The groundwater under the MDP lands, is modelled to drain storage nodes in the MDP lands and will be quantified in the upcoming Hydrogeology Assessment as discussed in **Section 5.2.3**. The same principles of the interim condition model for ground water apply to the ultimate model.

6.1.5 STORAGE ROUTING

Under the ultimate condition, SWMFs 1, 2 and 3 are the same as the interim, and SWMFs 4, 5, and 6 were added to the model with the same evaporation factor as the first SWMFs. The storage curves for the SWMFs are presented in **Appendix F.1 Ultimate Condition Model Parameter**.

SWMFs 4, 5 and 6 also have controlled discharges which were modelled as circular orifices and the same requirements for sizing the orifice apply from the interim model in **Section 5.1.6**. The various orifice sizes used in the ultimate post-development model is provided in **Table 6-2.**

6.1.6 CONVEYANCE ROUTING

Conveyance of flows for the ultimate development condition is also shown on Figure 6-1. North, south, and west adjacent land areas (areas 7-11) are assumed to drain into the proposed RR 284 trunk with a constant flow described in **Table 6-1**.

The east external upstream lands are now represented by three catchments that contribute to the proposed SWMFs 4, 5 and 6 and are connected to SWMFs 1, 2 or 3 using conduits (representing pipes) in the model. See Figure 6-1 for the ultimate conduit and SWMF arrangement.

6.1.7 ULTIMATE BOUNDARY CONDITIONS

Matching the interim condition elevations, the model outlets to the Shepard Ditch south of the Shepard Wetland.

Refer to **Section 6.3.2** as the boundary conditions may can change after the ECRDS Phase 2 modelling is complete.

6.1.8 WATER VOLUME CONTROL PRACTICES

6.1.8.1 General Industrial LID

As with the ASP study area, LID measures proposed for the lands east of the study area will need to be assessed on a site-specific basis with future SMDP reports in consultation with a geotechnical engineer. The same assumption of 10% of the developed ASP study area remains pervious is a conservative estimate and impervious areas can be drained to pervious areas to increase this estimate.

6.2 Analysis of Ultimate Model Results

6.2.1 STORMWATER MANAGEMENT FACILITIES

To determine the preliminary size of SWMFs, certain factors were considered that balance the preferred pond design criteria with the need to avoid public infrastructure with high SWMF volumes.

The same assumptions from the interim SWMF sizing in **Section 5.2.1** were used for the ultimate SWMF sizing.

The proposed ultimate stormwater management concept model was run for the 100-year, 100-year 2050 projection, 100-year 2080 projection and continuous event (max of the 55-year results and the statistical 100-year return period result). Results are summarized in **Table 6-2.** There is no overland flow from SWMFs 1 to 6 under the 100-year, 100-year 2050, or continuous events for the ultimate development condition; however, there are some amounts of spill in the 100-year, 2080 event.

Table 6-2: Ultimate Development Model Results Summary

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
	Design HWL Elev (m)	1020.5	1021	1021.5	1025	1024	1024
	HWL Depth (m)	2	2	2	2	2	2
	NWL Elev (m)	1018.5	1019	1019.5	1023	1022	1022
Pond Info	Bottom Elev (m)	1016.5	1017	1017.5	1021	1020	1020
	HWL Volume (m^3)	394,020	335,580	318,350	200,660	144,110	385,790
	Overland Spill Elev (m)	1020.5	1021	1021.5	1025.0	1024.0	1024.0
	Overland Spill Depth (m)	2	2	2	2	2	2
	Catchment Area (ha)	475.2	643.2	442.1	176.0	130.4	348.4
	Allowable Flow at 0.8 L/s/ha (L/s)[1]	380	515	354	141	104	279
	Orifice Size (mm) [1]	380	450	390	235	194	325

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
	Top of SWMF Perimeter Elevation (m)	1021.5	1022	1022.5	1026	1025	1025
	Overflow Weir Depth at 1 m^3/s	0.44	0.44	0.44	0.44	0.44	0.44
	Freeboard, Overflow Depth to Top of SWMF (m)	0.56	0.56	0.56	0.56	0.56	0.56
100-yr, 24 hr	Max Water Level (m) above NWL	1.43	1.35	1.36	1.39	1.43	1.40
	Max Wat Elev (m)	1019.93	1020.35	1020.86	1024.39	1023.43	1023.40
	% Full (HWL)	71.6%	67.3%	68.1%	69.3%	71.6%	70.2%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.307	0.411	0.269	0.116	0.088	0.228
	Max Outflow (L/s/ha)	0.647	0.638	0.609	0.657	0.671	0.654
	Max Active Volume (m^3)	265,420	221,000	207,050	136,000	100,900	266,800
	Max Active Volume (m3/ha)	559	344	468	773	774	766
100-yr, 24 hr (2050 Projection)	Max Water Level (m) above NWL	1.74	1.66	1.65	1.70	1.75	1.73
	Max Wat Elev (m)	1020.24	1020.66	1021.15	1024.70	1023.75	1023.73
	% Full (HWL)	86.8%	82.8%	82.7%	84.9%	87.7%	86.4%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.346	0.468	0.311	0.131	0.098	0.258
	Max Outflow (L/s/ha)	0.729	0.727	0.703	0.743	0.751	0.739
	Max Active Volume (m^3)	328,990	273,500	255,700	168,600	125,100	331,100
	Max Active Volume (m^3/ha)	692	425	578	958	959	950
100-yr, 24 hr (2080 Projection)	Max Water Level (m)	2.04	1.97	1.95	2.01	2.07	2.05
	Max Wat Elev (m)	1020.54	1020.97	1021.45	1025.01	1024.07	1024.06
	% Full (HWL)	102.1%	98.5%	97.4%	100.7%	103.5%	102.7%
	Overland Spill Flow (m^3/s)	0.001	0.000	0	0.005	0.058	0.043
	Max Outflow (including overland spill m^3/s)	0.383	0.520	0.349	0.149	0.164	0.324
	Max Outflow (L/s/ha)	0.807	0.809	0.789	0.848	1.258	0.931
	Max Active Volume (m^3)	395,080	327,900	306,200	202,000	149,300	396,800

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
	Max Active Volume (m^3/ha)	831	510	693	1,148	1,145	1,139
Continuous	Max Water Level (m) above NWL	1.93	1.89	1.92	1.90	1.93	1.91
	Max Wat Elev (m)	1020.43	1020.89	1021.42	1024.90	1023.93	1023.91
	% Full (HWL)	96.3%	94.4%	96.0%	94.9%	96.3%	95.7%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.369	0.507	0.345	0.140	0.103	0.273
	Max Outflow (L/s/ha)	0.776	0.788	0.781	0.793	0.790	0.785
	Max Active Volume (m^3)	369,690	313,600	301,300	189,700	138,300	368,500
	Max Active Volume (m^3/ha)	778	488	682	1,078	1,061	1,058
	Freq Analysis 100 yr Water Level (m) above NWL	1.91	1.96	1.93	1.87	1.89	1.99
	Freq Analysis 100 yr Active Volume (m^3)	367,000	325,000	303,000	188,000	136,000	384,000

Using the continuous model results, **Table 6-3** summarizes the annual volume of offsite discharge runoff from SWMFs 1 to 6 for the ultimate development condition.

Table 6-3: Ultimate Development SWMF Characteristics and Outflow Summary (Continuous Simulation)

SWMF	Total 55-year Outflow Volume (m^3)	Upstream Catchment Area (ha)	Depth (mm/yr)
1	59,159,700	475.2	226
2	77,942,900	643.3	220
3	54,159,900	442.1	223
4	21,772,200	176.0	225
5	16,610,400	130.4	232
6	41,172,200	348.4	215

In addition to the SWMF sizing, a modeling exercise was completed to check the pipe capacity for the design storm sewers under the 100-year single event, with the current, 2050 projection and 2080 projection, and continuous simulation. See **Appendix F.2 Ultimate Condition Results** for the comprehensive results that show the pipes operate within their allowable capacity.

6.2.2 RUNOFF VOLUMES

6.2.2.1 Ultimate ASP Study Area and East External Upstream Lands Draining to Shepard Ditch

Table 6-4 summarizes the post-development catchment inflows and outflows based on the assumptions previously described for water volume control practices in **Section 6.1.8** and water loss only occurring through evaporation, as the SWMFs do not have seepage.

Table 6-4: Water Balance Volume Analysis in SWMFs Under Ultimate Condition

SWMF	Inflow		Outflow		Evaporation	
	(mm/yr)[1]	(%)	(mm/yr)[1]	(%)	(mm/yr)[1]	(%)
1	261	100.0%	226	86.6%	35	13.4%
2	246	100.0%	220	89.7%	25	10.3%
3	256	100.0%	223	87.1%	33	12.9%
4	277	100.0%	225	81.1%	53	17.9%
5	282	100.0%	232	82.1%	50	17.9%
6	263	100.0%	215	81.7%	48	18.3%

Notes:
[1] Divided by upstream catchment area

6.2.2.2 External Upstream Area Draining to North

The same modelling exercise undertaken during the interim condition (**Section 5.2.2.2**) was completed for the ultimate condition to match post-development continuous volume contributions to the existing wetlands between the ASP lands and the Shepard Slough Complex to those from the pre-development condition.

The 5.5 ha previously identified for the ASP lands in **Section 5.2.2.2** will continue to be directed to north of the ASP lands, but because parts of the external upstream lands also flow to the existing wetlands to the north of the ASP lands between the ASP lands and the Shepard Slough Complex, additional lands will need to be drained in that direction.

The same approach was used as the interim condition to determine a single catchment size with 90% imperviousness (under the continuous simulation) that produces roughly the same volume of stormwater as the existing model (described in **Section 3.3.1.3** and **Section 5.2.2.2**).

A total area of 15.6 ha (of which 10.1 ha falls in the external upstream lands) produces a closely matching total volume discharge of 2,468,360 m^3 over the stretch of 55 years to maintain the hydroperiod of the existing wetlands north of the MDP lands between the MDP lands and the Shepard Slough Complex

During the SMDP phases, the actual configuration of a staged discharge structure can be set up to manage peak flows at various return periods. The SMDP will also need to consider the water quality of the flow entering the wetlands and forebay design.

Table 6-5 presents the comparison of the flow spills from the MDP to the north with the future drainage area.

Table 6-5: Peak Flow and Volumes Comparison from the MDP Lands (Existing and Ultimate) to North

Event	Existing Model		Ultimate Model	
	Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)
100-year	2.233	39,999	2.611	12,750
Continuous (55-year)	1.324	2,463,510	0.589	2,468,360

Figure 6-2 provides the spill flow duration curve from the ultimate condition for the ASP area compared to the existing condition.

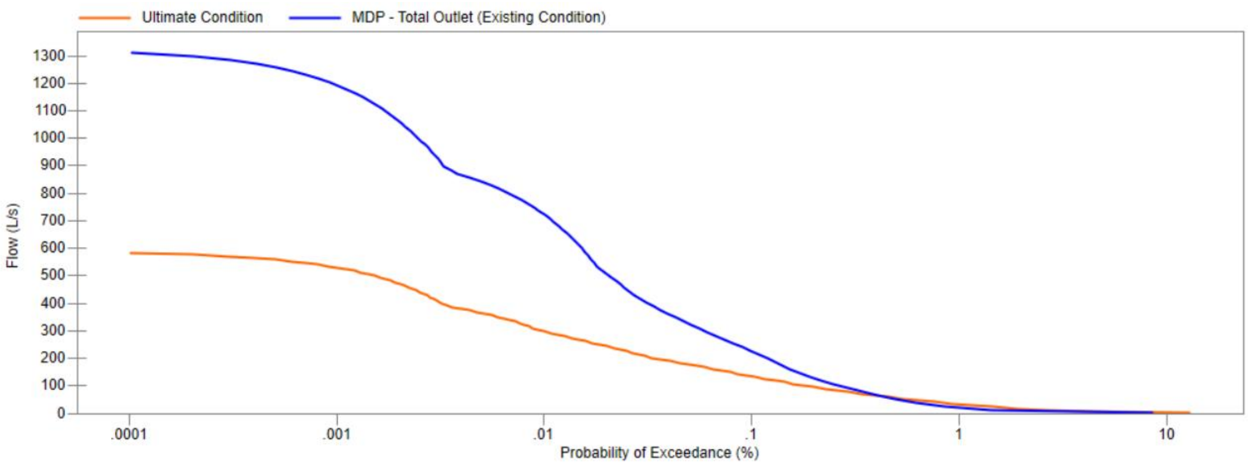


Figure 6-2: Flow Duration Curve at Future ASP Area Outlet (Continuous model)

6.2.3 CLIMATE CHANGE RESILIENCE

As the effects of climate change are becoming more apparent with the increase in extreme weather events and changes to the frequency, duration and timing of precipitation patterns it is crucial to estimate how this may impact storm infrastructure planning and design.

A climate change impact assessment was performed using the 2022 Climate Projections for Calgary which describes an estimated 1:100 year, 24 hour design storm event in the years 2050 and 2080 that the CoC has projected to include local climate change for the region. The design storm is described by the rainfall intensity formula:

$I = A/(B+t)^c$, where:

- I = intensity (mm/hr)
- t = time (min)
- A, B, C = best fit IDF constants for each IDF curve, see **Table 6-6.**

Table 6-6: IDF Parameters – Regional

Parameters of IDF Curve, Return Frequency 100 years, 24 hours			
	Historical	2050	2080
A	42.650	54.628	64.915
B	0.004	0.003	0.004
C	0.742	0.743	0.743
Table data source: (City of Calgary (CoC), 2022)			

The results of the climate change impact assessment modelling are summarized in **Table 6-7**, which shows that all active water depths for 1:100 year event, continuous simulation and the 1:100 year 2050 projection event were less than 2.0 m, meeting City of Calgary Standards. Therefore, there are no spills out of any of the SWMFs during the 2050 projected 1:100-year event. Rocky View County has also advised Stantec that they would like the storm infrastructure design to accommodate a minimum of the 1:100-year 2050 projection, and the above table confirms the design has the capacity. For the 1:100-year 2080 projection event, water depths exceed the 2.0 m above NWL criteria at SWMFs 1, 2, 4 and 5.

Table 6-7: Depth above Normal Water Level of SWMFs during 2050 and 2080 Single Storm Events

SWMF	Current 100 yr, 24-hour Depth above NWL (m)	2050 Projected 100 yr, 24-hour Depth above NWL (m)	2080 Projected 100 yr, 24-hour Depth above NWL (m)	Continuous Max Depth above NWL (m)	Freq Analysis 100 yr, Depth above NWL (m)
1	1.43	1.74	2.04	1.93	1.91
2	1.35	1.66	1.97	1.89	1.96
3	1.36	1.65	1.95	1.92	1.93
4	1.39	1.70	2.01	1.90	1.87
5	1.43	1.75	2.07	1.93	1.89
6	1.40	1.73	2.05	1.91	1.99

Table 6-8 provides a summary of the maximum water level, peak spill flow, and spill volume for each SWMF during the projected 100-year, 24-hour event in 2080. It highlights that SWMFs 2 and 3 will not spill, SWMFs 1 and 4 will have a negligible overland flow, and SWMFs 4 and 5 will have a significant overland flow.

Table 6-8 Spill flow from SWMFs during 2080 Single Storm Event

SWMF	2080 Projected 100 yr, 24-hour Depth above NWL (m)	2080 Projected 100 yr, 24-hour Peak Flow (m^3/s)	2080 Projected 100 yr, 24-hour Spill Volume (m^3)
1	2.04	0.001	42
2	1.97	0	0
3	1.95	0	0
4	2.01	0.005	69
5	2.07	0.058	1,796
6	2.05	0.043	1,516

6.2.3.1 Bow River and Climate Change

A review of the proposed SWMF NWLs and the existing downstream Bow River Outfall elevation was also completed to assess if changed to the Bow River water level would impact the MDP study area.

- Lowest NWL in the proposed SWMF (#1) is 1018.50 m
- Maximum HGL of the Bow River Drop Structure is 966.24 m

The Bow River would need to rise an additional 52 m above the design maximum HGL of the outfall drop structure to have an impact on the proposed stormwater management concept.

6.2.4 GROUNDWATER IMPACTS

Similar to the interim condition, under the ultimate condition SWMFs 4, 5, and 6 do not infiltrate or have seepage, but if wetlands are retained, they will have both of these characteristics. The amount of groundwater flow will be reviewed further in the supplementary Hydrogeology Assessment as described in **Section 5.2.3**.

6.2.5 IMPACTS TO DRAINAGE COURSES

As the ASP lands are developed in both the ultimate and the interim condition, there is no difference in the net change in flow to the Shepard Bypass. However, there was a change in flow in the receiving drainage course from the MDP lands draining north. See **Table 6-9** for the net change in flow between the existing and ultimate condition for the MDP lands draining north.

Table 6-9: Ultimate Post Development Peak Flows in Drainage Courses (Continuous)

Receiving Drainage Course	ECRDS Ph 1 Existing Flow (m^3/s)	ECRDS Ph1 Ultimate Flow (m^3/s)	MDP Ultimate Flow (m^3/s)	Net Change in Peak Flow (m^3/s)[1]
ASP lands draining to North	2.23 [2] (275 ha)	-	0.59 (15.6 ha)	- 1.64
East External Upstream Lands to the North				

[1] Negative net change is a decrease in flow compared to the ECRDS Phase 1.
[2] Flow from existing MDP model, as existing and ultimate ECRDS Ph 1 model did not include.

6.3 Alignment with Ongoing Studies

It is understood that ECRDS Phase 2 modelling is underway by the CoC and RVC. This section describes potential changes that would be required to the MDP based on results of ECRDS Phase 2.

6.3.1 UPDATE TO UNIT AREA RELEASE RATES

One revision the ECRDS Phase 2 modelling may lead to is that the Shepard Ditch is under less capacity issues than shown by the ECRDS Phase 1 model, allowing an increase in the UARR across the entire contributing watershed, including the MDP area. The MDP area has currently been design for a 0.8 L/s/ha UARR, and an increase in the release rate would allow the SWMFs to release additional flow and potentially provide less storage. This change could be evaluated at the SMDP level, or even partially through development as the MDP has already sized infrastructure for the lower UARR, with the higher volume of stormwater storage required, and compared to an increased UARR, which would have a lower volume of stormwater storage required.

6.3.2 UPDATE TO BOUNDARY CONDITIONS

The current 100-year water level in the Shepard Ditch is anticipated to be revised with the ECRDS Phase 2 continuous modelling. As the top of the Shepard Ditch at the outlet location is 0.6 m lower than the lowest NWL of the SWMFs (SWMF 1), an increase in the 1:100-year water elevation at the Shepard Ditch is not anticipated to impact the overall stormwater management concept within the ASP area.

Table 6-10: Ultimate Condition Elevations Summary

Source	Location	Elevation (m)
MDP Interim and Ultimate Model	Invert of trunk at outlet location	1014.00
ECRDS Phase 1 Ultimate Model	1:100-year, 24-hour single event, max water elevation at outlet location	1015.33
MDP Ultimate Model	1:100-year, 24-hour single event, max water elevation at outlet location	1014.95
	Continuous model, max water elevation at outlet location	1014.95
ECRDS Phase 1 Existing Model	Top of ditch	1017.99
MDP Interim and Ultimate Model	Lowest pond NWL (SWMF 1)	1018.50

6.3.3 DISCUSSION OF SERVICING OPTION IMPACTS ON MDP AREA

This section reiterates the different offsite trunk servicing options presented in **Sections 4.2.1** through **4.2.3** for impacts to the interim and ultimate development condition stormwater management concept. In summary, the Options presented were:

- Option 1: drainage area considers all areas 1-11. This is the assumed interim and ultimate condition drainage analysis area.
- Option 2: drainage area considers only areas 1-3 and 7-10 (i.e. not including the external upstream lands to the east)
- Option 3: drainage area considers only areas 1-8 (i.e. no accommodation for lands north of the abandoned rail ROW)

The MDP pipes and MDP SWMFs will still function properly regardless of which option is pursued. Inverts and pond levels were preliminarily set to work with the higher inverts in Options 3, however, they could be lowered if Option 1 or 2 is chosen. This could allow for additional flexibility in future detailed grading design.

6.3.4 DISCUSSION ON SUBSEQUENT PLANNING/DESIGN STAGES

The CoC requires a SMDP as the next stormwater management design requirement, but RVC does not have this requirement. RVC typically uses a SCMDP for land use planning and re-designation. RVC has agreed that the CoC planning and design processes should be followed for the Prairie Gateway Area and this includes the SMDP following the MDP as the next required stormwater management plan.

7 Opinion of Probable Cost

The following section is a summary of the estimated costs to supply and install the stormwater infrastructure outside the ASP area that will be required to service the MDP areas under both the interim and ultimate condition. The Opinion of Probable Cost (OPC) is Class 5, which is a concept level estimate that can be used for planning. With limited information available, and the recent high level of inflation being experienced by the construction industry, the estimate accuracy can be up to +50%. The unit costs are based upon CoC projects, similar projects within the City of Edmonton, and projected to 2024 rates.

7.1 Ultimate Servicing Option 1 – Area 1-11

See **Table 7-1** for the OPC for the ultimate storm trunk on RR 284 and TWP 231 to service all of the lands presented in the study area. See **Figure 7-1** for the infrastructure included in the OPC.

Table 7-1: Opinion of Probable Cost - Option 1

Item	Description	Quantity	Unit	Unit Cost	Total
1	**Storm Sewer Trunks - Supply, Install, Excavation and Backfill**				
	a) 900 mm @ 0-4 m depth	1,360	l.m.	$1,090	$1,482,400
	b) 1200 mm @ 4-5 m depth	1,925	l.m.	$1,980	$3,811,500
	c) 1500 mm @ 0-4 m depth	640	l.m.	$2,500	$1,600,000
	d) 1650 mm @ 0-4 m depth	350	l.m.	$2,800	$980,000
	e) 1800 mm @ 0-4 m depth	230	l.m.	$3,010	$692,300
	f) 1800 mm @ 4-5 m depth	350	l.m.	$3,700	$1,295,000
	g) 1800 mm @ 5-6 m depth	300	l.m.	$4,700	$1,410,000
	h) 1800 mm @ 6-7 m depth	400	l.m.	$5,900	$2,360,000
	i) 2100 mm @ 0-4 m depth	1,180	l.m.	$3,800	$4,484,000
2	**Storm Manholes - Supply, Install, Excavation and Backfill**				
	a) 1.8 m 1-S manhole	155	v.m.	$6,500	$1,007,500
	b) 2.4 m 1-S manhole	105	v.m.	$8,000	$840,000
	c) 2.8 m 1-S manhole	55	v.m.	$9,800	$539,000
3	**Track Crossing (PC Sum)**	2	p.c.	$200,000	$400,000
4	**Ditch Excavation (Daylight Trunk - Township RD 231 - Tie in to Shepard Ditch)**				
	a) Excavation, topsoil, seed	720	l.m.	$320	$230,400
Note: linear metre (l.m.), vertical metre (v.m.), prime cost sum (p.c.)					
				Subtotal:	$21,132,100
				25% Mobilization and Demobilization, Survey, ESC, Traffic Control, Testing:	$5,283,100
				50% Contingency:	$13,207,600
				Total:	**$39,622,800**

The stormwater management infrastructure that was included in the OPC meets three criteria: it is 900 mm in diameter or greater, it is downstream of a SWMF, and it services lands owned by more than one owner / developer (City of Calgary (CoC), 2011).

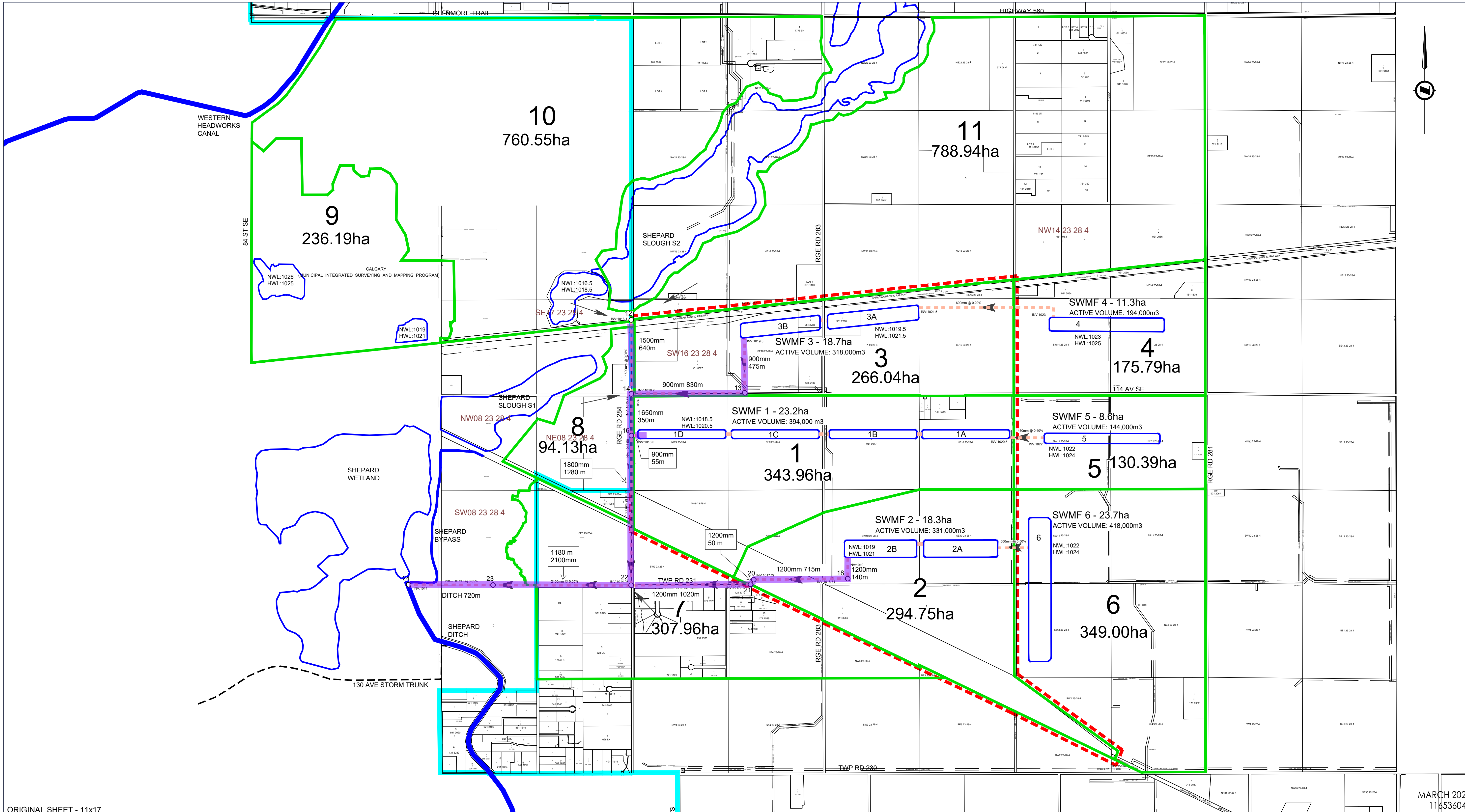
The following assumptions were used for the OPC:

- Land acquisition costs have not been included in the OPC. It is assumed these will be accounted for in the overall servicing, trasportation and utility costs.
- The estimate does not include modifications to the existing Shepard Ditch or Shepard Slough Complex, future planning studies or engineering consultant fees.
- The manholes are assumed to be every 130 m of pipe length, and up to 1,200 mm diameter pipes have a 1.8 m 1-S manhole, 1,350 mm to1,800 mm diameter pipes have 2.4 m 1-S manholes, and greater than 1,800 mm diameter pipes have 2.8 m 1-S manholes. Each manhole is assumed to be approximately 6 m deep.
- The costing also assumes open cut construction for all infrastructure items. A geotechnical investigation is required to help inform a more detailed estimate and if tunnelling would be a cost effective option.

In Year 1 the cost of the trunk from the connection at the Shepard Ditch to SWMF 1 as described further in **Section 4.2.4,** is estimated to be $ 22.1 Million.

The section of trunk that runs north from SWMF 1 to the north edge of the MDP study area (node 12 to 16), is an estimated $ 5.6 Million construction cost. The timing of this section of trunk is unknown and based on the development schedule of the lands to the north and west of the MDP study area.

Lastly, by Year 20, the storm trunks connecting SWMF 3 to the trunk on RR 284, and SWMF 2 to the trunk on RR 284 is estimated to cost $ 8.8 Million.



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Legend

- PRAIRIE GATEWAY ASP AREA
- CITY OF CALGARY LIMITS
- STORM CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- PROPOSED SWMF
- CONTRIBUTING AREA

Notes

- INCLUDED IN OPC

Client/Project
SHEPARD DEV. CORPORATION
PRAIRIE GATEWAY
MASTER DRAINAGE PLAN

Figure No.
7.1

Title
OPC SERVICING OPTION 1
(AREA 1-11)

7.2 Ultimate Servicing Option 2 – Area 1-3, 7-10

See **Table 7-2** for the OPC for the ultimate storm trunk on RR 284 and TWP 231 to service only Area 1-3 and 7-10. See **Figure 7-2** for the infrastructure included in the OPC.

Table 7-2: Opinion of Probable Cost - Option 2

Item	Description	Quantity	Unit	Unit Cost	Total
1	**Storm Sewer Trunks - Supply, Install, Excavation and Backfill**				
	a) 1200 mm @ 4-5 m depth	640	l.m.	$1,980	$1,267,200
	b) 1350 mm @ 4-5 m depth	355	l.m.	$2,500	$887,500
	c) 1500 mm @ 4-5 m depth	350	l.m.	$2,700	$945,000
	d) 1500 mm @ 5-6 m depth	500	l.m.	$3,900	$1,950,000
	e) 1500 mm @ 6-7 m depth	430	l.m.	$5,200	$2,236,000
	f) 1950 mm @ 0-4 m depth	1,180	l.m.	$3,500	$4,130,000
2	**Storm Manholes - Supply, Install, Excavation and Backfill**				
	a) 1.8 m 1-S manhole	30	v.m.	$6,500	$195,000
	b) 2.4 m 1-S manhole	80	v.m.	$8,000	$640,000
	c) 2.8 m 1-S manhole	60	v.m.	$9,800	$588,000
3	**Track Crossing (PC Sum)**	1	p.c.	$200,000	$200,000
4	**Ditch Excavation (Daylight Trunk - Township RD 231 - Tie in to Shepard Ditch)**				
	a) Excavation, topsoil, seed	720	l.m.	$320	$230,400
				Subtotal:	$13,269,100
				25% Mobilization and Demobili(zation, Survey, ESC, Traffic Control, Testing:	$3,317,300
				50% Contingency:	$8,293,200
				Total:	**$24,879,600**

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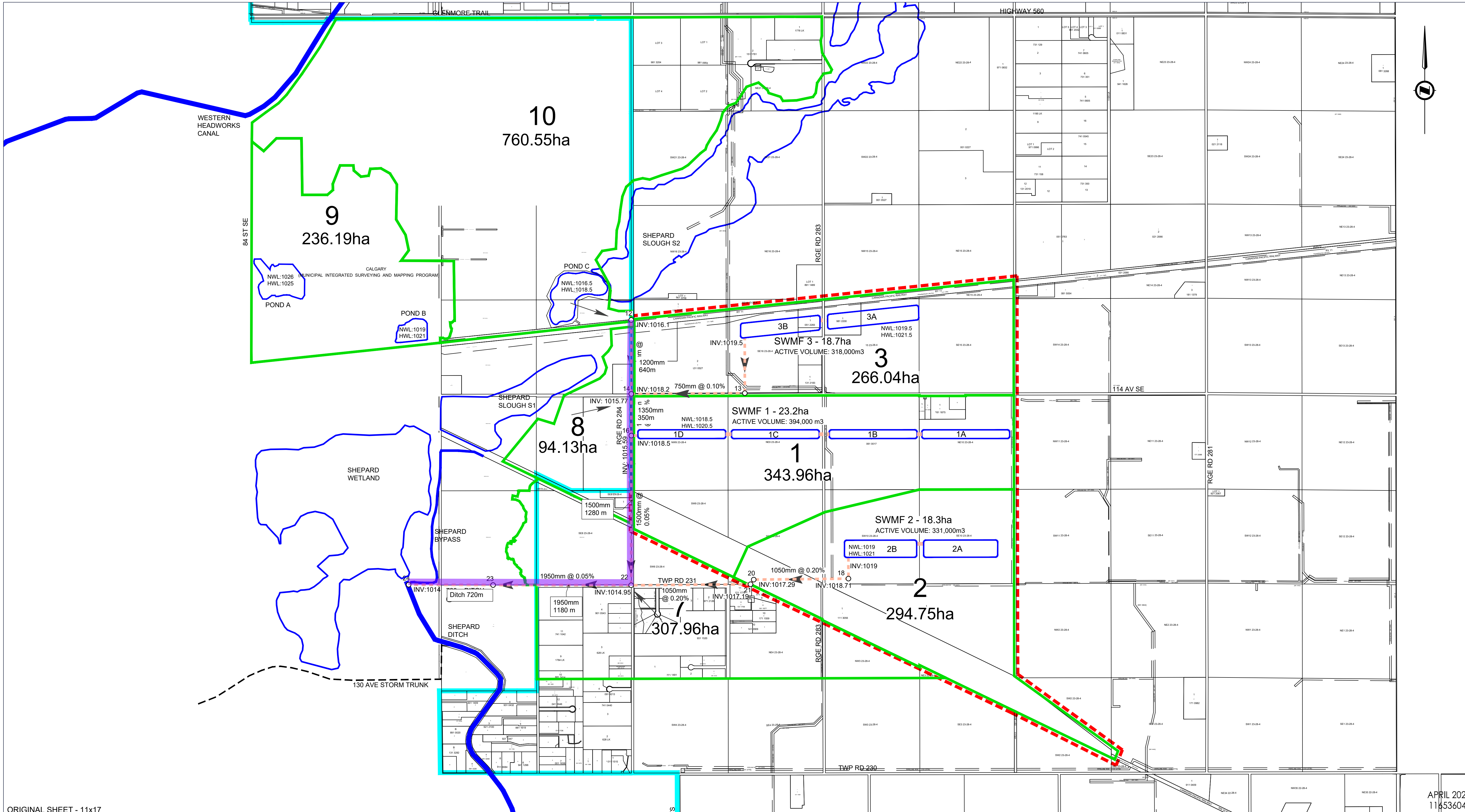

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- CITY OF CALGARY LIMITS
- STORM CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- PROPOSED SWMF
- CONTRIBUTING AREA

Notes

- INCLUDED IN OPC

Client/Project

SHEPARD DEV. CORPORATION
PRAIRIE GATEWAY
MASTER DRAINAGE PLAN

Figure No.

7.2

Title

OPC SERVICING OPTION 2
(AREA 1-3, 7-10)

7.3 Ultimate Servicing Option 3 – Area 1-8

See **Table 7-3** for the OPC for the ultimate storm trunk on RR 284 and TWP 231 to service only Area 1-8. See **Figure 7-3** for the infrastructure included in the OPC.

Table 7-3: Opinion of Probable Cost - Option 3

Item	Description	Quantity	Unit	Unit Cost	Total
1	**Storm Sewer Trunks - Supply, Install, Excavation and Backfill**				
	a) 900 mm @ 0-4 m depth	1,710	l.m.	$1,090	$1,863,900
	b) 1050 mm @ 0-4 m depth	420	l.m.	$1,500	$630,000
	c) 1050 mm @ 4-5 m depth	400	l.m.	$1,750	$700,000
	d) 1050 mm @ 5-6 m depth	460	l.m.	$2,600	$1,196,000
	b) 1200 mm @ 4-5 m depth	1,925	l.m.	$1,980	$3,811,500
	e) 1650 mm @ 0-4 m depth	1,180	l.m.	$2,800	$3,304,000
2	**Storm Manholes - Supply, Install, Excavation and Backfill**				
	a) 1.8 m 1-S manhole	230	v.m.	$6,500	$1,495,000
	b) 2.4 m 1-S manhole	50	v.m.	$8,000	$400,000
3	**Track Crossing (P.C. Sum)**	2	p.c.	$175,000	$350,000
4	**Ditch Excavation (Daylight Trunk - Township RD 231 - Tie in to Shepard Ditch)**				
	a) Excavation, topsoil, seed	720	l.m.	$320	$230,400
				Subtotal:	$13,980,800
	25% Mobilization and Demobilization, Survey, ESC, Traffic Control, Testing:				$3,495,200
				50% Contingency:	$8,738,000
				Total:	**$26,214,000**

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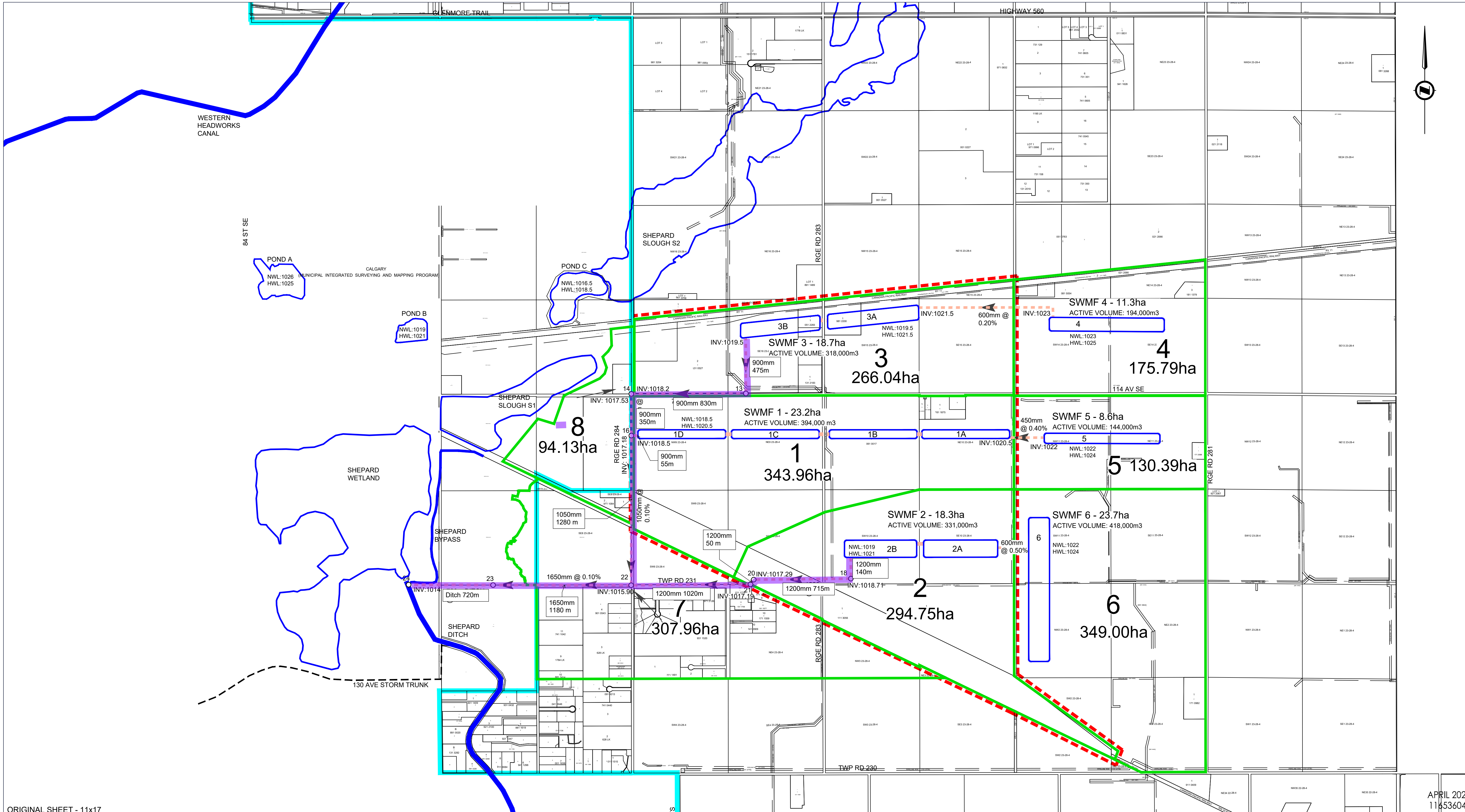

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Legend

- PRAIRIE GATEWAY ASP AREA
- CITY OF CALGARY LIMITS
- STORM CATCHMENT BOUNDARY
- PROPOSED STORM TRUNK
- PROPOSED SWMF
- CONTRIBUTING AREA

Notes

- INCLUDED IN OPC

Client/Project
SHEPARD DEV. CORPORATION
PRAIRIE GATEWAY
MASTER DRAINAGE PLAN

Figure No.
7.3

Title
OPC SERVICING OPTION 3
(AREA 1-8)

8 Conclusions and Recommendations

This MDP has been developed to support the Prairie Gateway ASP submission for the ASP lands study area and the upstream contributing drainage area to the east. Adjacent areas to the north, northwest, west and south were evaluated only for storm trunk sizing purposes and were not analyzed in detail.

Under existing conditions, the ASP lands largely pond stormwater in five main internal wetlands, and recharge the groundwater, with a small 141 ha area that drains north to existing wetlands north of the ASP lands, between the ASP lands and the Shepard Slough Complex. The five main internal wetlands were assumed to be removed for this study only as a conservative assumption for stormwater management. This MDP was written with the intent of directing future designers to review **Figure 2-4: Wetland Retention Decision Tree** and assess if each wetland is to be retained.

The proposed stormwater management concept breaks up the ASP lands into 4 main catchments with 3 SWMFs (1, 2 and 3) that will convey the flow to the west to a proposed storm trunk that flows south following RR 284, and then west along TWP 231 until it connects to the existing Shepard Ditch south of the Shepard Wetland. Each of the SWMFs is comprised of cells that are separated by berms that are intended to be a route for rail or roads to cross the water bodies. The cells are connected by conduits under the berms. The fourth catchment within the ASP lands is only 5.5 ha, and under a development condition of 90% imperviousness, was found to produce a total volume discharge over the stretch of 55 years continuous model that closely matched the existing discharge volume. The fourth catchment was separated from the first three catchments as the fourth catchment drains to the wetlands to the north of the site between the ASP lands and the Shepard Slough Complex to retain the hydrologic periods of those wetlands.

Under existing conditions the east external upstream lands have many small wetlands and depressions that hold the runoff. There is an existing catchment that is 134 ha that flows north to the existing wetlands between the ASP lands and the Shepard Slough Complex.

In the proposed stormwater management concept, the east external upstream lands are divided into four main catchments with three SWMFs (4, 5 and 6). The proposed SWMFs 4, 5 and 6 convey flow through pipes to SWMFs 3, 1 and 2, respectively. The fourth catchment of 10.1 ha located along the north side of the external upstream lands was separated from the first three catchments as the fourth catchment drains to the wetlands to the north of the site to retain the hydrologic periods of those wetlands.

8.1 Summary of Model Results

The proposed ultimate stormwater management concept model was run for the 100-year, 100-year 2050 projection, 100-year 2080 projection and continuous simulation (55 years). Results for the 100-year and continuous simulation are summarized in **Table 8-1.**

There is no overland flow from SWMFs 1 to 6 under the 100-year, 100-year 2050, or continuous simulation for the ultimate development condition; however, there are some amounts of spill in the 100-year, 2080 event.

Table 8-1: Pond Information and Ultimate Development Model Results Summary

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
Pond Info	Design HWL Elev (m)	1020.5	1021	1021.5	1025	1024	1024
	HWL Depth (m)	2	2	2	2	2	2
	NWL Elev (m)	1018.5	1019	1019.5	1023	1022	1022
	Bottom Elev (m)	1016.5	1017	1017.5	1021	1020	1020
	HWL Volume (m^3)	394,020	335,580	318,350	200,660	144,110	385,790
	Overland Spill Elev (m)	1020.5	1021	1021.5	1025.0	1024.0	1024.0
	Overland Spill Depth (m)	2	2	2	2	2	2
	Catchment Area (ha)	475.2	643.2	442.1	176.0	130.4	348.4
	Allowable Flow at 0.8 L/s/ha (L/s)[1]	380	515	354	141	104	279
	Orifice Size (mm) [1]	380	450	390	235	194	325
	Top of SWMF Perimeter Elevation (m)	1021.5	1022	1022.5	1026	1025	1025
	Overflow Weir Depth at 1 m^3/s	0.44	0.44	0.44	0.44	0.44	0.44
	Freeboard, Overflow Depth to Top of SWMF (m)	0.56	0.56	0.56	0.56	0.56	0.56
100-yr, 24 hr	Max Water Level (m) above NWL	1.43	1.35	1.36	1.39	1.43	1.40
	Max Wat Elev (m)	1019.93	1020.35	1020.86	1024.39	1023.43	1023.40
	% Full (HWL)	71.6%	67.3%	68.1%	69.3%	71.6%	70.2%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.307	0.411	0.269	0.116	0.088	0.228
	Max Outflow (L/s/ha)	0.647	0.638	0.609	0.657	0.671	0.654
	Max Active Volume (m^3)	265,420	221,000	207,050	136,000	100,900	266,800
	Max Active Volume (m3/ha)	559	344	468	773	774	766
Continuous	Max Water Level (m) above NWL	1.93	1.89	1.92	1.90	1.93	1.91
	Max Wat Elev (m)	1020.43	1020.89	1021.42	1024.90	1023.93	1023.91
	% Full (HWL)	96.3%	94.4%	96.0%	94.9%	96.3%	95.7%
	Overland Spill Flow (m^3/s)	0	0	0	0	0	0
	Max Outflow (including overland spill m^3/s)	0.369	0.507	0.345	0.140	0.103	0.273

Storm Event	Parameter	SWMF 1	SWMF 2	SWMF 3	SWMF 4	SWMF 5	SWMF 6
	Max Outflow (L/s/ha)	0.776	0.788	0.781	0.793	0.790	0.785
	Max Active Volume (m^3)	369,690	313,600	301,300	189,700	138,300	368,500
	Max Active Volume (m^3/ha)	778	488	682	1,078	1,061	1,058
	Freq Analysis 100 yr Water Level (m) above NWL	1.91	1.96	1.93	1.87	1.89	1.99
	Freq Analysis 100 yr Active Volume (m^3)	367,000	325,000	303,000	188,000	136,000	384,000

8.2 Design Criteria Compliance

Table 8-2, is a summary of the design guidelines that were used to develop the MDP, and a confirmation that all conditions were met.

Table 8-2: Stormwater Management Concept Compliance with Design Criteria

Design Criteria	Method	Result
0.8 L/s/ha discharge for all pipe sizing and outflows	Pipe and spreadsheet and orifices in interim and ultimate model	Done
Pond sizing – maximum volume of shape is not exceeded (100 year return period from the continuous model)	Interim and ultimate model	Done
Overland emergency flow path	Major flow grading analysis	All except SWMF 2
NWL to HWL does not exceed 2.0 m	Interim and ultimate model	Done
Matching the volume of runoff directed to the wetlands north of the MDP area between the existing conditions and the interim/ ultimate post-development conditions.	Single catchment model	Done

8.3 Next Steps

Advancing the MDP to the SMDP will require additional studies, site visits and further assessments. There is a planned MDP revision due to time constraints on the current version of the MDP and the time of year not allowing for a field program to obtain hydrogeology, geotechnical and survey data. After the site investigations, field programs and assessments of the retrieve data, the results will be compared with the input parameter assumptions for the existing conditions, interim development, and ultimate development models and if the parameters assumed differ from the field data, the model parameters will be updated. The three models will then be rerun and SWMF sizing reviewed. See **Table 8-3** for a detailed list of the requirements for the MDP revision.

Note, if the current landowner does not grant access to the site for the field programs, the nearest data points obtained will be extrapolated to include the land not accessed.

The “Prior to Impacted SMDP” line items in **Table 8-3** are intended to be completed for only the areas that are to be included in that upcoming SMDP. The items are required to gain the additional site-specific information to complete the full SMDP.

Table 8-3: Next Steps to Further the Stormwater Management Concept Design for the MDP Study Lands

Study	Section Reference	Notes	Purpose of Data Obtained
MDP Revision			
Site Investigation	3.2.1, 3.2.10	• To confirm culvert crossings/ boundary conditions within MDP study area, and at boundaries • Culvert data: material, inverts, diameter, condition within MDP study area, and at boundaries	• Update in model if required.
General Hydrogeology Investigation	3.1, 3.2.7	• Initial water levels for surface and groundwater • Hydraulic conductivity testing • Testing for surface and ground water general chemistry • Commence 1 year of monitoring for surface water level of wetlands and ground water level monitoring	• Extrapolate using data gathered to overall MDP to confirm model input parameters. Update in model if required. • Add hydraulic conductivity to existing model
General Geotechnical Investigation	3.2.6.3	• Confirm soil type • Infiltration testing	• Extrapolate using data gathered to overall MDP to confirm model input parameters. Update in model if required. • Revised hydrology model and hydrogeology assessment with updated soil type and infiltration rate.
Wetland Retention Performance Criteria	2.3.1	• Hydroperiod (stage duration curve) for any wetland likely to be retained from within the 17 wetlands that are being reviewed for crown claimability. • General water quality for discharge to a retained wetland inside or outside the MDP.	• Flow, volume, water quality targets • Will not be able to provide any single wetlands specific water quality requirements
Rerun MDP models		• Update soil type, hydraulic conductivity, groundwater and surface water connections	• Update/optimize stormwater management concept including SWMF sizing and location.
Prior to Impacted SMDPs			
Hydrogeology Investigation	3.1, 3.2.7	• Complete 1 year of ground water monitoring well data • Hydraulic conductivity testing • Surface and groundwater sampling and general chemistry testing	• Evaluate changes in groundwater levels and flow patterns over time. • Evaluate chemistry for potential groundwater-surface water interactions
Surface Water Level Monitoring	3.1.3	• Complete 1 year of monitoring for surface water level of wetlands.	• Evaluate interaction between groundwater and surface water • For detailed stormwater modelling in SMDP
Geotechnical Investigation	3.2.6.3	• Confirm SMDP site specific soil type and conditions.	• For detailed stormwater modelling in SMDP • To update infrastructure cost estimate and modify design if required.
Water Body Permanence Assessment Results	2.2	• Receive initial confirmation of which wetlands of the 17 reviewed are Crown claimable	• For wetland retention determination in SMDP.
Bed and Shore Survey	2.2	• Confirms boundary for any Crown wetland's legal boundary	• Use boundary for outline plan and detailed design.

Study	Section Reference	Notes	Purpose of Data Obtained
Capital Infrastructure Design (to be completed by City of Calgary)			
Site Survey	4.4, 5.2.4	• Confirm RR 284 drainage elevations. • Topo elevations along route of trunk to Shepard Ditch tie in. • Shepard Ditch cross sections, existing culvert sizes and inverts near tie in location.	• Use during SMDP to confirm daylight location for storm trunk, and storm trunk cover. • Use for design of daylight location, and ditch upgrades from daylight location to existing Shepard Ditch.
Geotechnical Investigation	3.2.6.3	• Confirm soil type, conditions, groundwater level, bedrock depth	• To use in trunk design and cost estimating.
Assessment of Existing Conditions of Shepard Ditch	5.2.4	• Site visit to assess stability, erosion and seepage concerns related to the tie in.	• Suggest erosion mitigation measures for tie in location.

SMDP's developed for the Prairie Gateway MDP study area are required to include additional items to the standard SMDP due to the site-specific nature of wetlands within the MDP study area. These additional items, listed in **Table 8-4** are to be completed for the SMDP area at the time a developer is interested in pursuing development, as there will likely be many SMDPs with potentially different developers covered by this MDP.

Table 8-4: SMDP Requirements

<table>
<tr><th>SMDP Phase</th><th>Section Reference</th><th>Notes</th></tr>
<tr><td>CoC requirements</td><td></td><td>• Chapter 11 of the CoC Stormwater Design Manual, and any applicable bulletins or updated CoC Storwmater Design Manuals.</td></tr>
<tr><td>Wetland Confirmation with SMDP Boundary</td><td>2.2</td><td>• Update stormwater management concept to retain wetlands if wetland decision matrix required retention.</td></tr>
<tr><td>Biophysical Impact Assessment</td><td>Appendix A</td><td>• To support wetland decision matrix assessments.</td></tr>
<tr><td colspan="3">• Minimum road and building elevations.
• Appropriate horizontal setback horizontally from the major drainage infrastructure
• Discharge configuration for flows directed to the wetlands to the north of the ASP lands to mimic the existing flows. The SMDP will also need to consider the water quality of the flow entering the retained wetlands, and the existing wetlands to the north of the ASP study area, between the ASP lands and the Shepard Slough Complex.
• SMDP to also determine the requirements of the forebay design or OGS design for SWMFs.</td></tr>
</table>

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APPENDICES

Appendix A Environmental Screening Addendum – Prairie Gateway (Shepard Industrial lands) Area Structure Plan

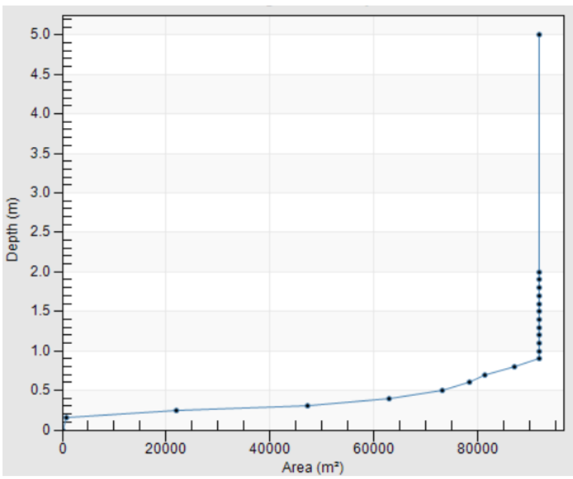
Appendix B Waterbody Permanence Assessment – Prairie Gateway (Shepard Industrial lands) Area Structure Plan

Appendix C Existing Model Parameters and Results

C.1 Existing Condition Input Parameters

Storage Curves at Calibration Wetlands

Wetland #1



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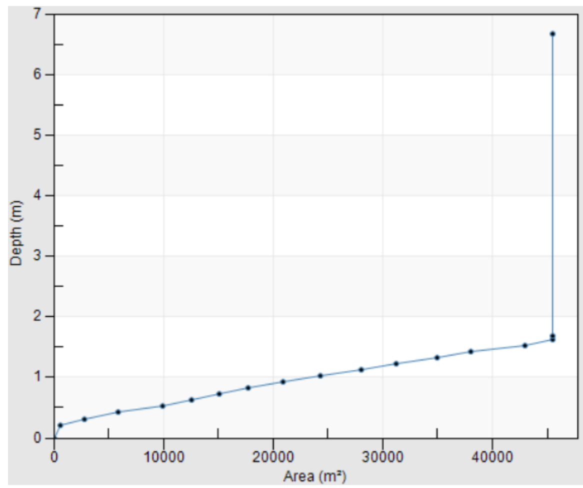

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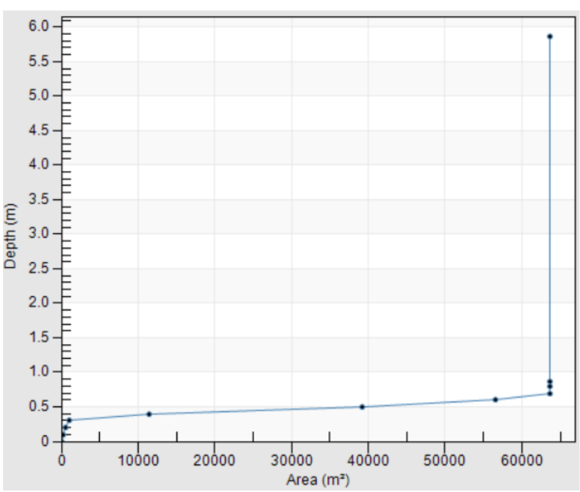
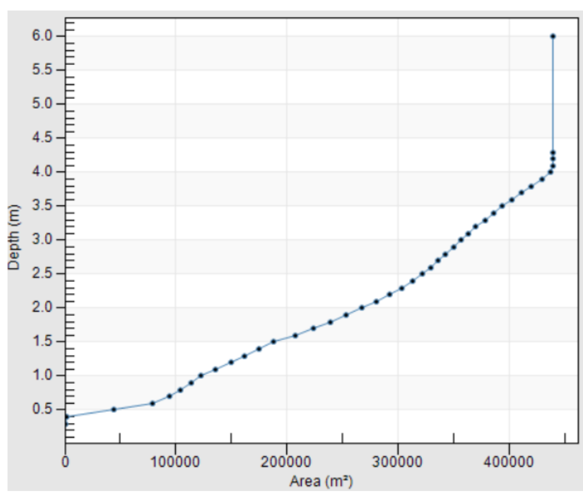
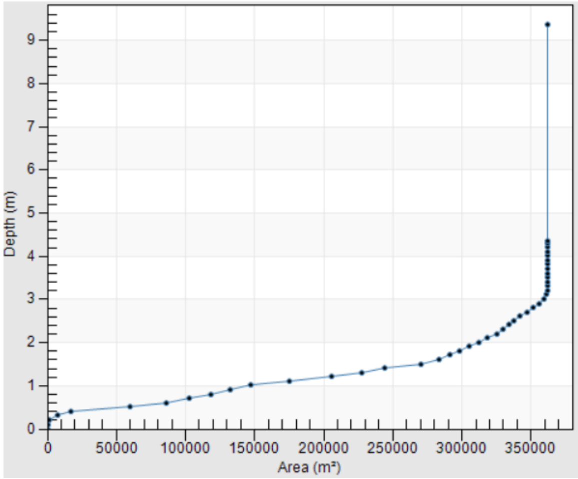


Wetland #4



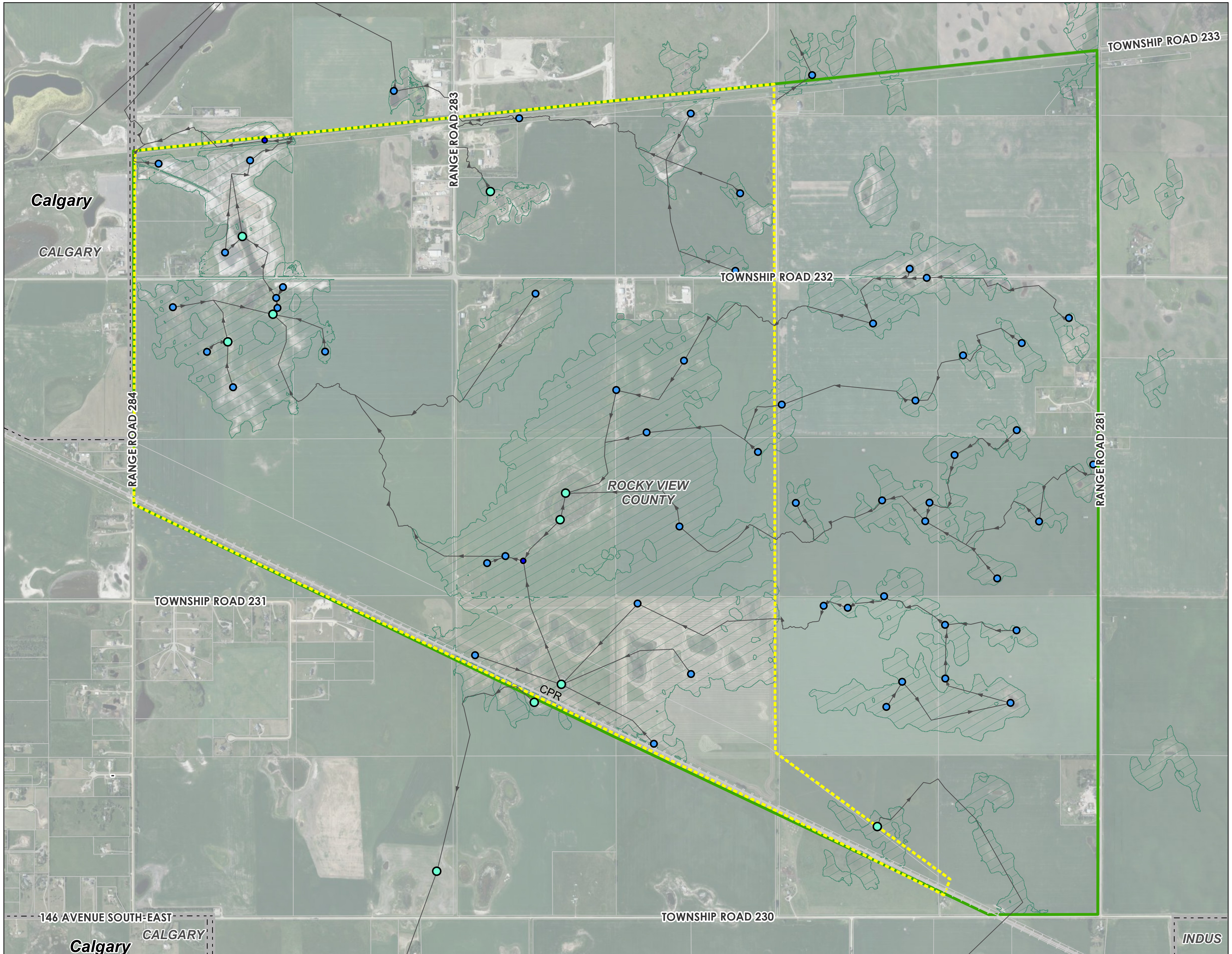
Wetland #5



Aquifer	**Parameters**	
Porosity	0.471	
Wilting Point	0.21	
Field Capacity	0.342	
Conductivity	0.5	
Conduct. Slope	10	
Tension Slope	15	
Upper Evap. Fraction	0	
Lower Evap. Depth	0	
Lower GW Loss Rate	10	
Unsat. Zone Moisture	0.4	
Bottom Elevation (m)	Aquifer-SP11	1021.7
	Aquifer-SP14m	1017.5
	Aquifer-SP14r	1017.6
	Aquifer-SP16h	1021.7
	Aquifer-SP16o	1020.9
	Aquifer-SP6j	1017.4
Water Table Elevation (m)	Aquifer-SP11	1021.7
	Aquifer-SP14m	1017.5
	Aquifer-SP14r	1017.6
	Aquifer-SP16h	1021.7
	Aquifer-SP16o	1020.9
	Aquifer-SP6j	1017.4

SnowMelt	
Dividing temperature between snow and rain (C)	0
ATI weight (fraction)	0.5
Negative melt ratio (fraction)	0.6
Elevation above MSL	1000
Latitude (degrees)	51
Longtitude correction (min)	0

C.2 Existing Condition Results



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Modelled Wetland
- Modelled Conduit

Maximum Volume (1000 m³)

- 0
- > 0 to ≤ 10
- > 10 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes

1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
The City of Calgary

Project Location
SE Calgary
Alberta

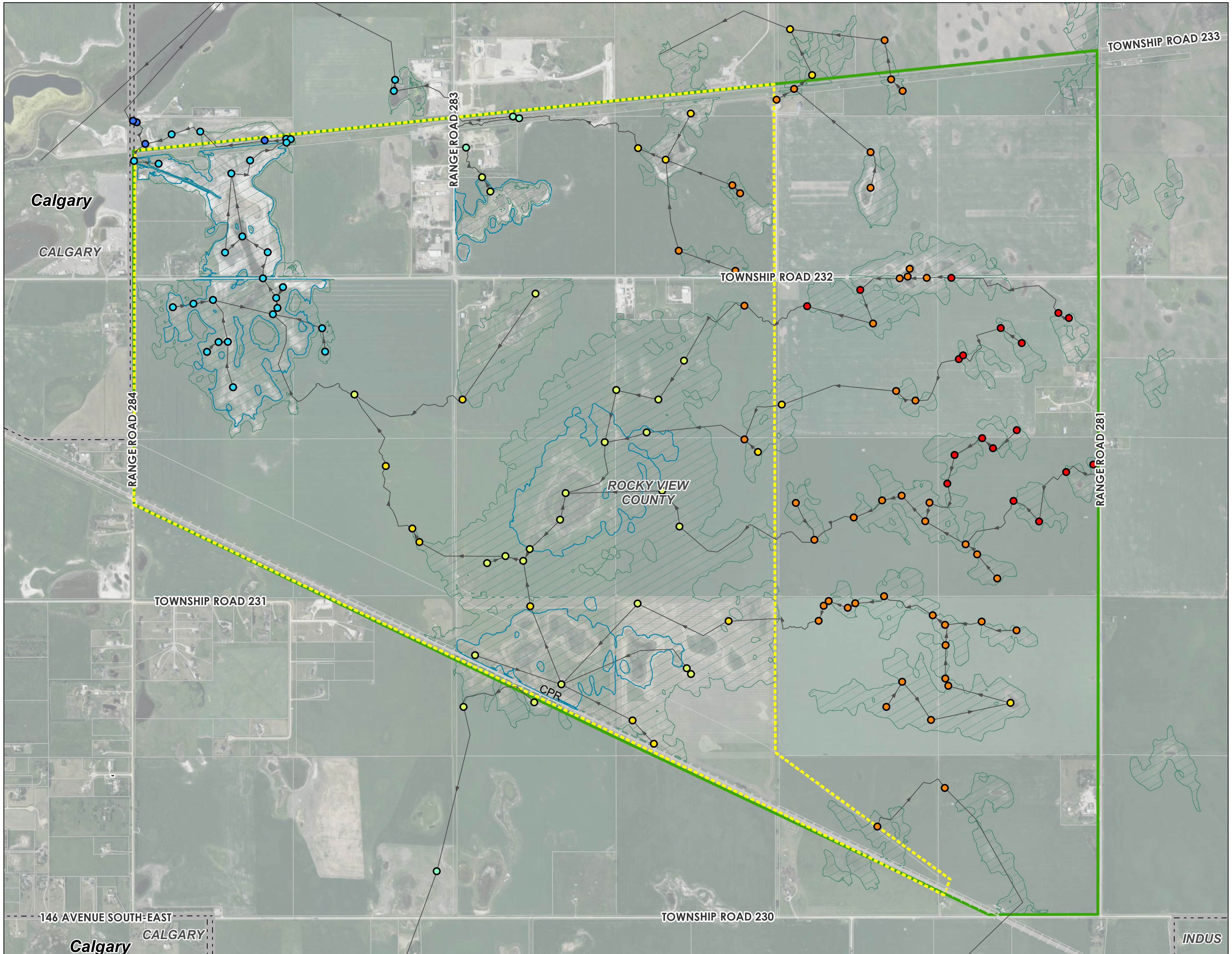
Prepared by KDB on 2024-02-02
TR by NF on 2024-02-14

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.1

Title
Modelled Maximum Volume
100-year Scenario, Existing Conditions

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_FigC-1_100yr_StorageVol.mxd Revised: 2024-04-19 By: kebuchanan



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Modelled Wetland
- Modelled Conduit

Maximum HGL (m)

- 1028 - 1030
- 1026 - 1028
- 1024 - 1026
- 1022 - 1024
- 1020 - 1022
- 1018 - 1020
- 1016 - 1018
- 100-Year Model HGL Contour

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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Project Location
SE Calgary
Alberta

Prepared by KDB on 2024-02-02
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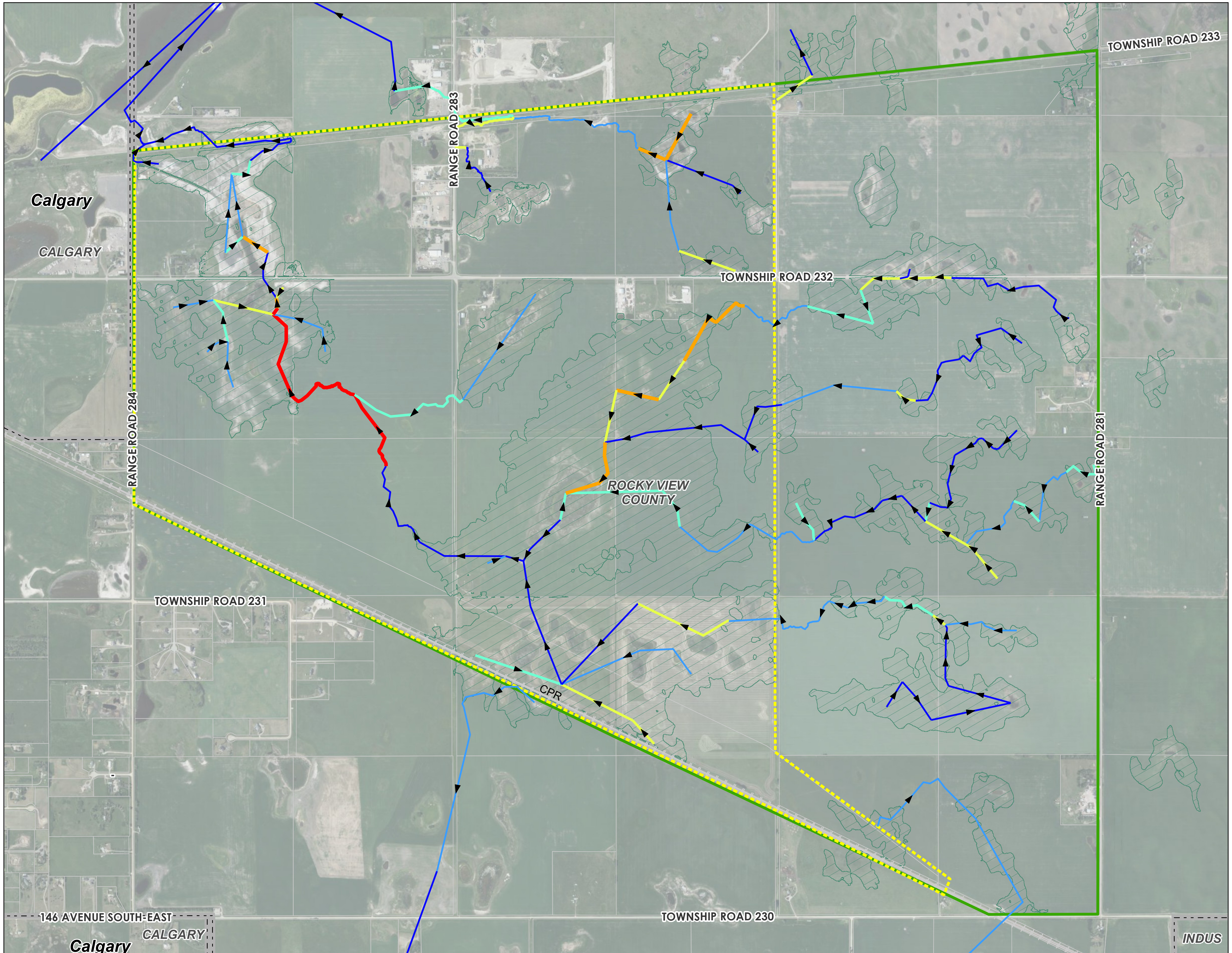
Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.2

Title
Modelled Maximum HGL
100-year Scenario, Existing Conditions

\\ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM1\116536040_TM1_FigC-2_100yr_StorageHGL.mxd Revised: 2024-04-26 By: kebuchanan



Stantec

ASP Boundary
MDP Boundary
Railway
Municipal Boundary

Maximum Flow (m³/s)

- 0.00
- > 0.00 to ≤ 0.10
- > 0.10 to ≤ 0.25
- > 0.25 to ≤ 0.50
- > 0.50 to ≤ 1.00
- > 1.00

N

0 250 500 metres
(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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Project Location
SE Calgary
Alberta

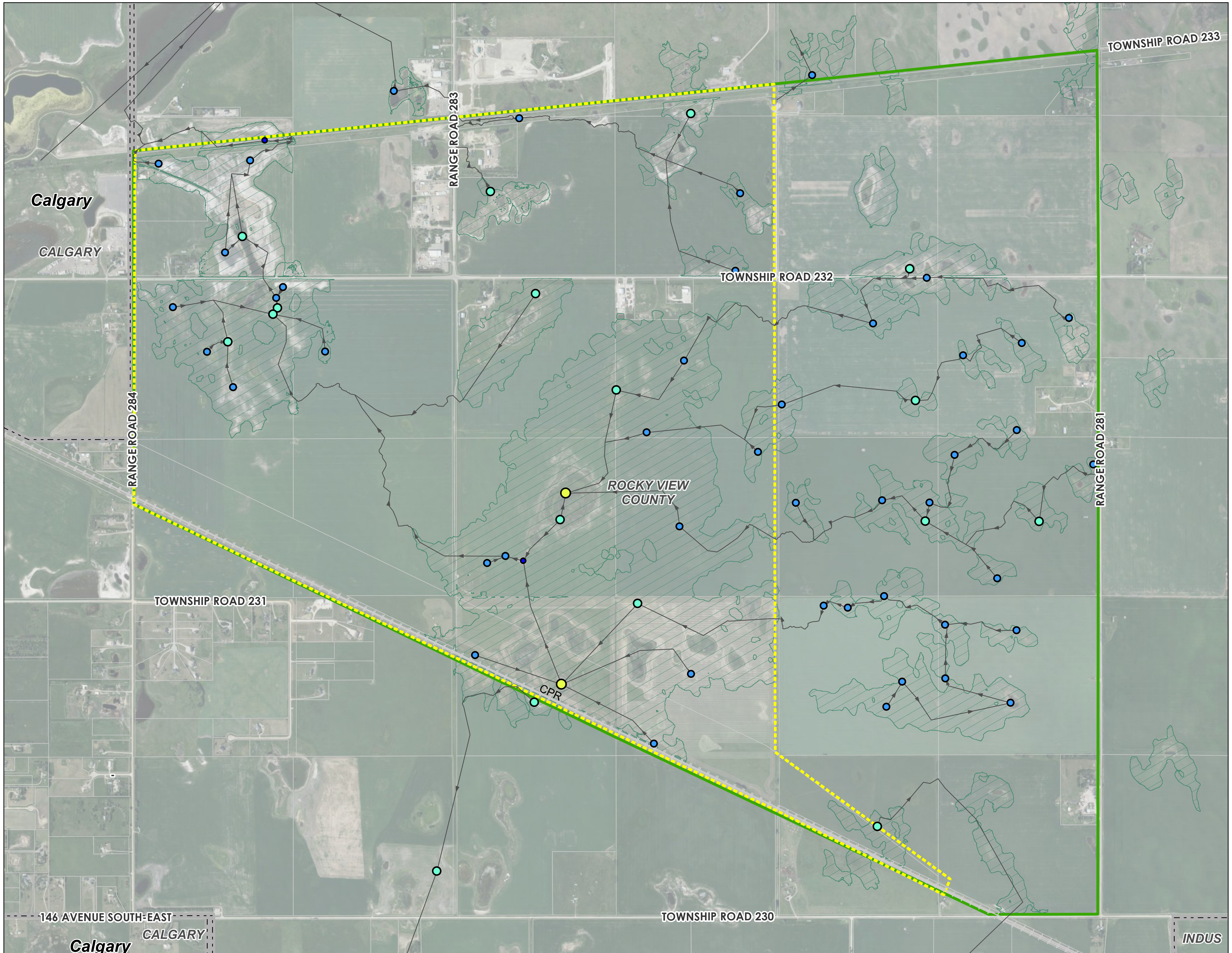
Prepared by KDB on 2024-02-02
TR by NF on 2024-02-14

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.3

Title
Modelled Maximum Flow
100-year Scenario, Existing Conditions

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_FigC-3_100yr_Conduit.mxd Revised: 2024-04-19 By: kebuchanan



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Modelled Wetland
- Modelled Conduit

Maximum Volume (1000 m³)

- 0
- > 0 to ≤ 10
- > 10 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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SE Calgary
Alberta

Prepared by KDB on 2024-02-02
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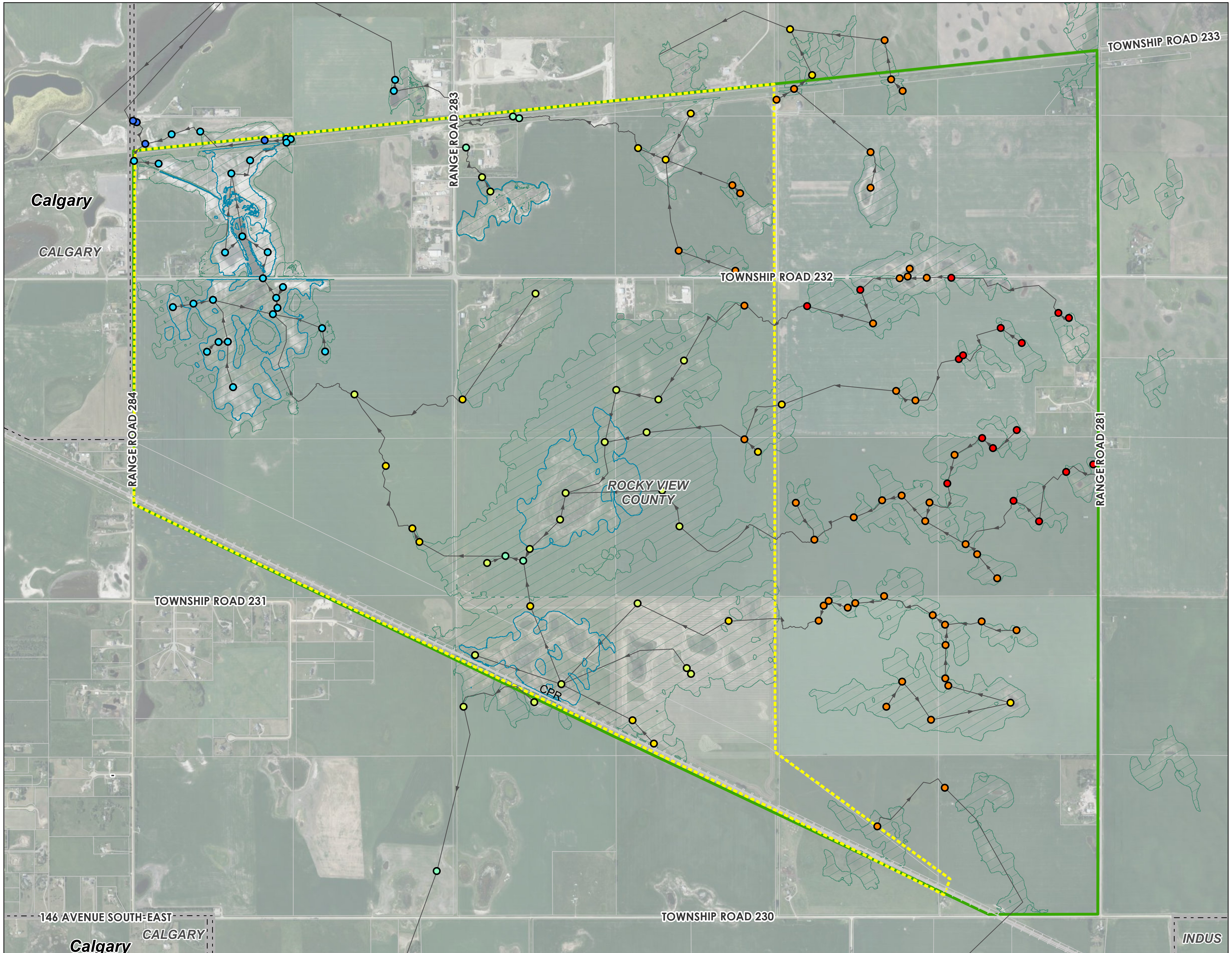
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.4

Title
Modelled Maximum Volume
Continuous Scenario, Existing Conditions

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_FigC-4_Continuous_StorageVol.mxd Revised: 2024-04-19 By: kebuchanan



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Modelled Wetland
- Modelled Conduit

Maximum HGL (m)

- 1028 - 1030
- 1026 - 1028
- 1024 - 1026
- 1022 - 1024
- 1020 - 1022
- 1018 - 1020
- 1016 - 1018
- Continuous Model HGL Contour

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes
1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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Project Location
SE Calgary
Alberta

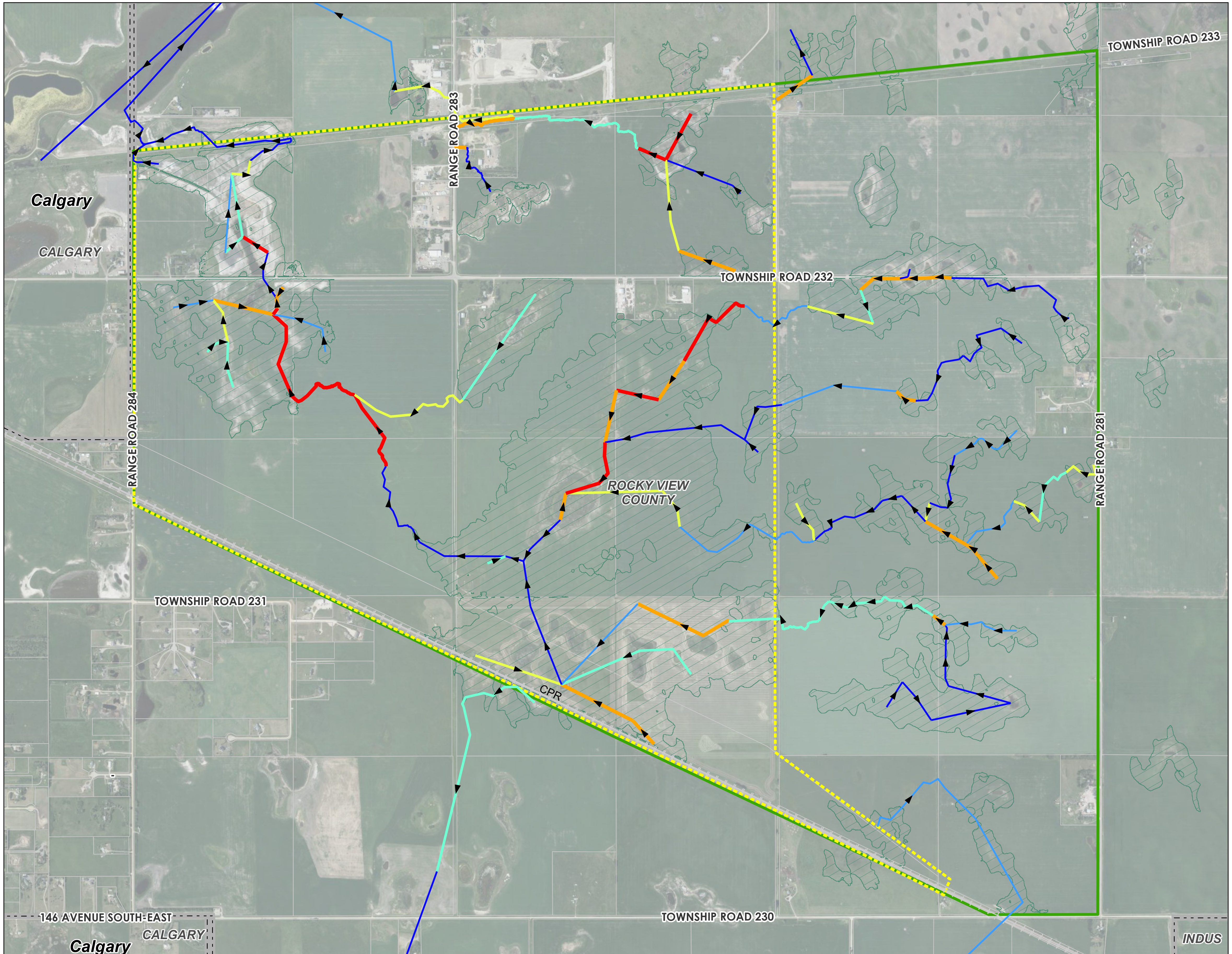
Prepared by KDB on 2024-02-02
TR by NF on 2024-02-14

Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.5

Title
Modelled Maximum HGL
Continuous Scenario, Existing Conditions

\\ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM1\116536040_TM1_FigC-5_Continuous_StorageHGL.mxd Revised: 2024-04-26 By: kebuchanan



Stantec

- ASP Boundary
- MDP Boundary
- Railway
- Municipal Boundary
- Modelled Wetland

Maximum Flow (m³/s)

- 0.00
- > 0.00 to ≤ 0.10
- > 0.10 to ≤ 0.25
- > 0.25 to ≤ 0.50
- > 0.50 to ≤ 1.00
- > 1.00

N

0 250 500 metres

(At original document size of 11x17)
1:20,000

Notes

1. Coordinate System: NAD 1983 3TM 114
2. Data Sources: Stantec Consulting Ltd, Government of Alberta, City of Calgary
3. Background: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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Project Location
SE Calgary
Alberta

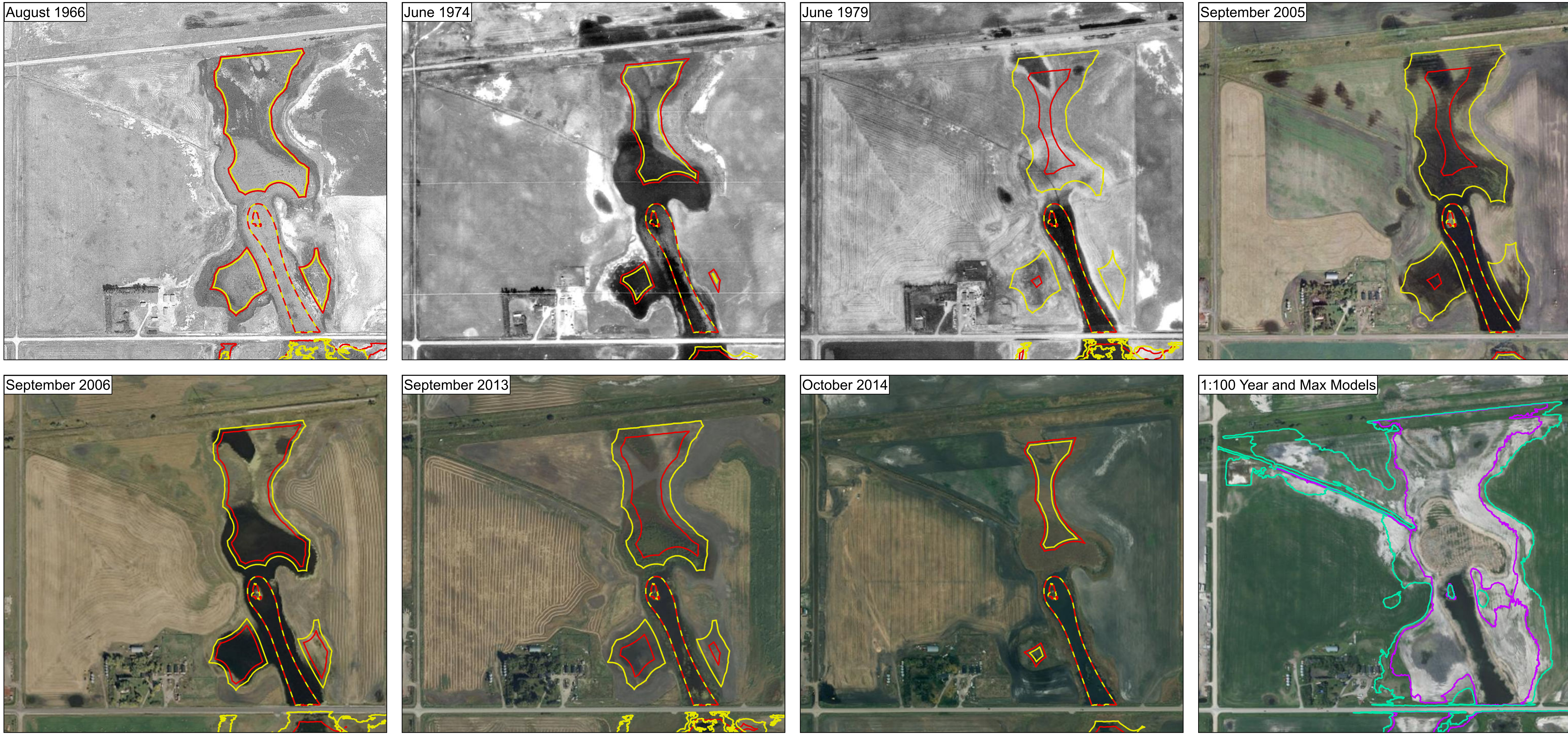
Prepared by KDB on 2024-02-02
TR by NF on 2024-02-14

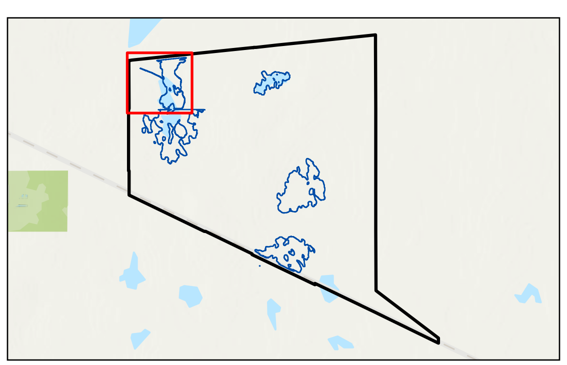
Client/Project 116536040_001
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C.6

Title
Modelled Maximum Flow
Continuous Scenario, Existing Conditions

\\CA0217-PPFSS01\work_group\1165\active\116536040\GIS\mxd\TM1\116536040_TM1_FigC-6_Continuous_Conduit.mxd Revised: 2024-04-19 By: kebuchanan





Legend

Inundation Extent

- Existing Conditions Continuous Model (at indicated date)
- Water Level Estiamte from Aerial Imagery
- Existing Conditions 100 year, 24 hour event
- Existing Conditions Continuous Model (Max Water Level of 55 year period)

Note: there are significant changes in topography and morphology due to land owner modifications over the 55 years, which make the comparison of the modern day lidar contours to the historical aerial imagery inconsistent.

0 150 300 Meters

(At original document size of 11x17)
1:9,000

N

Notes

1. Coordinate System: NAD 1983 3TM 114

2. Data Sources: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, City of Calgary, Esri, NASA, NGA, USGS, Esri, NASA, NGA, USGS, FEMA, Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA, NRCan, Parks Canada, ATLIS Geomatics, City of Calgary

Stantec

Project Location Prepared by kaitang on 5/13/2024

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Alberta

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Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

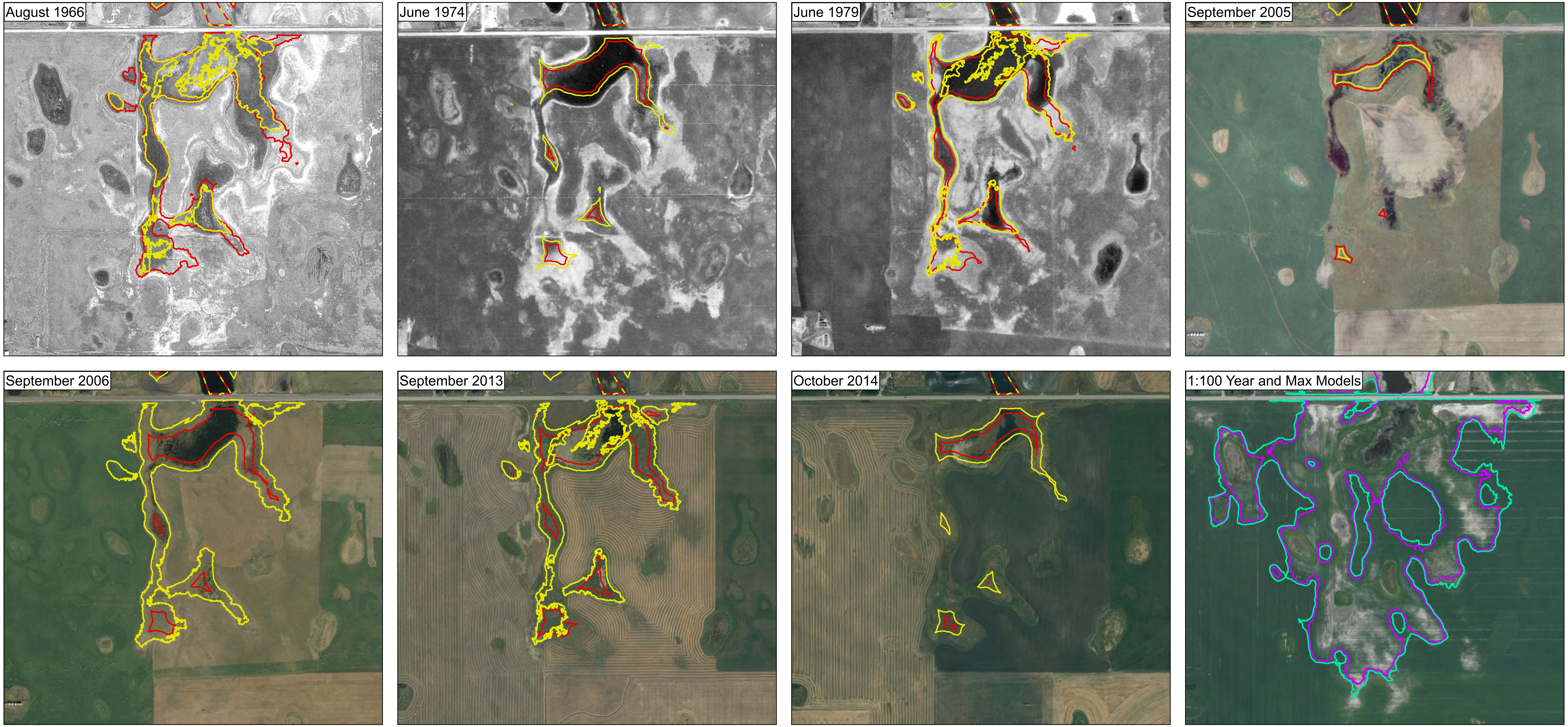
Figure No.

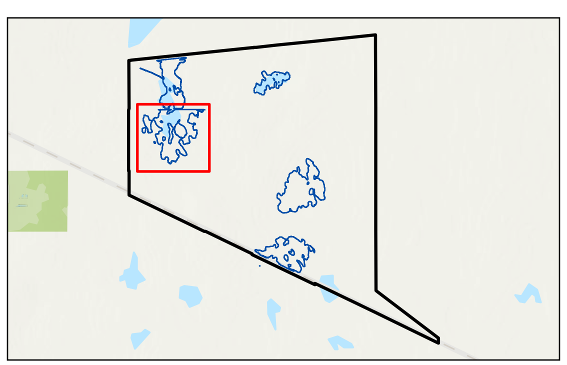
C7

Title

Calibration Wetland #1
Inundation Extents

\\Ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM11ARPX\PrairieGateway.aprx Revised: 2024-05-13 By: kaitang





Legend

Inundation Extent

- Existing Conditions Continuous Model (at indicated date)
- Water Level Estiamte from Aerial Imagery
- Existing Conditions 100 year, 24 hour event
- Existing Conditions Continuous Model (Max Water Level of 55 year period)

Note: there are significant changes in topography and morphology due to land owner modifications over the 55 years, which make the comparison of the modern day lidar contours to the historical aerial imagery inconsistent.

0 150 300 Meters

(At original document size of 11x17)
1:10,000

N

Notes

1. Coordinate System: NAD 1983 3TM 114

2. Data Sources: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, City of Calgary, Esri, NASA, NGA, USGS, Esri, NASA, NGA, USGS, FEMA, Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA, NRCan, Parks Canada, ATLIS Geomatics, City of Calgary

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Alberta

Client/Project 116536040

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Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

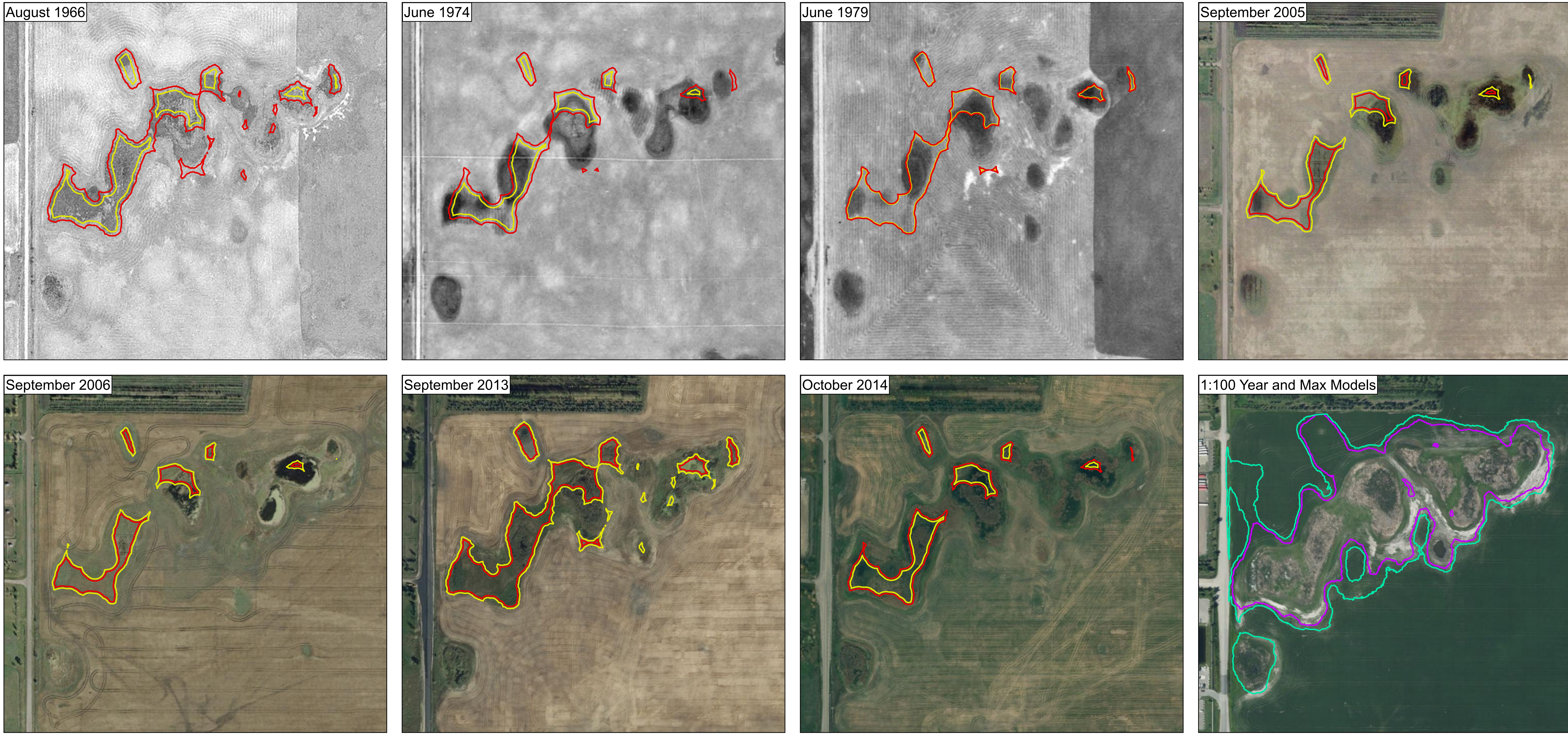
Figure No.

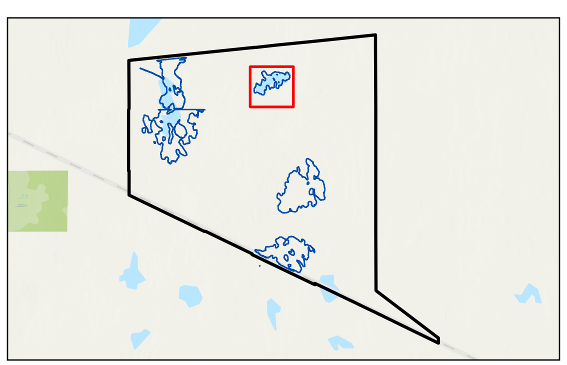
C8

Title

Calibration Wetland #2
Inundation Extents

\\Ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM1ARPX\PrairieGateway.aprx Revised: 2024-05-13 By: kaitang





Legend

Inundation Extent

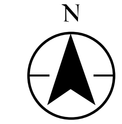
- Existing Conditions Continuous Model (at indicated date)
- Water Level Estiamte from Aerial Imagery
- Existing Conditions 100 year, 24 hour event
- Existing Conditions Continuous Model (Max Water Level of 55 year period)

Note: there are significant changes in topography and morphology due to land owner modifications over the 55 years, which make the comparison of the modern day lidar contours to the historical aerial imagery inconsistent.

0 150 300 Meters

(At original document size of 11x17)
1:6,000

N



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SE Calgary
Alberta

Client/Project 116536040

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Prairie Gateway (Shepherd Industrial Lands)
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Figure No.

C9

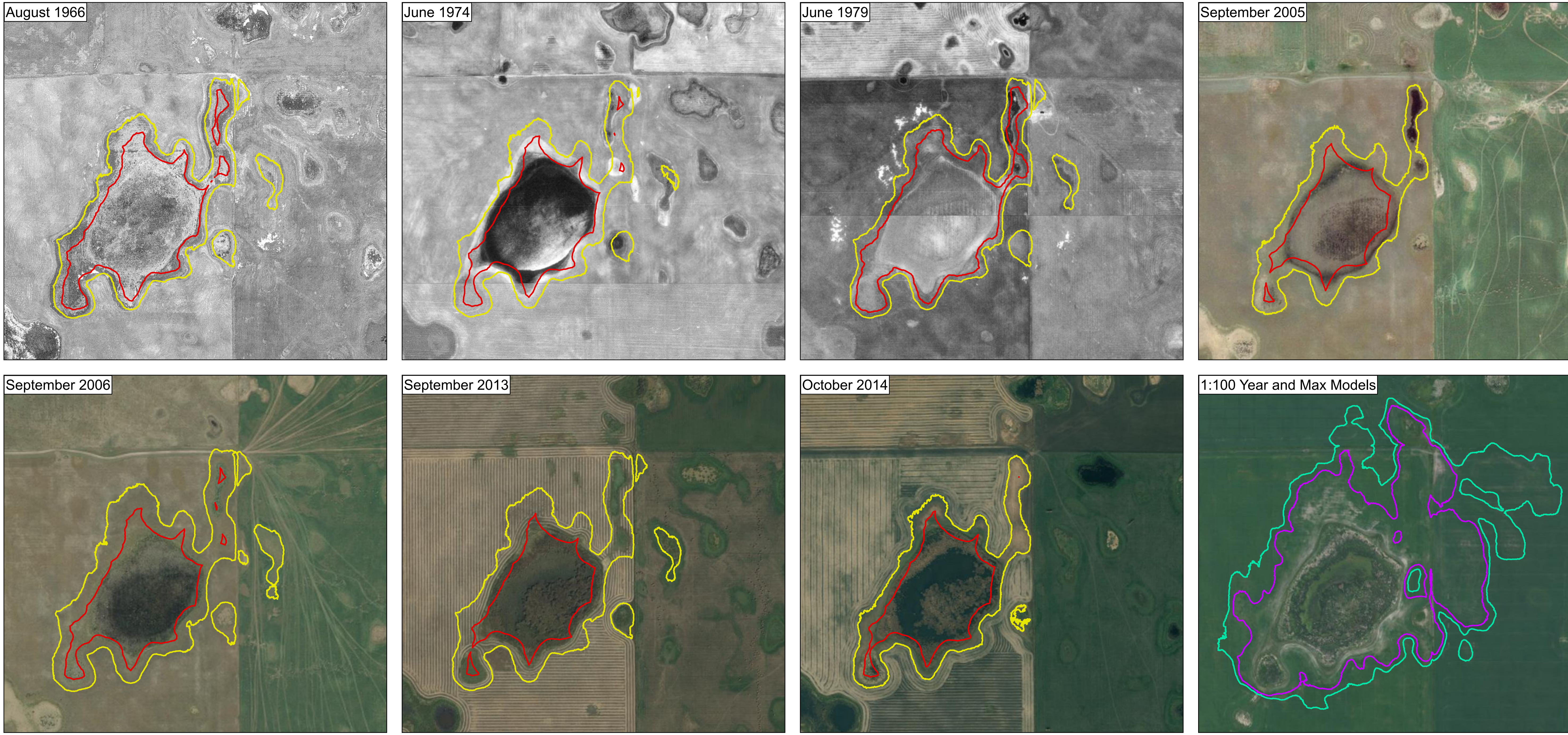
Title

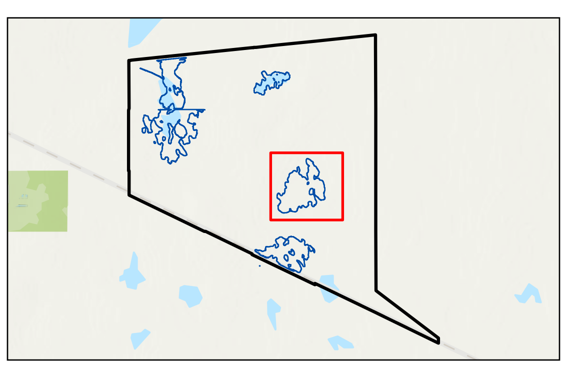
Calibration Wetland #3
Inundation Extents

Notes

1. Coordinate System: NAD 1983 3TM 114

2. Data Sources: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, City of Calgary, Esri, NASA, NGA, USGS, Esri, NASA, NGA, USGS, FEMA, Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS,





Legend

Inundation Extent

- Existing Conditions Continuous Model (at indicated date)
- Water Level Estiamte from Aerial Imagery
- Existing Conditions 100 year, 24 hour event
- Existing Conditions Continuous Model (Max Water Level of 55 year period)

Note: there are significant changes in topography and morphology due to land owner modifications over the 55 years, which make the comparison of the modern day lidar contours to the historical aerial imagery inconsistent.

0 150 300 Meters

(At original document size of 11x17)
1:10,000

N

Notes

1. Coordinate System: NAD 1983 3TM 114

2. Data Sources: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, City of Calgary, Esri, NASA, NGA, USGS, Esri, NASA, NGA, USGS, FEMA, Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA, NRCan, Parks Canada, ATLIS Geomatics, City of Calgary

Stantec

Project Location Prepared by kaitang on 5/13/2024

SE Calgary
Alberta

Client/Project 116536040

Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

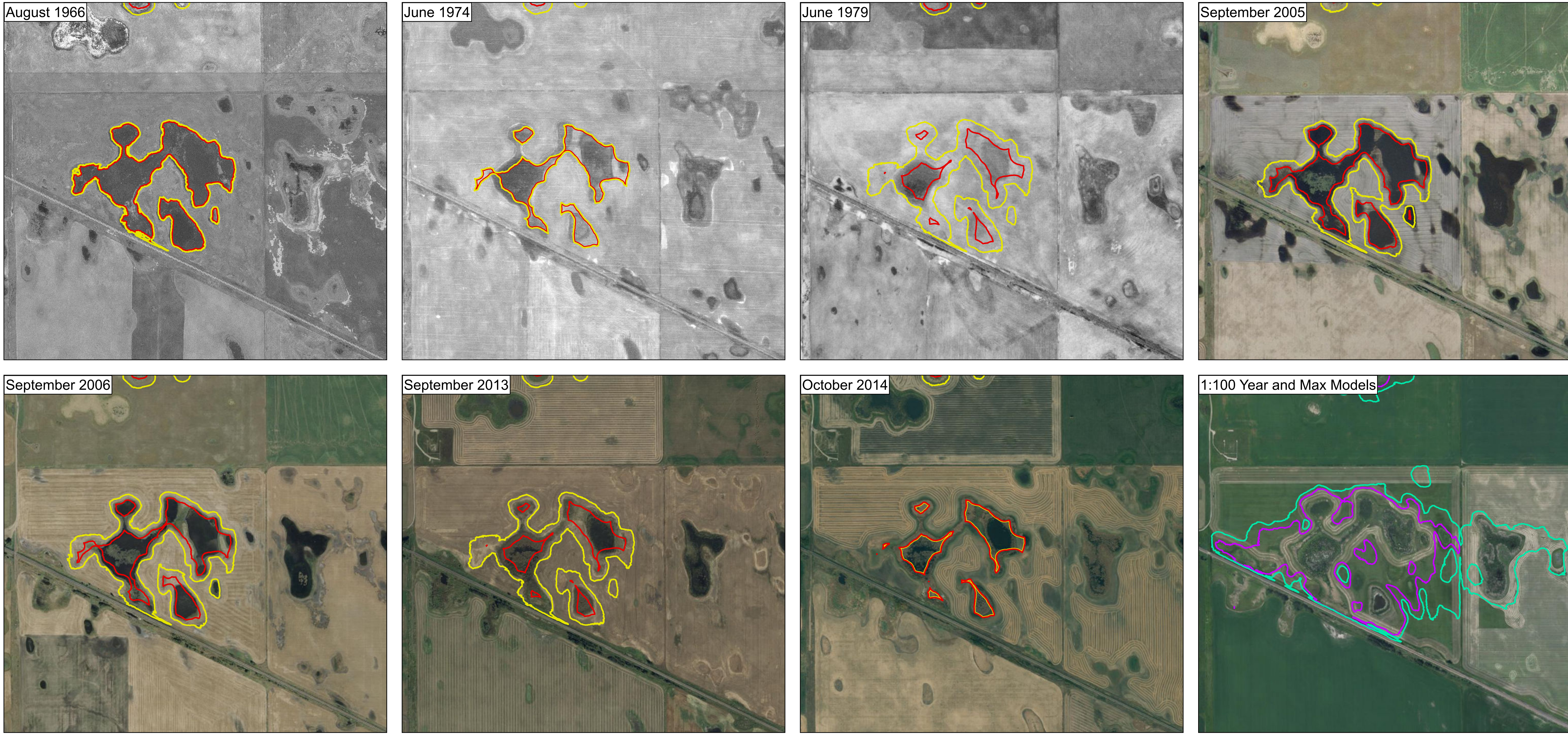
Figure No.

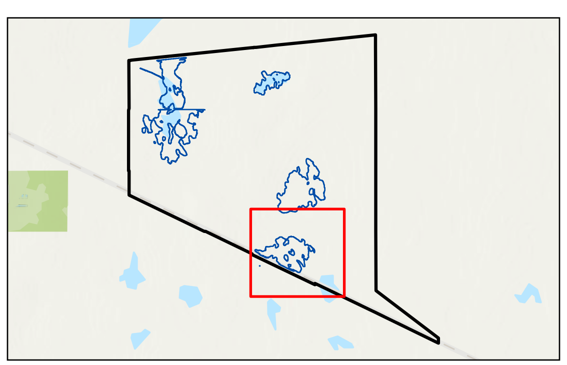
C10

Title

Calibration Wetland #4
Inundation Extents

\\Ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM1ARPX\PrairieGateway.aprx Revised: 2024-05-13 By: kaitang





Legend

Inundation Extent

- Existing Conditions Continuous Model (at indicated date)
- Water Level Estiamte from Aerial Imagery
- Existing Conditions 100 year, 24 hour event
- Existing Conditions Continuous Model (Max Water Level of 55 year period)

Note: there are significant changes in topography and morphology due to land owner modifications over the 55 years, which make the comparison of the modern day lidar contours to the historical aerial imagery inconsistent.

0 150 300 Meters

(At original document size of 11x17)
1:13,000

N

Notes

1. Coordinate System: NAD 1983 3TM 114

2. Data Sources: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, City of Calgary, Esri, NASA, NGA, USGS, Esri, NASA, NGA, USGS, FEMA, Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA, NRCan, Parks Canada, ATLIS Geomatics, City of Calgary

Stantec

Project Location
SE Calgary
Alberta

Prepared by kaitang on 5/13/2024

Client/Project 116536040
Shepherd Development Group
Prairie Gateway (Shepherd Industrial Lands)
Area Structure Plan Environmental Screening Addendum

Figure No.
C11

Title
Calibration Wetland #5
Inundation Extents

\\Ca0217-ppfss01\work_group\01656\active\116536040\GIS\Map\TM1\ARPX\PrairieGateway.aprx Revised: 2024-05-13 By: kaitang

Appendix D Minor Storm System Sizing Calculation Sheet

Stantec

PRAIRIE GATEWAY MASTER DRAINAGE PLAN	
DATE:	2024-05-10
REVISION:	0
DESIGNED BY:	AM
CHECKED BY:	NC

STORM SEWER DESIGN SHEET
(City of Calgary)

FILE NUMBER: 116536040

DESIGN PARAMETERS

$I = a / (t+b)^c$ (As per City of Calgary Guidelines, 2011)

	1:2 yr	1:5 yr	1:10 yr	1:100 yr			
a =	261.578	425.978	536.909	894.425	MANNING'S n =	0.022	
b =	3.004	3.004	3.004	3.004	MINIMUM COVER:	2.00	m
c =	0.705	0.735	0.747	0.769	TIME OF ENTRY	10	min

Qdischarge = 115 L/s/ha
BEDDING CLASS = B

LOCATION			DRAINAGE AREA																	
AREA ID NUMBER	FROM M.H.	TO M.H.	AREA (2-YEAR) (ha)	AREA (5-YEAR) (ha)	AREA (10-YEAR) (ha)	AREA (ha)	AREA (ROOF) (ha)	C (2-YEAR) (-)	C (5-YEAR) (-)	C (10-YEAR) (-)	C (-)	A x C (2-YEAR) (ha)	ACCUM AxC (2YR) (ha)	A x C (5-YEAR) (ha)	ACCUM. AxC (5YR) (ha)	A x C (10-YEAR) (ha)	ACCUM. AxC (10YR) (ha)	A x C (ha)	ACCUM. (ha)	Barrel
SWMF1a_(North)	N/A	N/A	0.00	0.00	0.00	24.25	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.124	2
SWMF1a_(South)	N/A	N/A	0.00	0.00	0.00	35.60	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	17.800	2
SWMF1b_(North)	N/A	N/A	0.00	0.00	0.00	23.94	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.970	2
SWMF1b_(South)	N/A	N/A	0.00	0.00	0.00	43.09	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	21.545	2
SWMF1c_(North)	N/A	N/A	0.00	0.00	0.00	23.98	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.992	2
SWMF1c_(South)	N/A	N/A	0.00	0.00	0.00	65.63	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	32.817	2
SWMF1d_(North)	N/A	N/A	0.00	0.00	0.00	23.75	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.873	2
SWMF1d_(South)	N/A	N/A	0.00	0.00	0.00	81.97	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	40.986	2
SWMF2a_(North)	N/A	N/A	0.00	0.00	0.00	36.49	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18.245	2
SWMF2a_(South)	N/A	N/A	0.00	0.00	0.00	108.86	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	54.428	2
SWMF2b_(North)	N/A	N/A	0.00	0.00	0.00	23.27	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.636	2
SWMF2b_(West)	N/A	N/A	0.00	0.00	0.00	58.46	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.231	2
SWMF2b_(South)	N/A	N/A	0.00	0.00	0.00	49.43	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.717	2
SWMF3a_(North-1)	N/A	N/A	0.00	0.00	0.00	10.96	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.478	2
SWMF3a_(North-2)	N/A	N/A	0.00	0.00	0.00	16.17	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.085	2
SWMF3a_(South-1)	N/A	N/A	0.00	0.00	0.00	49.07	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.533	2
SWMF3a_(South-2)	N/A	N/A	0.00	0.00	0.00	60.34	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	30.170	2
SWMF3b_(North-1)	N/A	N/A	0.00	0.00	0.00	15.55	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.776	2
SWMF3b_(North-2)	N/A	N/A	0.00	0.00	0.00	11.96	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.980	2
SWMF3b_(South-1)	N/A	N/A	0.00	0.00	0.00	40.80	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.400	2
SWMF3b_(South-2)	N/A	N/A	0.00	0.00	0.00	42.92	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	21.458	2
SWMF4_(North-1)	N/A	N/A	0.00	0.00	0.00	30.75	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.377	2
SWMF4_(North-2)	N/A	N/A	0.00	0.00	0.00	40.89	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.443	2
SWMF4_(South-1)	N/A	N/A	0.00	0.00	0.00	45.39	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22.694	2
SWMF4_(South-2)	N/A	N/A	0.00	0.00	0.00	47.70	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	23.850	2
SWMF5_(North-1)	N/A	N/A	0.00	0.00	0.00	26.95	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.474	2
SWMF5_(North-2)	N/A	N/A	0.00	0.00	0.00	29.14	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.572	2
SWMF5_(South-1)	N/A	N/A	0.00	0.00	0.00	32.07	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.036	2
SWMF5_(South-2)	N/A	N/A	0.00	0.00	0.00	34.23	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	17.117	2
SWMF6_(North)	N/A	N/A	0.00	0.00	0.00	110.96	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	55.482	2
SWMF6_(South)	N/A	N/A	0.00	0.00	0.00	188.35	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	94.176	2
SWMF6_(West)	N/A	N/A	0.00	0.00	0.00	25.66	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.830	2

AREA ID NUMBER	T of C (min)	I_{2-YEAR} (mm/h)	I_{5-YEAR} (mm/h)	$I_{10-YEAR}$ (mm/h)	$I_{100-YEAR}$ (mm/h)	$Q_{CONTROL}$ (L/s)	ACCUM. $Q_{CONTROL}$ (L/s)	Q_{ACT} (CIA/360) (L/s)	PROPOSED GRADING (m)	SWMF INLET INVERT (m)	**PIPE COVER (m)**	PIPE SELECTION: LENGTH (m)	PIPE WIDTH OR DIAMETE (mm)	PIPE HEIGHT (mm)	PIPE SHAPE (-)	MATERIAL (-)	CLASS (-)	SLOPE %	Q_{CAP} (FULL) (L/s)	% FULL (-)	VEL. (FULL) (m/s)	VEL. (ACT) (m/s)	TIME OF FLOW (min)
SWMF1a_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1394.2	1028.1	1017.1	**9.8**	240.0	1800	1200	RECTANGULAR	PVC	-	0.10	1571.2	**88.73%**	0.73	0.74	5.41
SWMF1a_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2047.0	1027.2	1017.1	**8.8**	373.0	2100	1350	RECTANGULAR	PVC	-	0.10	2252.2	**90.89%**	0.79	0.81	7.67
SWMF1b_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1376.6	1025.5	1017.1	**7.2**	243.0	1800	1200	RECTANGULAR	PVC	-	0.10	1571.2	**87.61%**	0.73	0.74	5.50
SWMF1b_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2477.7	1026.2	1017.1	**7.5**	559.0	2100	1650	RECTANGULAR	PVC	-	0.10	2976.5	**83.24%**	0.86	0.86	10.89
SWMF1c_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1379.1	1023.0	1017.0	**4.8**	258.0	1800	1200	RECTANGULAR	PVC	-	0.10	1571.2	**87.77%**	0.73	0.74	5.84
SWMF1c_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	3774.0	1026.6	1017.0	**7.8**	931.0	2440	1800	RECTANGULAR	PVC	-	0.10	4071.5	**92.69%**	0.93	0.95	16.26
SWMF1d_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1365.4	1021.3	1017.0	**3.1**	264.0	1800	1200	RECTANGULAR	PVC	-	0.10	1571.2	**86.90%**	0.73	0.74	5.98
SWMF1d_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	4713.4	1026.8	1017.0	**7.7**	1061.0	2440	2100	RECTANGULAR	PVC	-	0.10	5029.6	**93.71%**	0.98	1.01	17.43
SWMF2a_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2098.1	1026.8	1017.5	**7.9**	420.0	2100	1350	RECTANGULAR	PVC	-	0.10	2252.2	**93.16%**	0.79	0.82	8.56
SWMF2a_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	6259.2	1029.0	1017.5	**9.4**	1671.0	3050	2100	RECTANGULAR	PVC	-	0.10	6707.4	**93.32%**	1.05	1.08	25.83
SWMF2b_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1338.2	1026.6	1017.5	**7.9**	271.0	1800	1200	RECTANGULAR	PVC	-	0.10	1571.2	**85.17%**	0.73	0.73	6.20
SWMF2b_(West)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	3361.6	1026.5	1017.5	**7.4**	1090.0	2440	1650	RECTANGULAR	PVC	-	0.10	3607.4	**93.18%**	0.90	0.92	19.70
SWMF2b_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2842.4	1024.0	1017.5	**4.7**	910.0	2100	1800	RECTANGULAR	PVC	-	0.10	3352.2	**84.79%**	0.89	0.89	17.08
SWMF3a_(North-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	630.0	1020.5	1018.0	**1.6**	160.0	1350	900	RECTANGULAR	PVC	-	0.10	729.6	**86.35%**	0.60	0.60	4.41
SWMF3a_(North-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	929.8	1026.3	1018.0	**7.3**	886.0	1650	975	RECTANGULAR	PVC	-	0.10	1051.0	**88.46%**	0.65	0.66	22.24
SWMF3a_(South-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2821.3	1023.5	1018.0	**3.7**	549.0	2100	1800	RECTANGULAR	PVC	-	0.10	3352.2	**84.16%**	0.89	0.89	10.30
SWMF3a_(South-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	3469.6	1027.9	1018.0	**7.9**	1357.0	2100	1950	RECTANGULAR	PVC	-	0.10	3735.5	**92.88%**	0.91	0.94	24.08
SWMF3b_(North-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	894.3	1021.7	1018.0	**2.7**	894.0	1650	975	RECTANGULAR	PVC	-	0.10	1051.0	**85.09%**	0.65	0.65	22.77
SWMF3b_(North-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	687.7	1020.5	1018.0	**1.6**	148.0	1500	900	RECTANGULAR	PVC	-	0.10	833.0	**82.56%**	0.62	0.61	4.01
SWMF3b_(South-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2346.0	1021.6	1018.0	**2.1**	1328.0	2100	1500	RECTANGULAR	PVC	-	0.10	2609.4	**89.91%**	0.83	0.85	26.17
SWMF3b_(South-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2467.7	1022.6	1018.0	**3.3**	555.0	2440	1350	RECTANGULAR	PVC	-	0.10	2716.5	**90.84%**	0.82	0.84	10.99
SWMF4_(North-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1768.3	1026.8	1021.5	**3.9**	605.0	1950	1350	RECTANGULAR	PVC	-	0.10	2050.4	**86.24%**	0.78	0.78	12.86
SWMF4_(North-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2351.0	1030.5	1021.5	**7.5**	827.0	2100	1500	RECTANGULAR	PVC	-	0.10	2609.4	**90.10%**	0.83	0.85	16.30
SWMF4_(South-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2609.9	1028.1	1021.5	**5.1**	815.0	2440	1500	RECTANGULAR	PVC	-	0.10	3155.2	**82.72%**	0.86	0.86	15.82
SWMF4_(South-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	2742.7	1030.8	1021.5	**7.6**	825.0	2100	1650	RECTANGULAR	PVC	-	0.10	2976.5	**92.14%**	0.86	0.88	15.61
SWMF5_(North-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1549.5	1027.9	1020.5	**6.2**	573.0	1950	1200	RECTANGULAR	PVC	-	0.10	1738.0	**89.16%**	0.74	0.75	12.65
SWMF5_(North-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1675.8	1029.5	1020.5	**7.7**	685.0	1950	1350	RECTANGULAR	PVC	-	0.10	2050.4	**81.73%**	0.78	0.77	14.79
SWMF5_(South-1)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1844.2	1026.9	1020.5	**5.1**	567.0	1950	1350	RECTANGULAR	PVC	-	0.10	2050.4	**89.94%**	0.78	0.80	11.89
SWMF5_(South-2)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1968.4	1029.5	1020.5	**7.5**	722.0	1950	1500	RECTANGULAR	PVC	-	0.10	2372.6	**82.97%**	0.81	0.81	14.89
SWMF6_(North)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	6380.4	1030.4	1020.5	**7.5**	1550.0	3050	2440	RECTANGULAR	PVC	-	0.10	8253.9	**77.30%**	1.11	1.08	23.92
SWMF6_(South)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	10830.2	1027.3	1020.5	**3.8**	2217.0	3600	3050	RECTANGULAR	PVC	-	0.10	13889.3	**77.98%**	1.26	1.24	29.82
SWMF6_(West)	10.00	42.87	64.65	79.01	124.40	0.0	0.0	1475.4	1028.5	1020.5	**6.8**	302.0	1950	1200	RECTANGULAR	PVC	-	0.10	1738.0	**84.89%**	0.74	0.74	6.77

Appendix E Interim Development Condition Model Parameters and Results

E.1 Interim Condition Input Parameters

Interim Development Catchment Imperviousness

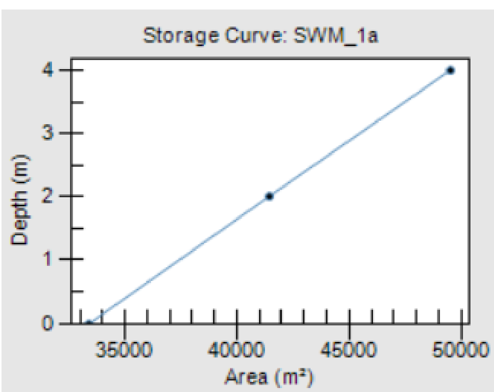
Catchment	Area (ha)	Imperviousness (%)	Routing (%)	Routing outlet	Notes
1	475	90	100	To the Shepard Ditch through the proposed trunk along RR 284.	Developed
2	643	90	100		Developed
3	441	90	100		Developed
East external upstream lands	437	5	100		Undeveloped

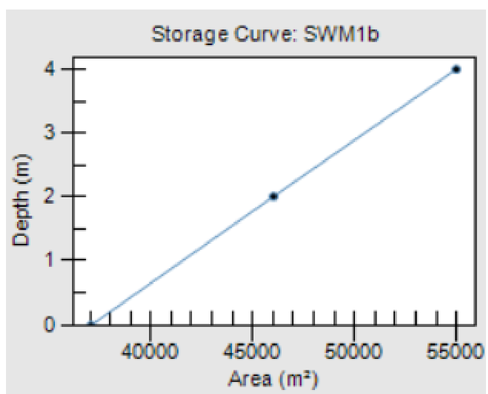
E.2 Interim Condition Results

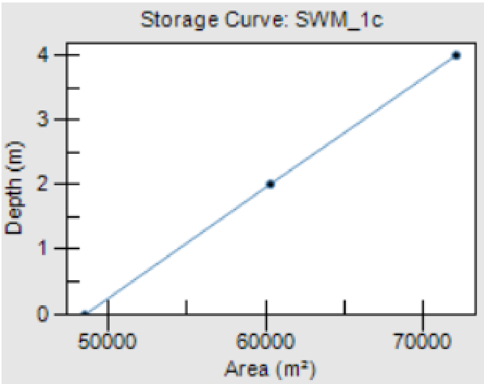
Peak Flows in Storm Sewers during the 100-yr Design Storm Event and Continuous Simulation

Name	From Node ID	To Node ID	Diameter (m)	Slope (%)	Pipe Capacity (m^3/s)	1:100-year Interim Condition		Continuous Simulation	
						Max Flow (m^3/s)	Max/Full Depth (%)	Max Flow (m^3/s)	Max/Full Depth (%)
C02	SWMF2O	J_ULT18	1.219	0.2%	1.739	0.402	35%	0.453	37%
C03	J_ULT18	J_ULT20	1.219	0.2%	1.710	0.402	32%	0.453	34%
C04	J_ULT20	J_ULT21	1.219	0.2%	1.845	0.402	30%	0.453	32%
C05	J_ULT21	J_ULT22	1.219	0.2%	1.818	0.402	64%	0.453	67%
C06	J_ULT22	J_ULT24	2.134	0.1%	4.047	2.705	54%	2.863	56%
C08	SWMF-1O	J_ULT16	0.914	0.1%	0.703	0.295	38%	0.345	41%
C09	J_ULT16	J_ULT22	1.829	0.1%	2.709	2.057	70%	2.164	73%
C12	SWMF-3O	J_ULT13	0.914	0.1%	0.597	0.258	59%	0.315	66%
C13	J_ULT12	J_ULT14	1.524	0.1%	1.682	2.503	80%	2.503	82%
C14	J_ULT14	J_ULT16	1.676	0.1%	2.125	1.784	72%	1.819	75%
C15	J_ULT13	J_ULT14	0.914	0.1%	0.543	0.258	40%	0.315	45%

Storage Curves (Interim Condition)



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Area (m²)
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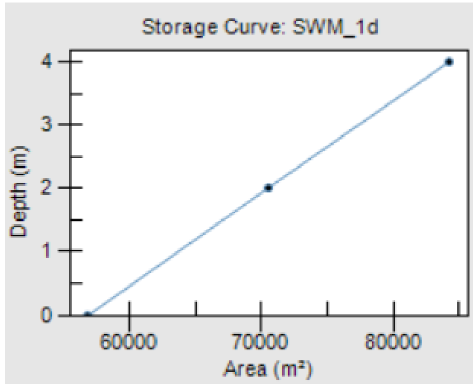
1
2
3
4
50000
60000
70000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Depth (m)
Area (m²)
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2
3
4
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70000
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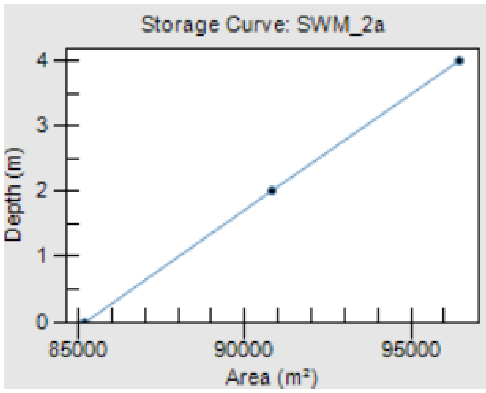
Storage Curve: SWM_2a
Depth (m)
Area (m²)
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2
3
4
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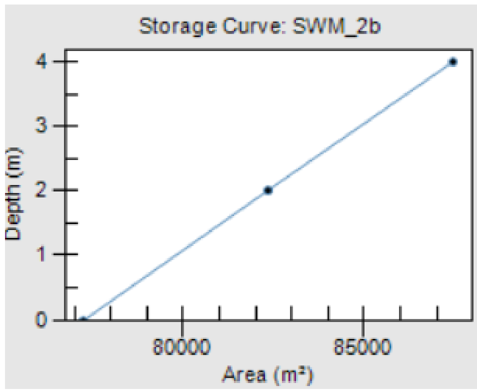
90000
95000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Area (m²)
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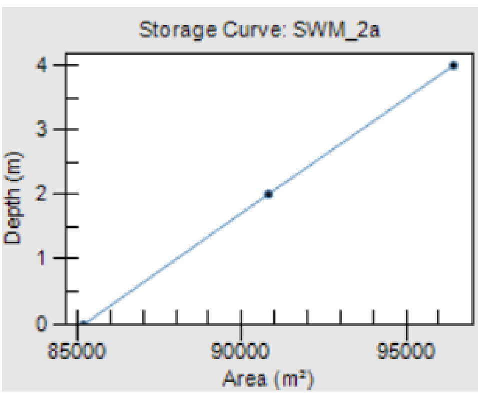
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Depth (m)
Area (m²)
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2
3
4
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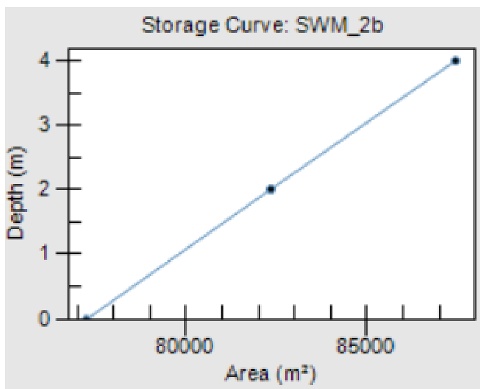
Storage Curve: SWM_2b
Depth (m)
Area (m²)
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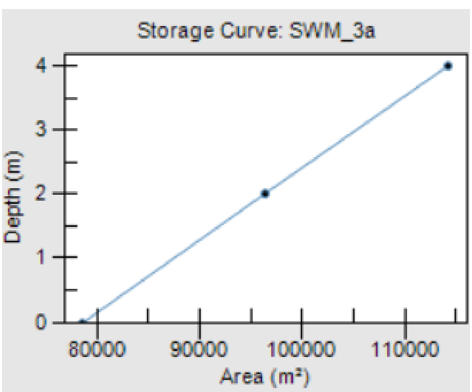
2
3
4
80000
85000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Depth (m)
Area (m²)
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2
3
4
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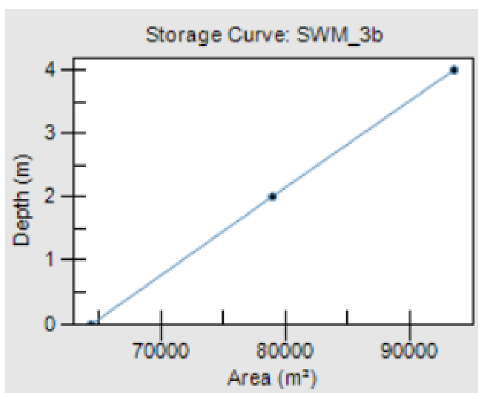
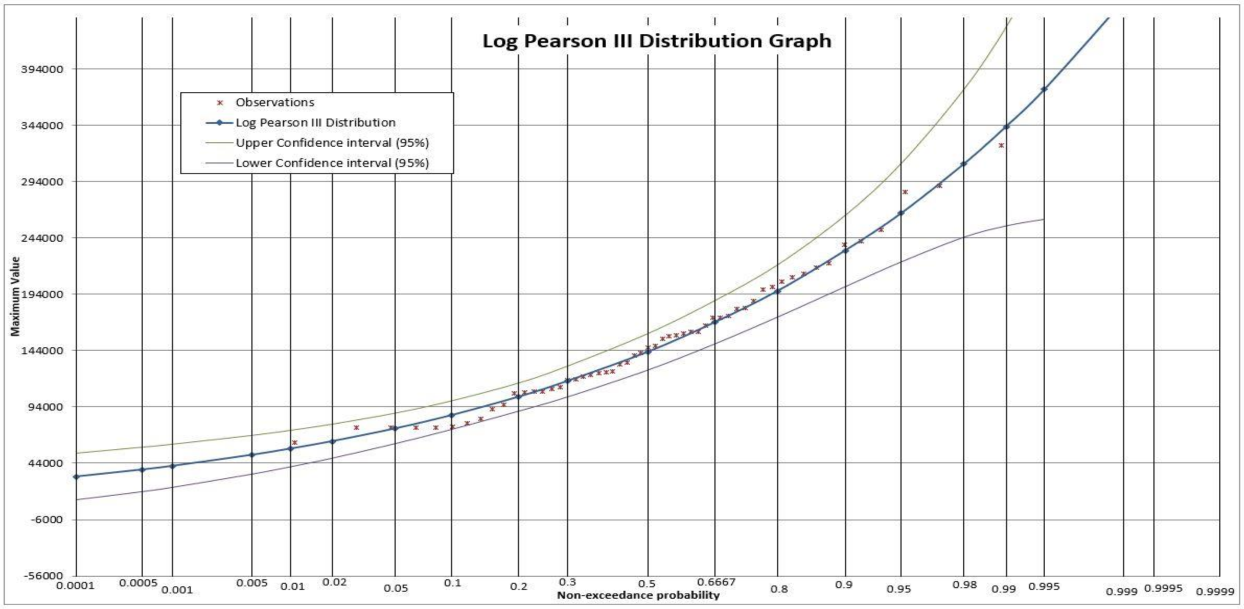
90000
100000
110000

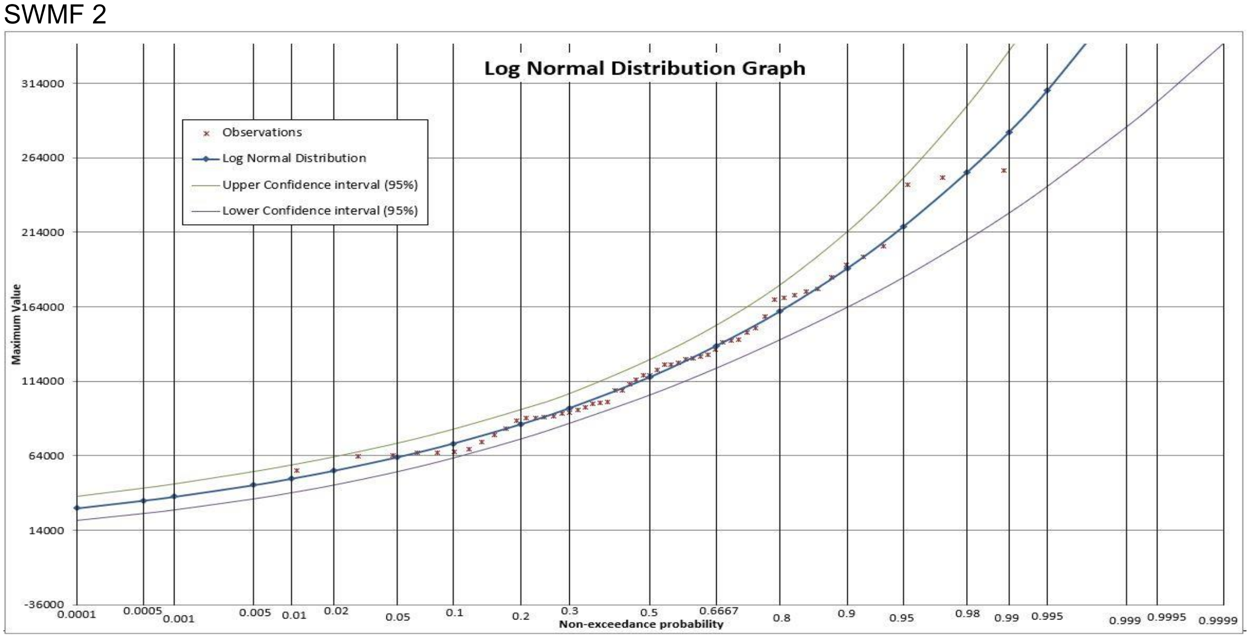

Storage Curve: SWM_3b
Depth (m)
Area (m²)
0
1
2
3
4
70000
80000
90000

Frequency Analysis Distribution Figures for Interim Condition

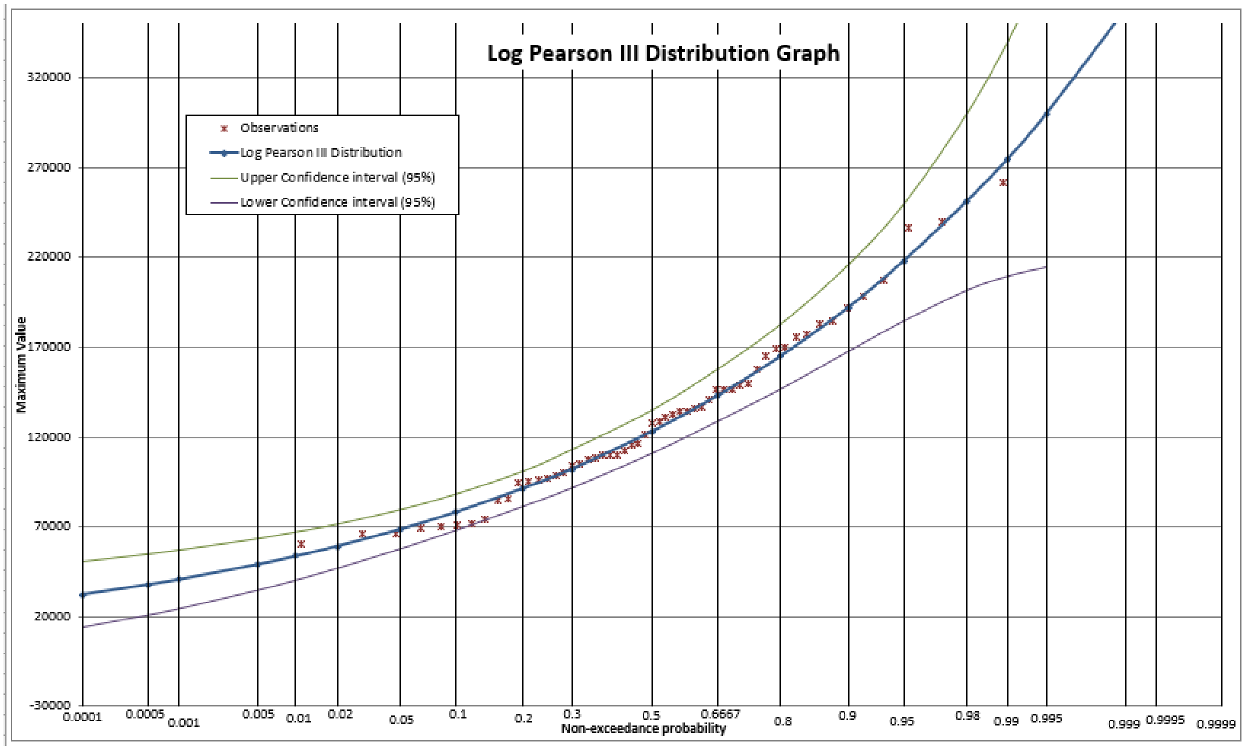
SWMF 1

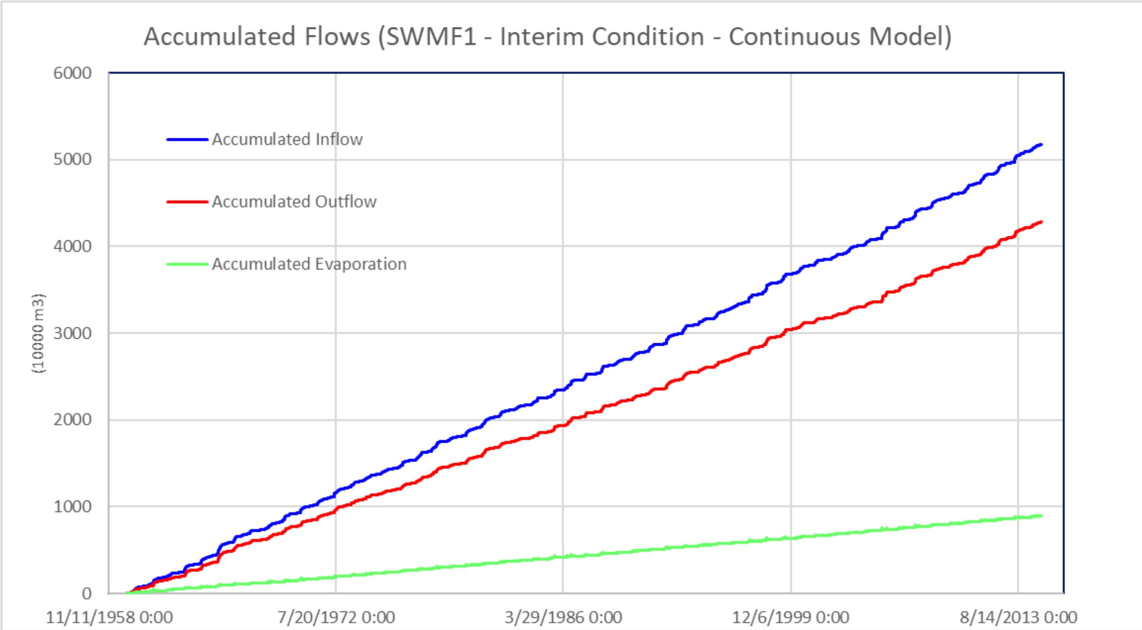


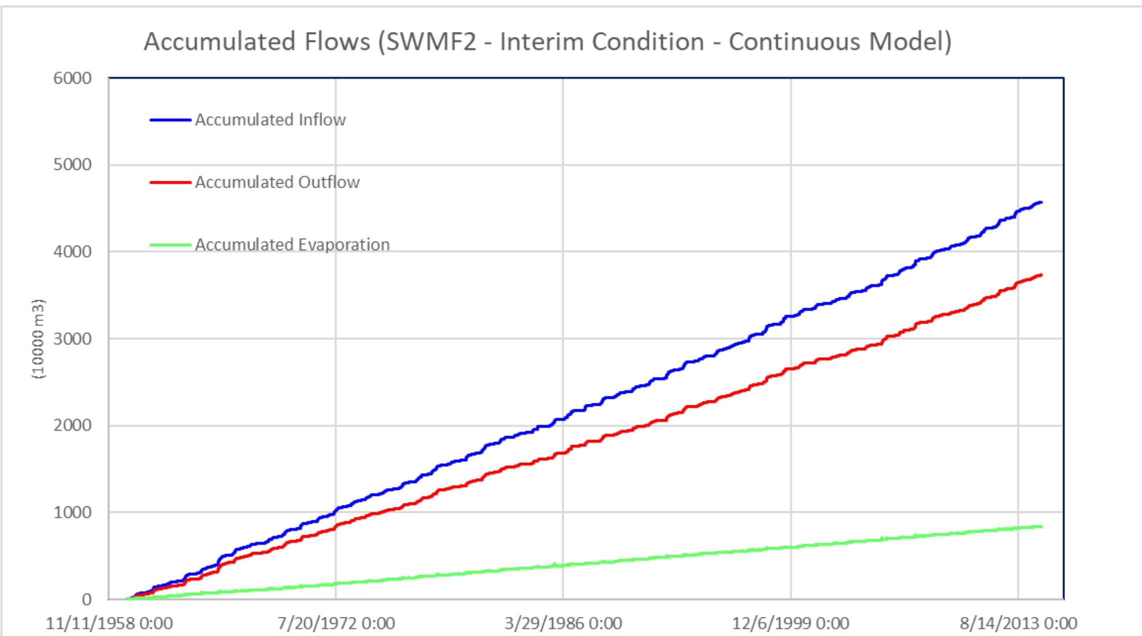
SWMF 2

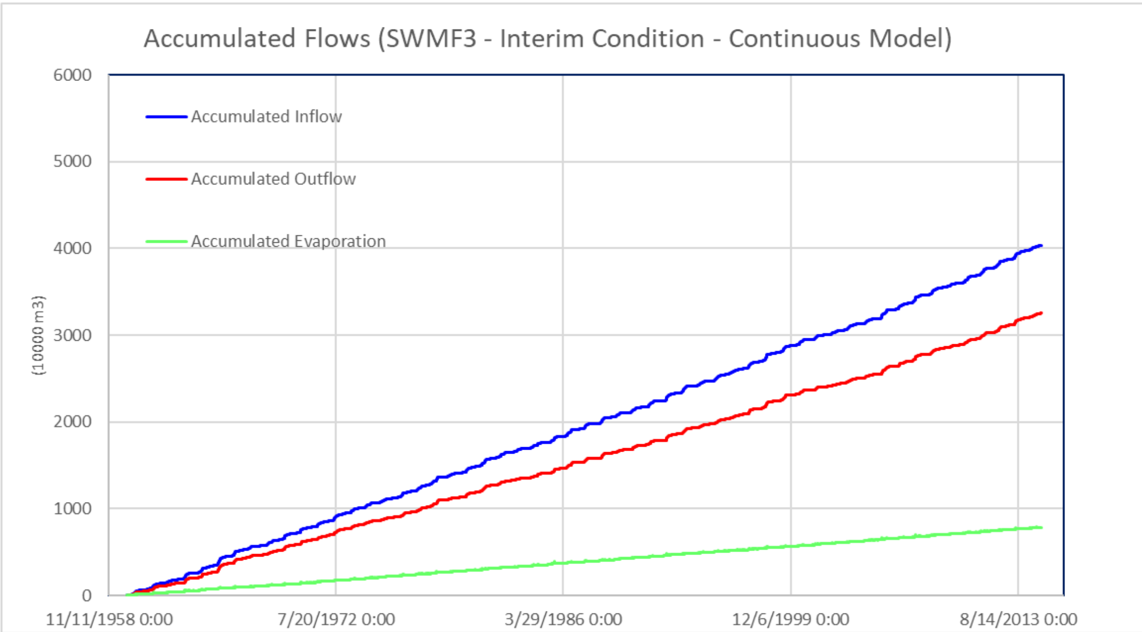


SWMF 3


Log Pearson III Distribution Graph
Observations
Log Pearson III Distribution
Upper Confidence interval (95%)
Lower Confidence interval (95%)
Maximum Value
320000
270000
220000
170000
120000
70000
20000
-30000
0.0001
0.0005
0.001
0.005
0.01
0.02
0.05
0.1
0.2
0.3
0.5
0.6667
0.8
0.9
0.95
0.98
0.99
0.995
0.999
0.9995
0.9999
Non-exceedance probability


Accumulated Flows (SWMF1 - Interim Condition - Continuous Model)
6000
5000
4000
3000
2000
1000
0
(10000 m3)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF2 - Interim Condition - Continuous Model)
6000
5000
4000
3000
2000
1000
0
(10000 m3)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF3 - Interim Condition - Continuous Model)
6000
5000
4000
3000
2000
1000
0
(10000 m3)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00

Appendix F Ultimate Development Condition Model Parameters and Results

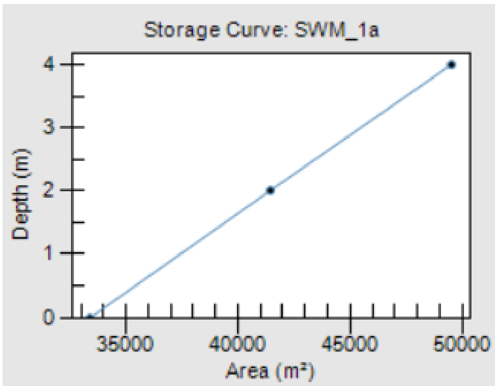
F.1 Ultimate Condition Model Parameter

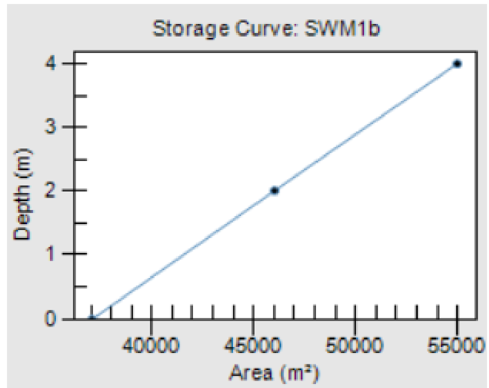
F.2 Ultimate Condition Results

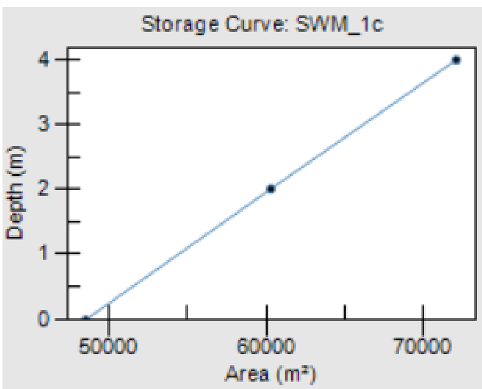
Peak Flows in Storm Sewers during the 100-yr Design Storm Event, 2050 Projection, 2080 Projection and Continuous Simulation

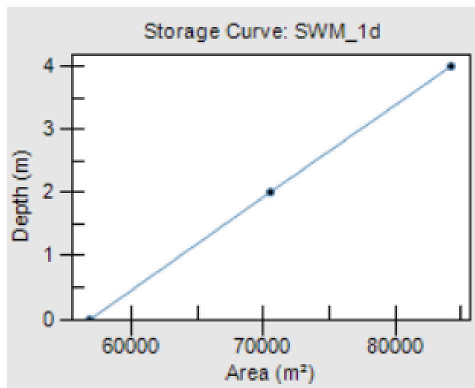
Name	From Node ID	To Node ID	Diameter (m)	Slope (%)	Pipe Capacity (m³/s)	1:100-year Ultimate Condition		1:100-year Ultimate Condition 2050 Projection		1:100-year Ultimate Condition 2080 Projection		Continuous Simulation	
						Max Flow (m³/s)	Max/Full Depth	Max Flow (m³/s)	Max/Full Depth (%)	Max Flow (m³/s)	Max/Full Depth (%)	Max Flow (m³/s)	Max/Full Depth (%)
C01	SWMF6O	SWMF2a	0.61	0.05%	0.143	0.147	70%	0.159	71%	0.171	72%	0.170	72%
C02	SWMF2O	J_ULT18	1.219	0.10%	1.298	0.434	43%	0.498	46%	0.557	49%	0.520	48%
C03	J_ULT18	J_ULT20	1.219	0.12%	1.385	0.434	38%	0.498	41%	0.557	43%	0.520	42%
C04	J_ULT20	J_ULT21	1.219	0.21%	1.854	0.434	31%	0.498	33%	0.557	35%	0.520	34%
C05	J_ULT21	J_ULT22	1.219	0.20%	1.818	0.434	65%	0.498	68%	0.557	69%	0.520	68%
C06	J_ULT22	J_ULT24	2.134	0.05%	4.047	2.753	55%	2.897	56%	3.029	57%	2.979	57%
C07	SWMF5O	SWMF1a	0.61	0.47%	0.440	0.084	30%	0.094	31%	0.135	38%	0.099	32%
C08	SWMF-1O	J_ULT16	0.914	0.10%	0.597	0.305	39%	0.345	42%	0.381	44%	0.368	43%
C09	J_ULT16	J_ULT22	1.829	0.05%	2.709	2.073	70%	2.154	73%	2.227	75%	2.212	75%
C11	SWMF4O	SWMF3a	0.447	0.40%	0.177	0.119	58%	0.133	62%	0.177	78%	0.141	64%
C12	SWMF-3O	J_ULT13	0.914	0.10%	0.597	0.264	58%	0.305	62%	0.342	66%	0.341	66%
C13	J_ULT12	J_ULT14	1.524	0.05%	1.682	2.503	80%	2.503	82%	2.503	84%	1.504	84%
C14	J_ULT14	J_ULT16	1.676	0.05%	2.125	1.784	73%	1.809	75%	1.846	77%	1.845	77%
C15	J_ULT13	J_ULT14	0.914	0.10%	0.584	0.264	39%	0.305	42%	0.342	45%	0.341	45%

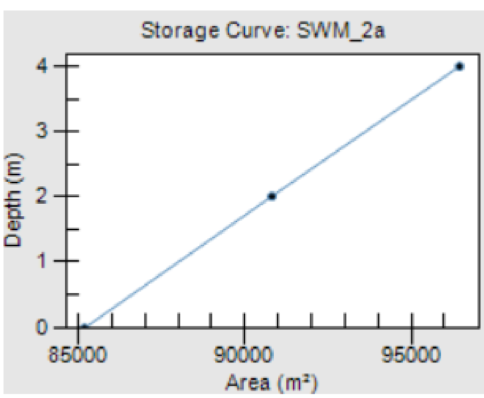
Storage Curves (Ultimate Condition)

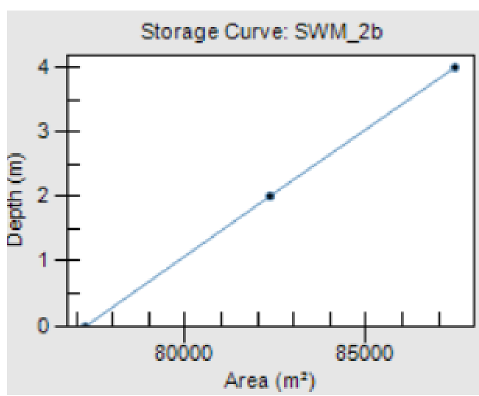


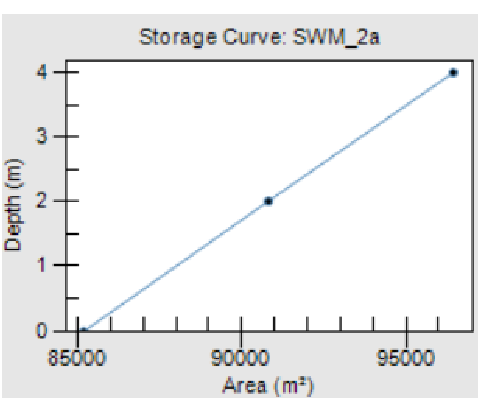


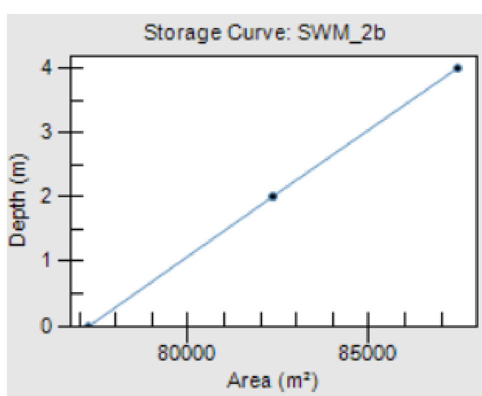


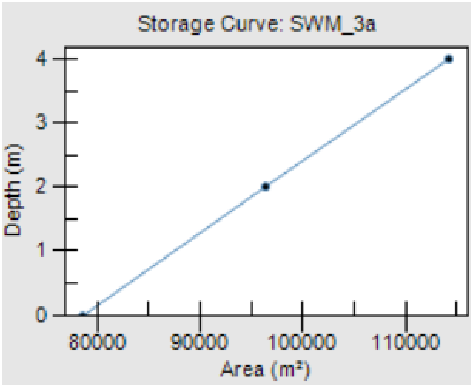


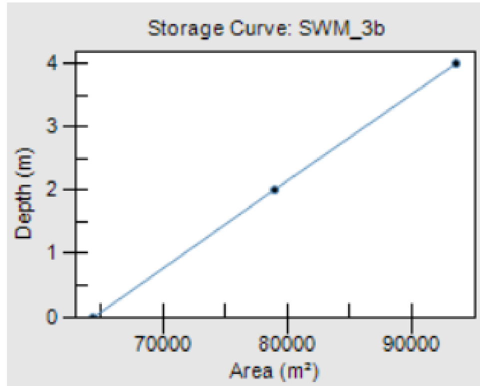


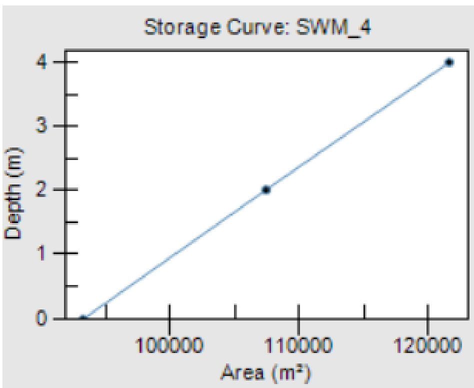


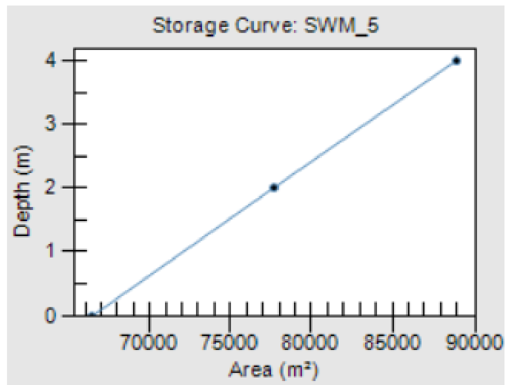


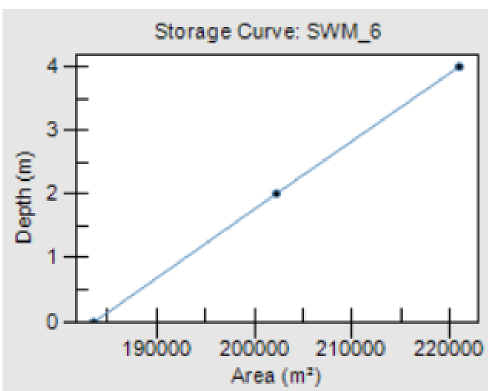



Storage Curve: SWM_3a
Depth (m)
0
1
2
3
4
80000
90000
100000
110000
Area (m²)


Storage Curve: SWM_3b
Depth (m)
0
1
2
3
4
70000
80000
90000
Area (m²)

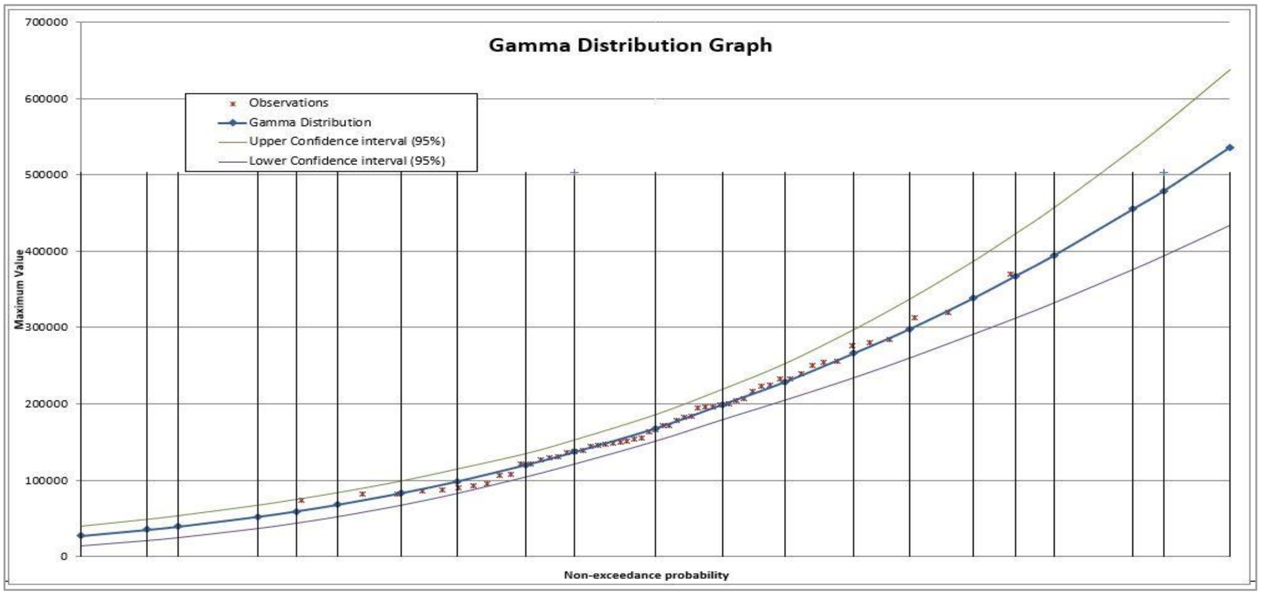

Storage Curve: SWM_4
Depth (m)
0
1
2
3
4
100000
110000
120000
Area (m²)


Storage Curve: SWM_5
Depth (m)
0
1
2
3
4
70000
75000
80000
85000
90000
Area (m²)

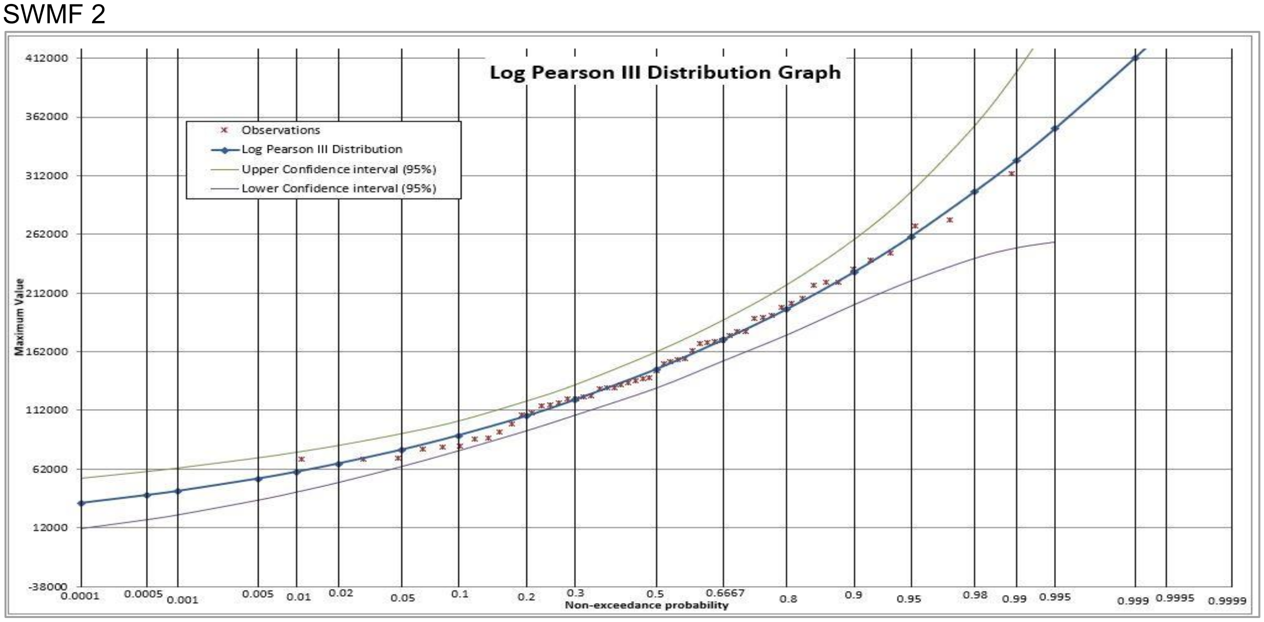

Storage Curve: SWM_6
Depth (m)
0
1
2
3
4
190000
200000
210000
220000
Area (m²)

Frequency Analysis Distribution Figures for Ultimate Condition

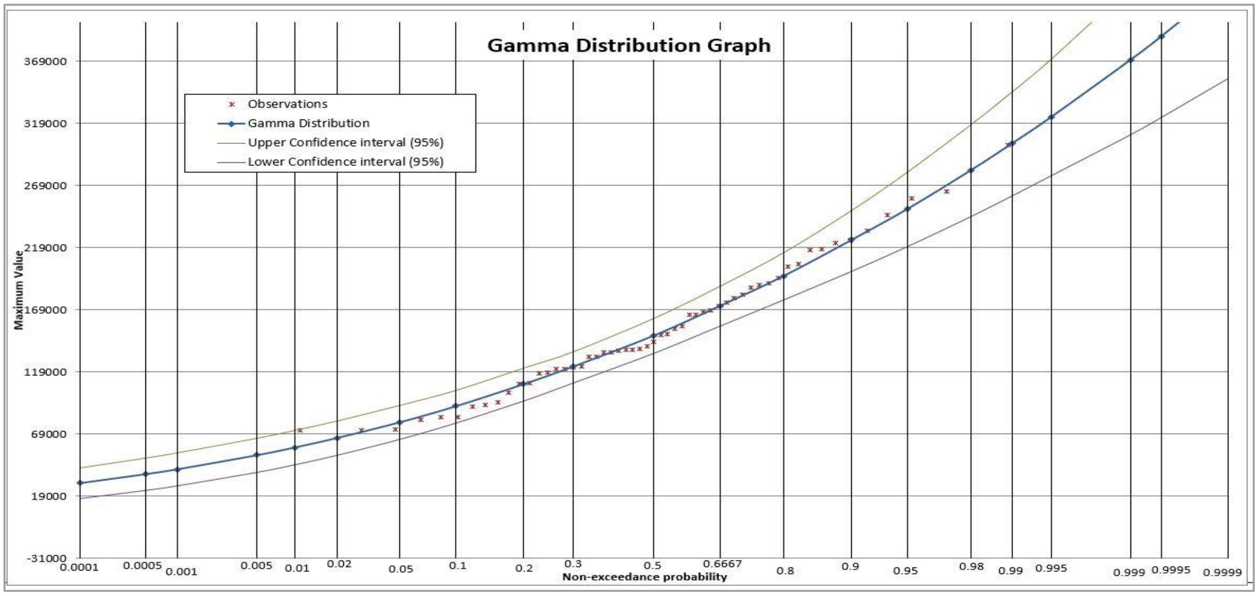
SWMF 1



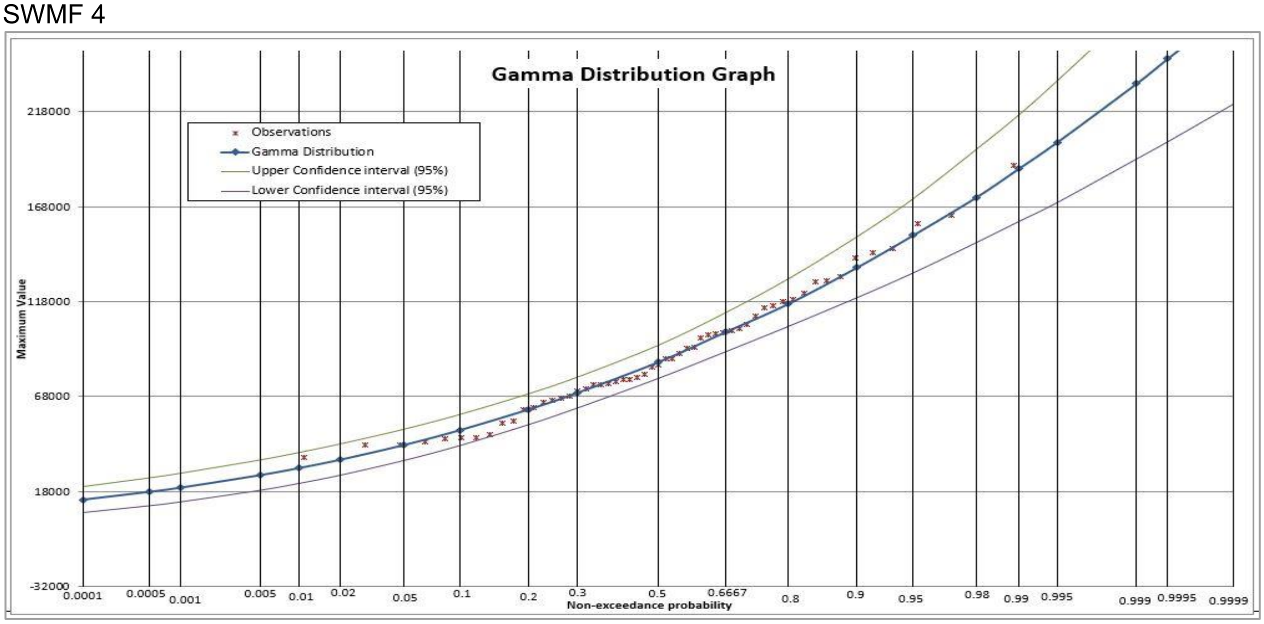
SWMF 2



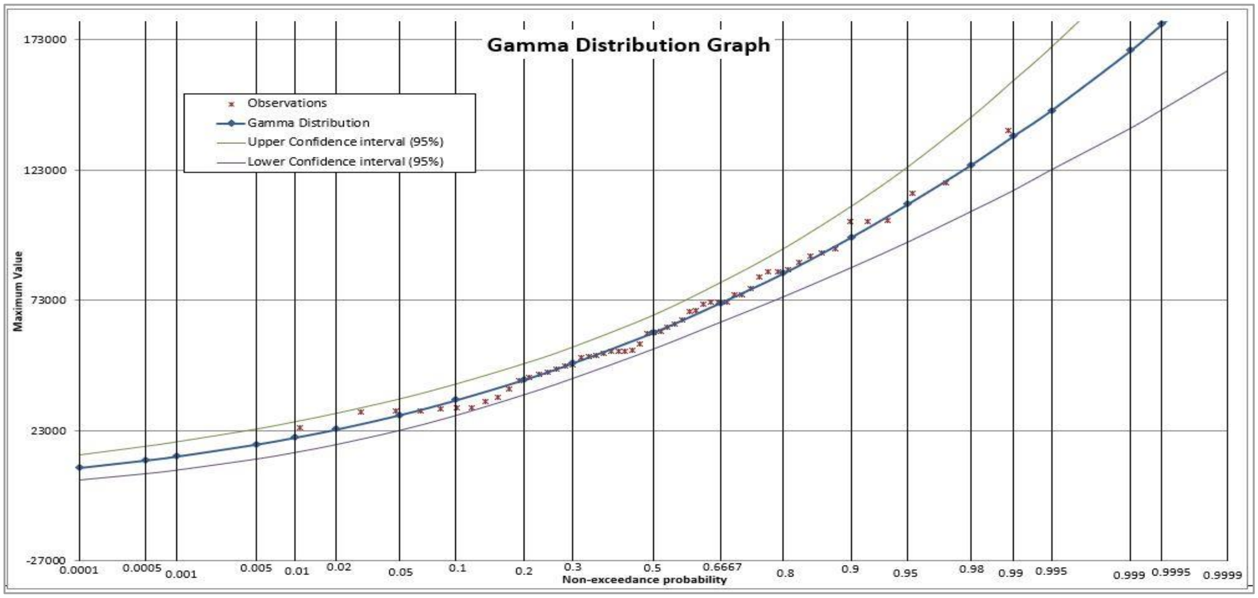
SWMF 3


Gamma Distribution Graph
Observations
Gamma Distribution
Upper Confidence interval (95%)
Lower Confidence interval (95%)
Maximum Value
369000
319000
269000
219000
169000
119000
69000
19000
-31000
0.0001
0.0005
0.001
0.005
0.01
0.02
0.05
0.1
0.2
0.3
0.5
0.6667
0.8
0.9
0.95
0.98
0.99
0.995
0.999
0.9995
0.9999
Non-exceedance probability

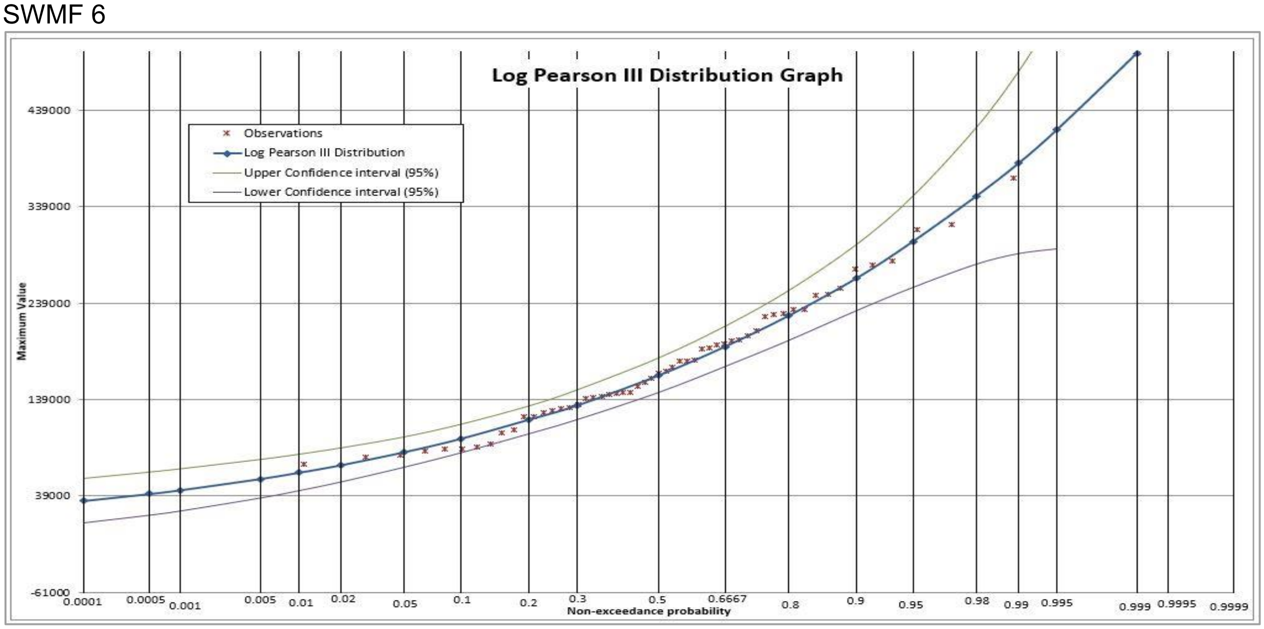
SWMF 4

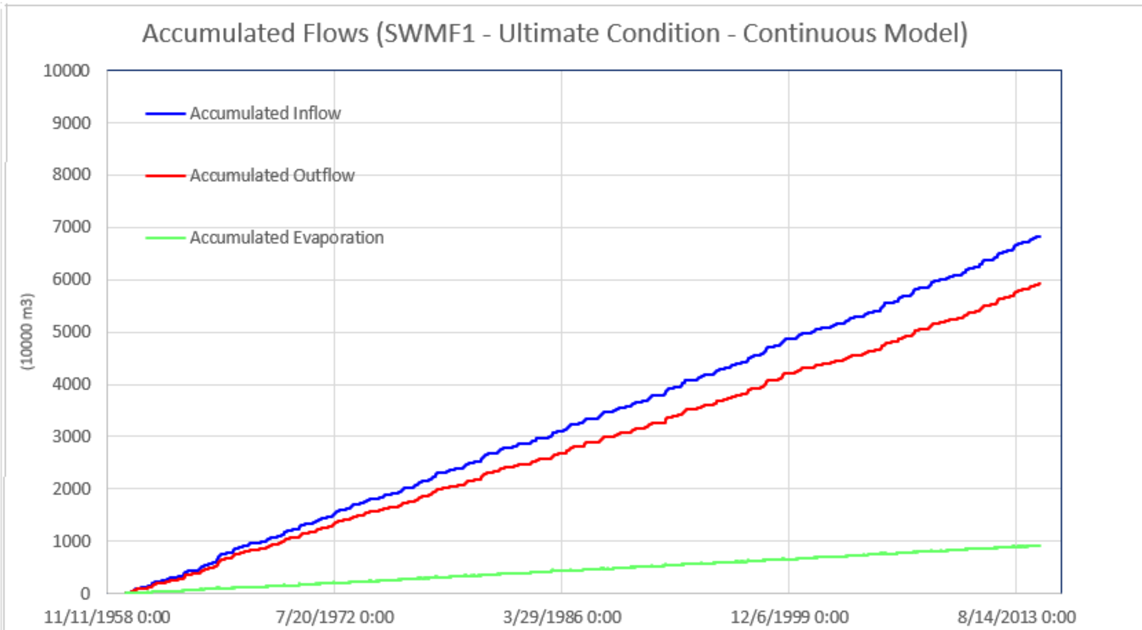

Gamma Distribution Graph
Observations
Gamma Distribution
Upper Confidence interval (95%)
Lower Confidence interval (95%)
Maximum Value
218000
168000
118000
68000
18000
-32000
0.0001
0.0005
0.001
0.005
0.01
0.02
0.05
0.1
0.2
0.3
0.5
0.6667
0.8
0.9
0.95
0.98
0.99
0.995
0.999
0.9995
0.9999
Non-exceedance probability

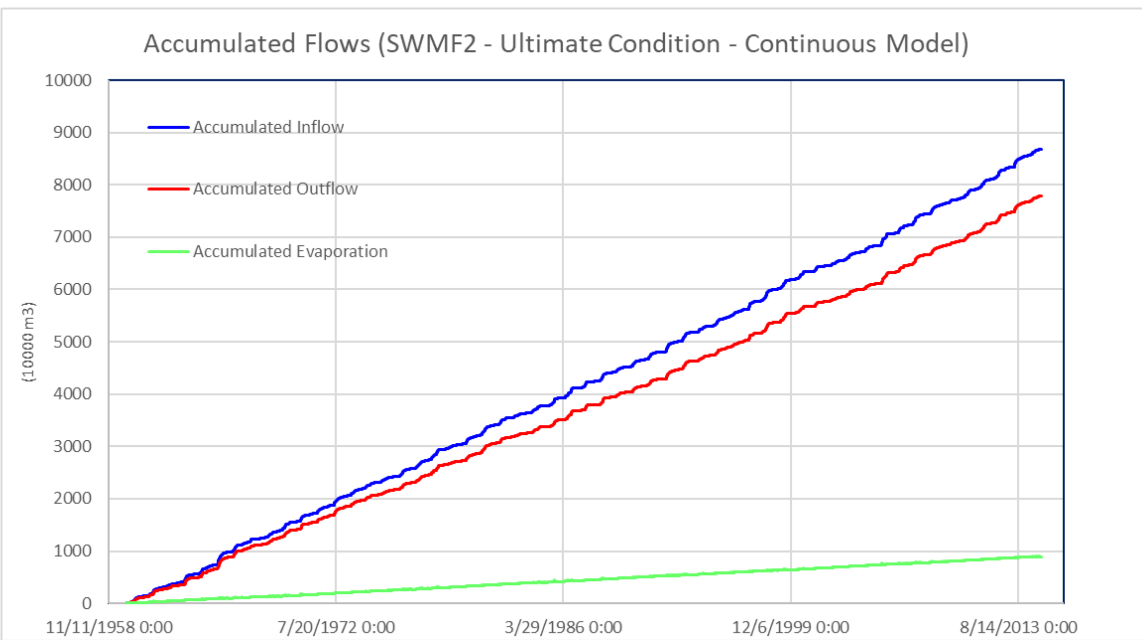
SWMF 5

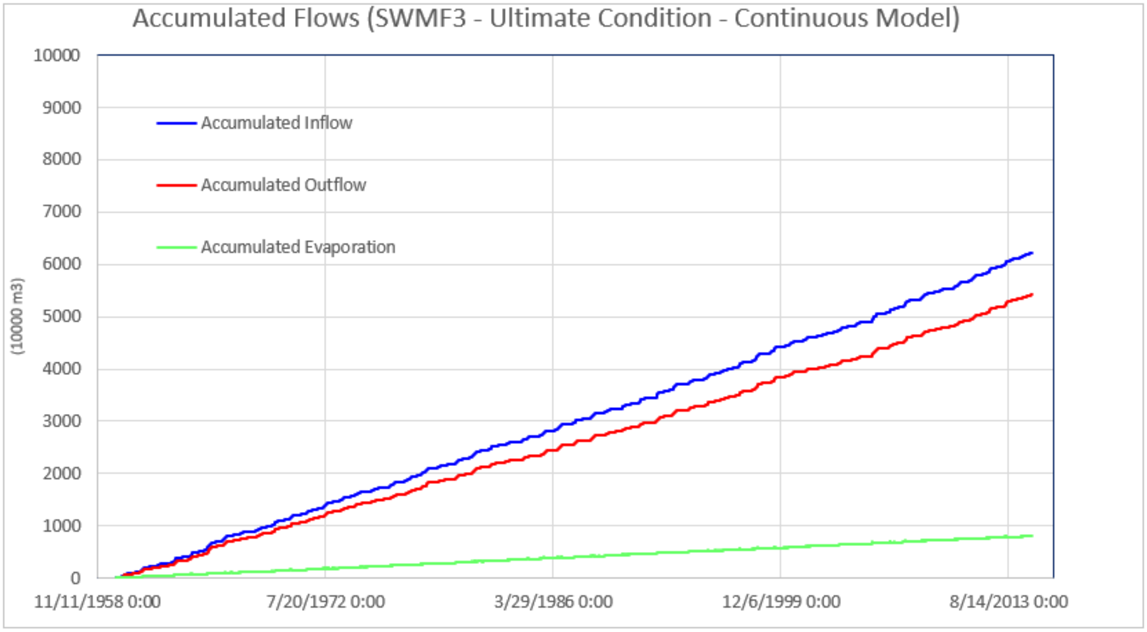

Gamma Distribution Graph
Observations
Gamma Distribution
Upper Confidence interval (95%)
Lower Confidence interval (95%)
Maximum Value
173000
123000
73000
23000
-27000
0.0001
0.0005
0.001
0.005
0.01
0.02
0.05
0.1
0.2
0.3
0.5
0.6667
0.8
0.9
0.95
0.98
0.99
0.995
0.999
0.9995
0.9999
Non-exceedance probability

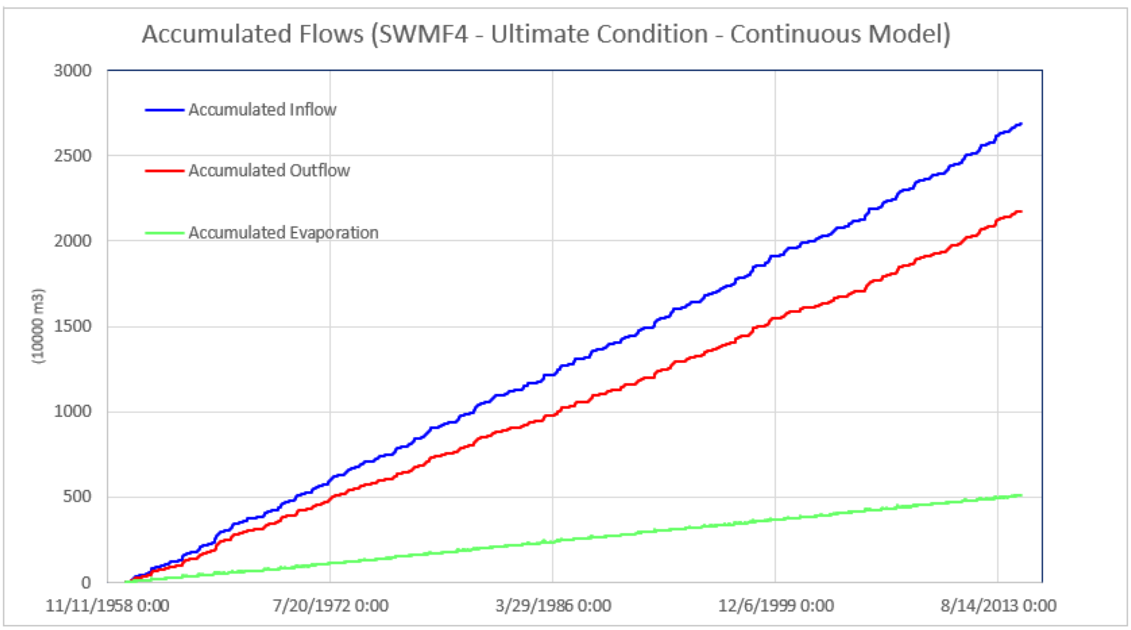
SWMF 6

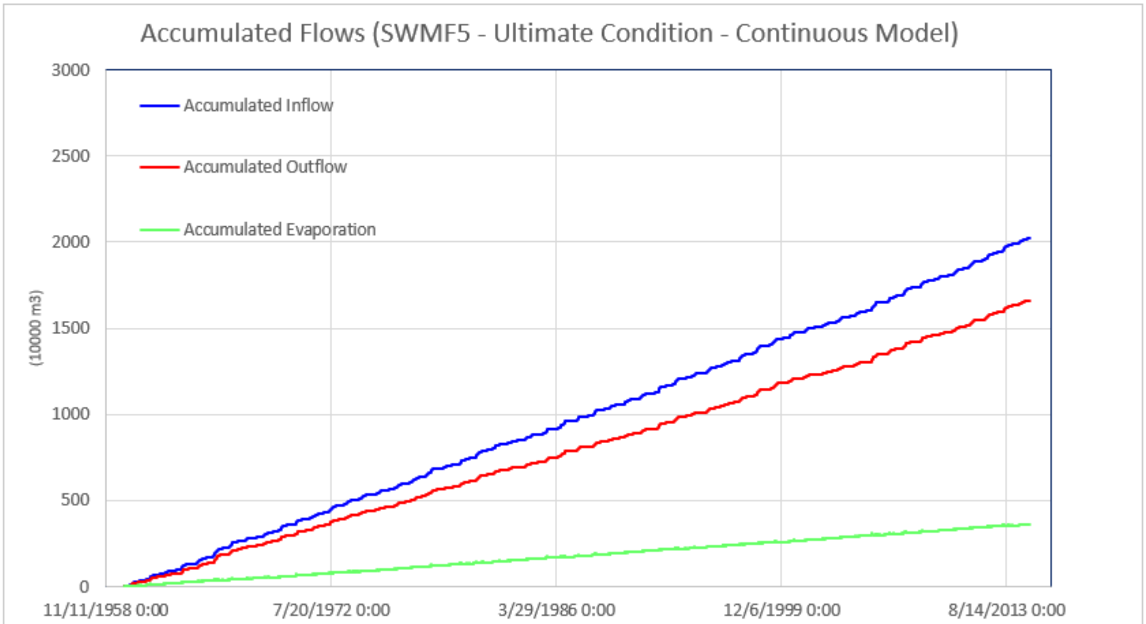

Log Pearson III Distribution Graph
Observations
Log Pearson III Distribution
Upper Confidence interval (95%)
Lower Confidence interval (95%)
Maximum Value
439000
339000
239000
139000
39000
-61000
0.0001
0.0005
0.001
0.005
0.01
0.02
0.05
0.1
0.2
0.3
0.5
0.6667
0.8
0.9
0.95
0.98
0.99
0.995
0.999
0.9995
0.9999
Non-exceedance probability

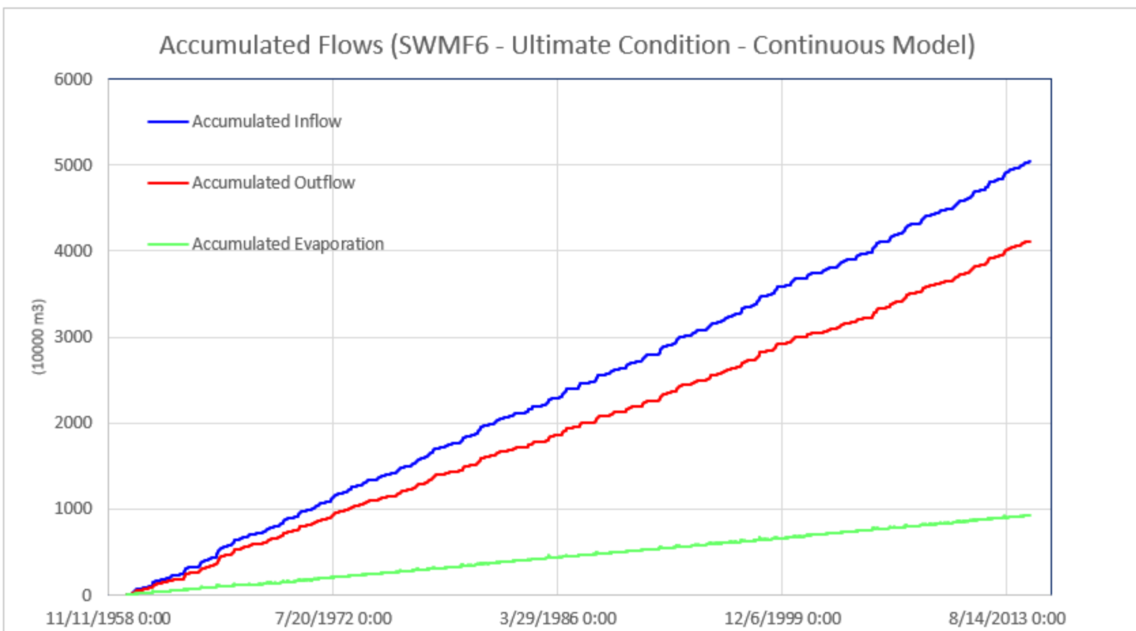

Accumulated Flows (SWMF1 - Ultimate Condition - Continuous Model)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
(10000 m3)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF2 - Ultimate Condition - Continuous Model)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
(10000 m3)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF3 - Ultimate Condition - Continuous Model)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
(10000 m3)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF4 - Ultimate Condition - Continuous Model)
3000
2500
2000
1500
1000
500
0
(10000 m3)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF5 - Ultimate Condition - Continuous Model)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
(10000 m3)
3000
2500
2000
1500
1000
500
0
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00


Accumulated Flows (SWMF6 - Ultimate Condition - Continuous Model)
Accumulated Inflow
Accumulated Outflow
Accumulated Evaporation
(10000 m3)
6000
5000
4000
3000
2000
1000
0
11/11/1958 0:00
7/20/1972 0:00
3/29/1986 0:00
12/6/1999 0:00
8/14/2013 0:00