MAGNA
ENGINEERING SERVICES INC.

NATURE-BASED STORMWATER FEASIBILITY STUDY

TOWN OF BON ACCORD

PREPARED ON:	**VERSION:**	**PREPARED FOR:**
17 May 2024	1	Town of Bon Accord

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1.0 INTRODUCTION

MAGNA Engineering Services Inc. (MAGNA) has been engaged by the Town of Bon Accord (the Town) to conduct a feasibility study and high-level concept design of a stormwater management facility (SWMF) to retrofit an existing stormwater wetland facility called “Natural Area 2” in the southeast portion of the Town.

The innovative solutions being examined are intended to support the City’s sustainability vision and values, outlined in the *Town of Bon Accord Municipal Development Plan* (2024).

The main objectives of this feasibility study are:

- To identify and analyze a spectrum of feasible SWMF options, such as nature-based storm parks, to replace or supplement the stormwater capacity of the existing Natural Area 2 in the southeast portion of the town.
- To assess and compare the SWMF options based on upfront capital costs, long-term operations, maintenance, and lifecycle needs, as well as the Town’s values, environmental benefits, and aesthetic appeal.
- Investigate stormwater quality improvement for water reuse opportunities for treated stormwater as a resource within the community to provide drought resilience.

The first objective will be met by developing conceptual SWMF designs that align with the *City of Edmonton Stormwater Management and Design Manual* (2022), the *Town of Bon Accord Stormwater Master Plan* (AE, 2019), and industry best practices. The second objective will be met by comparing each conceptual design on the basis of the values assessment completed during the background report phase. Some of the Town’s key values relevant to this study include:

- Developing a stormwater management solution that optimizes land use within the existing Natural Area 2 wetland and adjacent areas.
- Reducing flooding within the Town during storm and snow melt events by providing sufficient storage.
- Ensuring downstream stormwater discharge quality meets or exceeds Provincial requirements and meets the requirements of an integrated wetland facility.
- Economically viable in terms of its capital costs, operations, and maintenance (O&M) requirements.
- Can be phased in its construction to support various grant funding opportunities over a longer period of time.
- Provides environmental value for the site and enhances the public’s perception and aesthetic value of the site.
- Provides opportunities for stormwater reuse.

The Town’s values and priorities are integral to the feasibility study process.

Ultimately, the intention of this feasibility study is to provide the Town with solutions that help restore Natural Area 2 back as a natural amenity and increase its stormwater storage and treatment capacity.

2.0 PROJECT BACKGROUND

Nestled in central Alberta outside of Edmonton, St. Albert, and Fort Saskatchewan on Highway 28, the Town of Bon Accord is a rural community of approximately 1,500 residents in the heart of Sturgeon County (**Figure 2.1**).

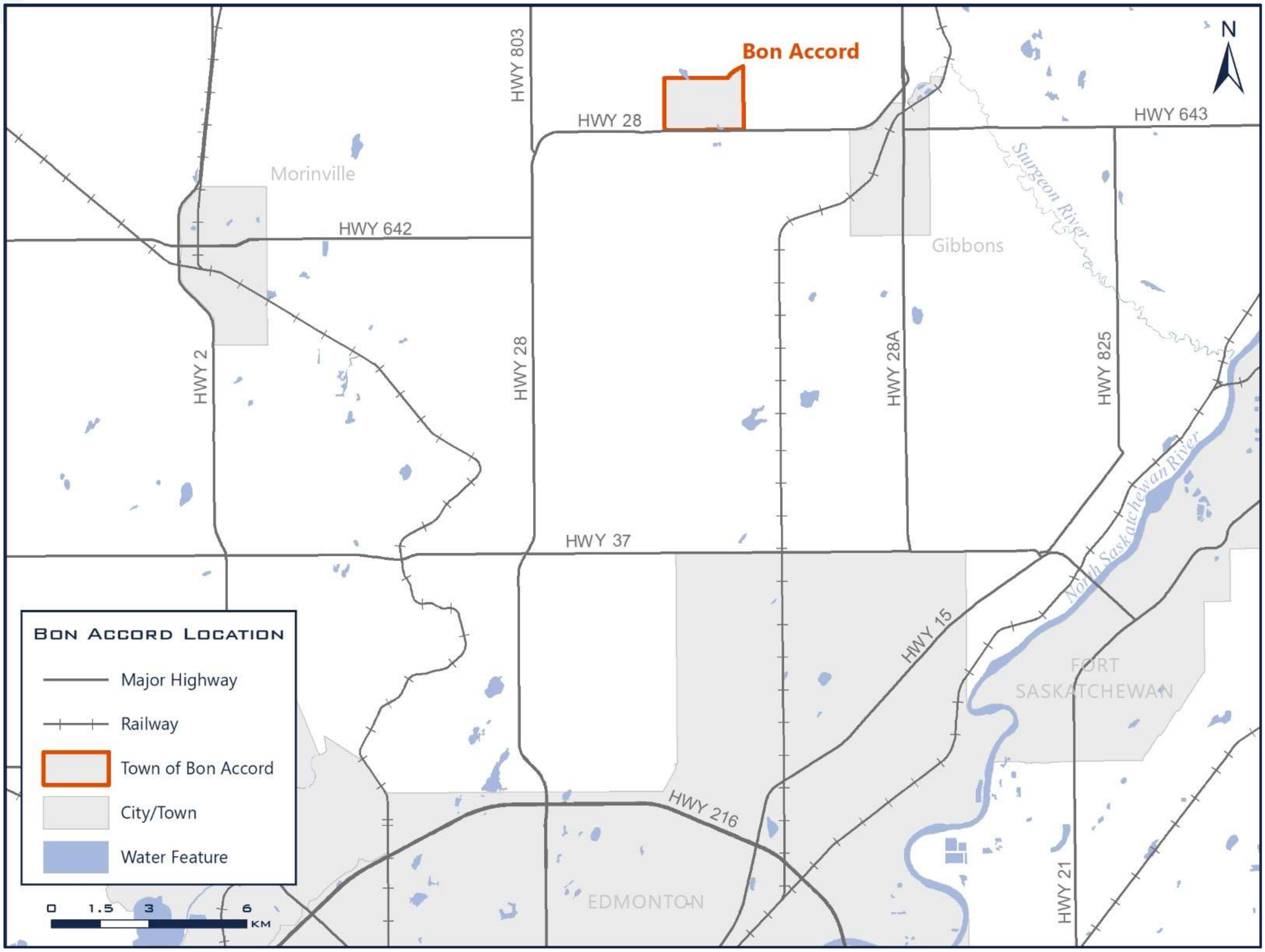

Figure 2.1: Bon Accord Location

> ***"[The Town of Bon Accord is] a prosperous, residential, and industrial community with vibrant spaces for recreation, celebration, and maintaining a hometown feeling."***
>
> ***(Town of Bon Accord Municipal Development Plan, 2024)***

Ensuring that *"culture, heritage, unique small-town character, and warm-heartedness is not only preserved amidst future development and re-development, but strengthened as well"* is particularly important to the Town (*Bon Accord Gateway Plan 2012*). Therefore, this study is significant because the potential economic, social, environmental, and recreational benefits of a nature-based stormwater solution such as a storm park will not only help preserve and strengthen Bon Accord's character and uniqueness but will also address two major strategic priorities outlined in the *July 4 2023 Town of Bon Accord Regular Council Meeting Agenda* around infrastructure and identity:

- *"The Town of Bon Accord is maintaining and improving all infrastructure in a fiscally responsible manner"* (Priority 3: Infrastructure).
- *"Bon Accord has a strong, positive identity as an environmentally progressive, family-oriented, welcoming community"* (Priority 4: Identity).

Improving the Town's stormwater management system will not only reduce risk of flooding and backups but will also ensure that the Town is prepared to discharge treated stormwater that meets all current provincial and regulatory requirements into the surrounding watershed. Beyond the primary objectives listed above, this feasibility study aims to provide a stormwater management strategy that offers sustainability, community integration, improved water quality, and effective control and discharge into downstream water bodies.

2.1 Existing System

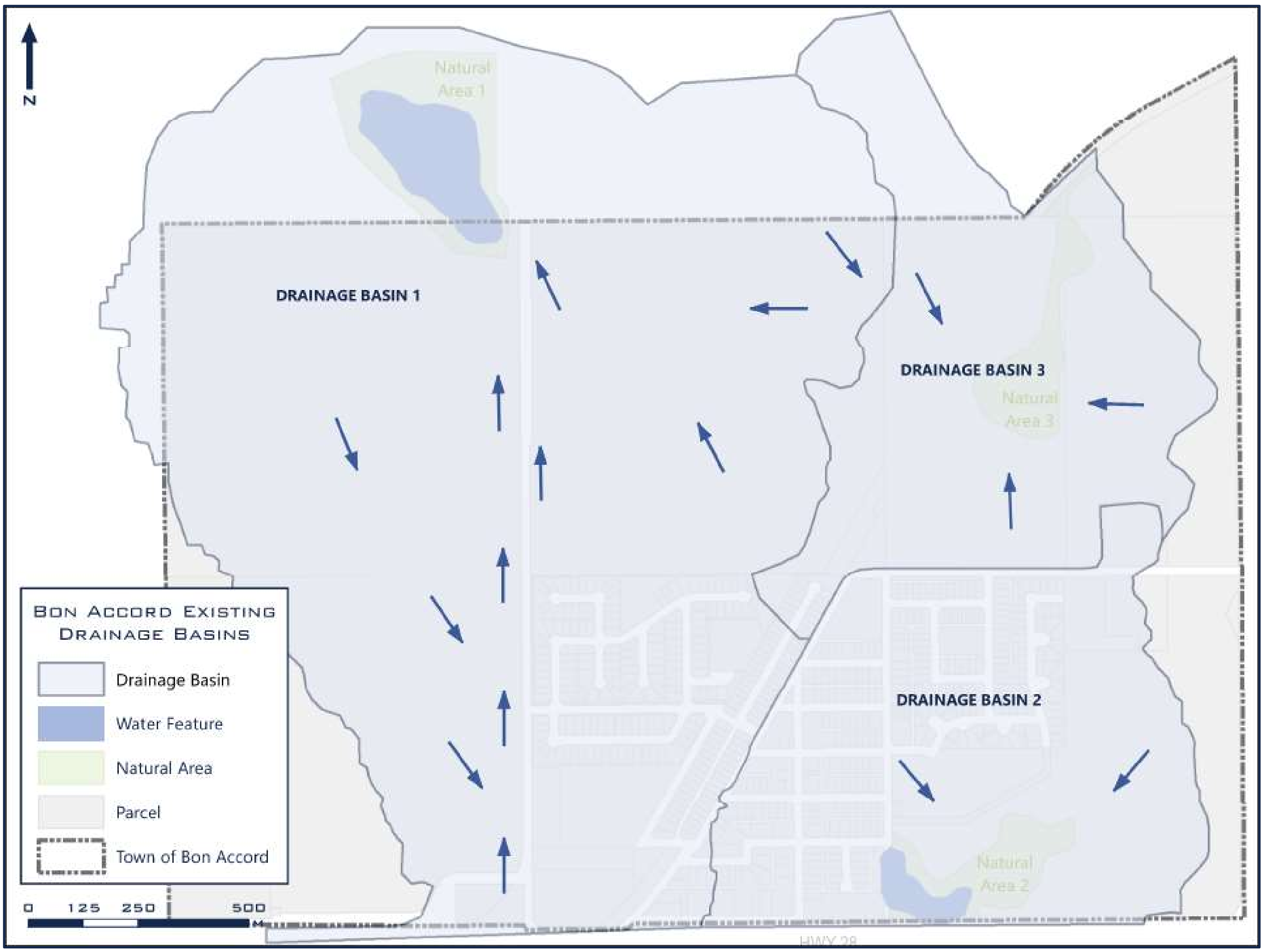

Figure 2.2: Town of Bon Accord Drainage Basins
Data Source: Associated Engineering (2019)

The Town currently operates and maintains a stormwater system consisting of underground storm sewers, manholes, ditches, and culverts, that discharge stormwater runoff to three 'Natural Areas', which function as the Town's SWMFs.

Runoff from most of the existing developed areas currently drains to 'Natural Area 2', located in the southeast portion of the Town.

In recent years, the Town has identified issues such as large sediment deposition, decreased stormwater capacity, and declining vegetation health within Natural Area 2, as well as flooding in the adjacent areas during storm and snowmelt events. The Town's *Wetland Storage Study (*AE 2021) noted that adjacent properties become flooded due to increased water levels in the natural area during storms and reported that the increased water level can also surcharge storm sewers, reducing their capacity to convey water away from homes. The *Town of Bon Accord Stormwater Master Plan* (AE 2019) also reported a potential stormwater ponding/flooding zone around Natural Area 2 (**Figure 2.3**) and suggested expanding the existing Natural Area 2 to accommodate existing and future stormwater flows to mitigate the observed flooding.

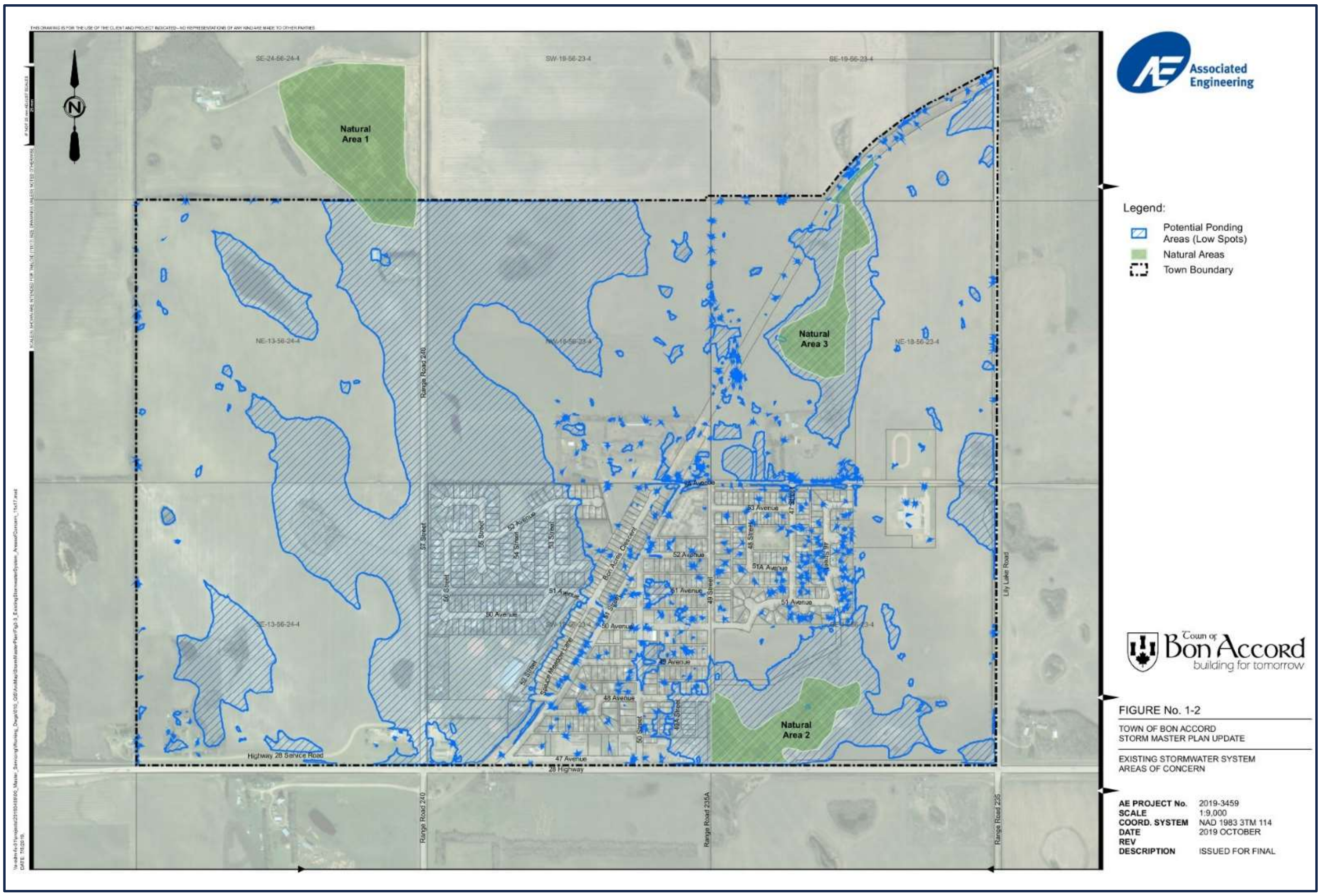

Figure 2.3: Existing Stormwater System Areas of Concern

Source: Town of Bon Accord Stormwater Master Plan, Associated Engineering (2019)

Therefore, the intent of this *Nature-Based Stormwater Feasibility Study* is to examine naturalized SWMF options to retrofit Natural Area 2 and address the Town's current and future stormwater needs for storage and water quality improvements. Specific objectives have been described in **Section 1**.

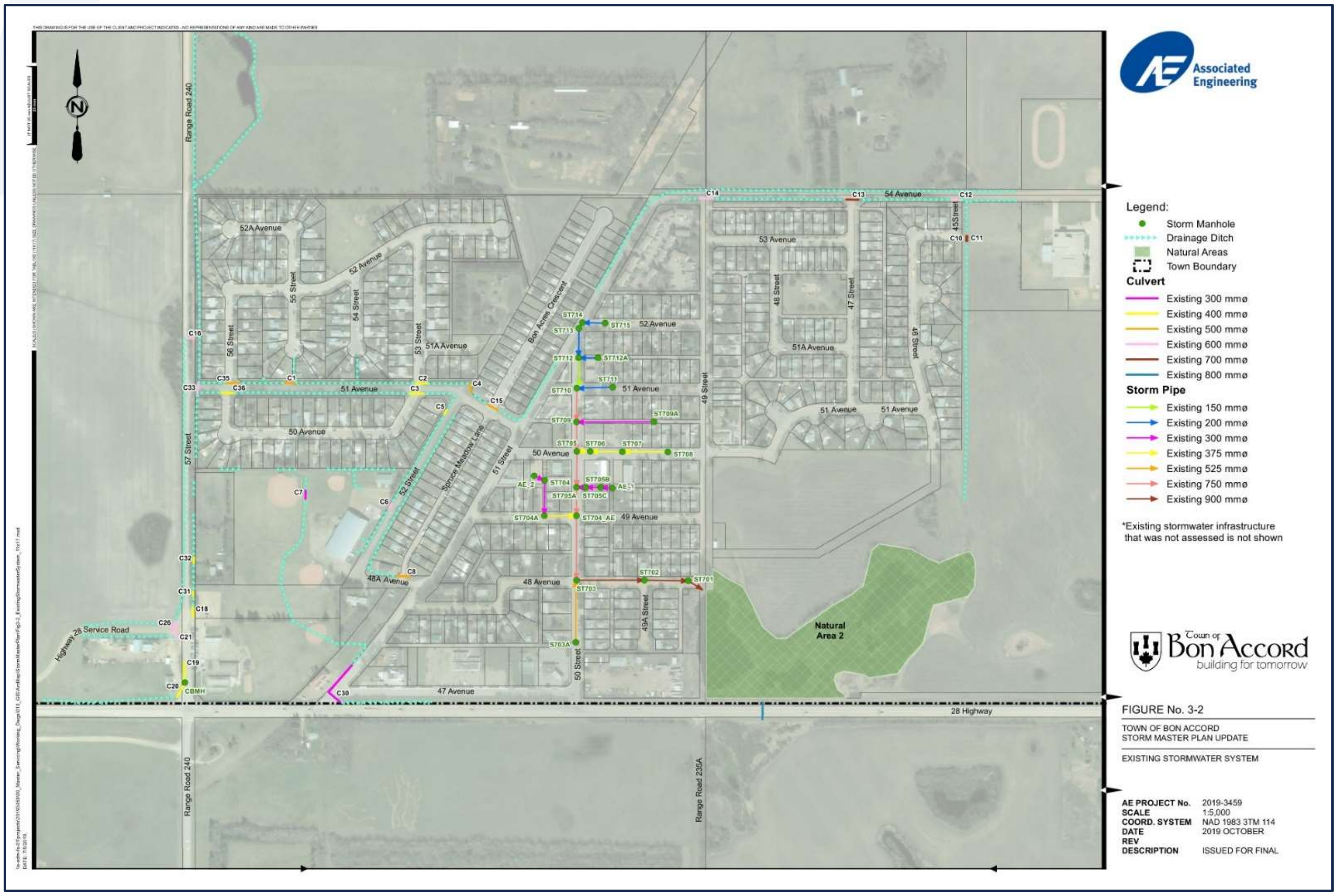

Figure 2.4: Existing Stormwater System

Source: Town of Bon Accord Stormwater Master Plan, Associated Engineering (2019)

2.2 Scope

This feasibility study is focused on providing potential solutions to retrofit and improve the stormwater capacity of Natural Area 2. The *Town of Bon Accord Stormwater Master Plan* (AE, 2019) also noted that the existing minor and major conveyance systems do not have sufficient capacities. The report proposed a number of upgrades that are not included as part of this assessment. **Figure 2.4** (above) shows the existing minor and major storm conveyance elements. The catchments and capacities of Natural Areas 1 and 3 are not within the scope of this report.

2.3 Reference Documents

Several background documents were reviewed to understand the Town's existing stormwater infrastructure and future needs. The reviewed documents include:

- *Town of Bon Accord Municipal Development Plan Bylaw 2023-10* (Town of Bon Accord, 2024)
- *Town of Bon Accord Stormwater Facility Feasibility Study Background Report* (MAGNA Engineering, 2023)
- *Town of Bon Accord GIS Shapefiles* (Personal Communication with the Town, 2023)
- *Town of Bon Accord Wetland Storage Study* (Associated Engineering, 2021)
- *Town of Bon Accord Stormwater Master Plan* (Associated Engineering, 2019)
- *Town of Bon Accord Drainage Study* (UMA Engineering, 2005)

The following additional documents were reviewed to guide the design process:

- *City of Edmonton Design and Construction Standards Volume 3-02: Stormwater Management and Design Manual* (City of Edmonton, 2022)
- *City of Edmonton Design and Construction Standards Volume 3-01: Development Planning Procedure and Framework* (City of Edmonton, 2021)
- *Alberta Wetland Mitigation Directive.* (Government of Alberta, 2018)
- *Municipal Policies and Procedures Manual* (Alberta Environment, 2001)
- *Stormwater Management Guidelines for the Province of Alberta* (Alberta Environmental Protection, 1999)

3.0 DESIGN PARAMETERS

3.1 Regulatory Requirements

The *Town of Bon Accord Stormwater Master Plan* (AE, 2019) recommended that the Town adopt the *City of Edmonton Design and Construction Standards* for its stormwater infrastructure. This section summarizes the relevant guidelines from *City of Edmonton Design and Construction Standards*, the *Stormwater Management Guidelines for the Province of Alberta*, and the *Town of Bon Accord Stormwater Master Plan* applicable to this feasibility study.

3.1.1 Storage Capacity

Design Storms

The *City of Edmonton Design and Construction Standard* (2021) recommends that SWMFs provide, as a default, a retention volume equivalent to 120 mm of rainfall over the total catchment area draining to the facility. If a suitable outlet is available for the SWMF, the outflow during runoff events is also considered in the determination of the required storage. Additionally, each SWMF design (considering available outflows) should be verified through computer simulation for its response to the following design rainfall events:

- 1:100-year, 24-hour synthetic design event based on the Huff distribution
- July 14 - 15, 1937 storm event
- July 10 - 11, 1978 storm event
- July 2 - 3, 2004 storm event
- July 12, 2012 storm event

The 1:100-year, 24-hour design storm was used as the primary design criteria for this study.

Post-Event Drawdown

The *City of Edmonton Design and Construction Standard* (2021) recommends that SMWF outlets should have sufficient capacity to allow post-event drawdown of facility water levels such that the SWMF storage capacity is restored as follows:

- 1:5-year runoff capacity within 24 hours
- 1:25-year runoff capacity within 48 hours
- 90% of the facility full volume within 96 hours

This drawdown analysis should be evaluated using the Huff distribution design storms provided by the City of Edmonton (2022). If the storage capacity cannot be restored through post-event drawdown, the SWMF capacity should be evaluated for sequential rainfall events using continuous rainfall records.

Outflow Release Rate

The *Town of Bon Accord Stormwater Master Plan* (AE, 2019) recommends that the outflow from SMWFs be limited to 6 L/s/ha.

3.1.2 Water Quality

According to the *Stormwater Management Guidelines for the Province of Alberta (1999)*, sediment in stormwater runoff is a major pollutant to receiving waters (*i.e.,* streams and rivers). As sediment in stormwater runoff reaches the receiving waters, it reduces water clarity by limiting light penetration, negatively affects fish habitats by restricting spawning and rearing areas, and transports attached nutrients and contaminants. Additionally, sediment accumulated in a stream or river can alter its conveyance and storage capacities, leading to increased erosion and flood risks. Therefore, reducing the amount of sediment in stormwater runoff through the collection in a SWMF is crucial for maintaining downstream water quality and protecting aquatic ecosystems.

The *City of Edmonton Design and Construction Standard* (2022) and *Alberta Municipal Policies and Procedures Manual* (2001) recommend that any proposed SWMF should remove, at a minimum, 85% of sediment with a particle size of 75µm or greater from stormwater runoff prior to discharge. Particularly for constructed wetlands, the *City of Edmonton Design and Construction Standard* (2022) recommends the use of sediment forebays to provide sediment removal as pre-treatment.

3.2 Additional Considerations

3.2.1 Phasing

As the Town experiences future land use changes through development within the Natural Area 2 catchment, an increase in both the volume and rate of stormwater runoff is also anticipated. Therefore, the proposed solutions were also analyzed in terms of their capacity to meet future demands. The existing catchment characteristics were determined using the Town's GIS Shapefiles (2023) and the *Stormwater Master Plan* (AE, 2019). The expected future catchment characteristics were determined from the *Town of Bon Accord Municipal Development Plan* (2024).

Additionally, to manage the costs associated with the full-build out of the stormwater management facility, a phased-construction approach was investigated. The goal of the facility phasing is to ensure an effective balance between the Town's stormwater management needs and overall construction and maintenance costs. Phasing considerations are discussed in **Section 8**.

3.2.2 Facility Location and Wetland Disturbance

The Town anticipates that proposed SWMFs can be retrofit within the footprint of the existing Natural Area 2. However, the classification and description of this area varies in past reports. The Town's *Wetland Storage Study* (AE, 2021) notes that Natural Area 2 is a "crown-claimed wetland", whereas the *Drainage Study* (UMA, 2005) records this as a "natural marsh area" and the *Town of Bon Accord Stormwater Master Plan* (AE, 2019) simply refers to it as a "natural area".

Any wetland disturbance will need to align with the *Alberta Wetland Mitigation Directive* (2018). Some of the permits and approvals process include an evaluation of the Natural Area 2 by a wetland specialist, and subsequent engagement regarding minimization, reclamation, or replacement, associated compensations for replacement and monitoring, and potential credits for reconstruction.

MAGNA has previously undertaken and successfully completed projects involving wetland reconstruction and integration into SWMFs for credit, such as the *Livingston Phase 26 Storm Pond E* located in northeast Calgary. The Pond E facility was specifically designed as a combined storm pond and constructed wetland (*i.e.,* a storm park) facility to replace a portion of an existing large wetland through successful coordination with target groups including the City of Calgary and the Province under formal *Water Act* and *Environmental Protection and Enhancement Act (EPEA)* applications. More details regarding the Pond E project are included in **Appendix B**.

It is currently expected that Natural Area 2 can be disturbed and retrofit to enhance its stormwater capacity. However, alternate locations for the facility may be considered during detailed design if regulatory requirements do not allow for the disturbance of Natural Area 2.

3.2.3 Discharge Location

Typically, stormwater collected in a SWMF is discharged downstream by gravity through a dedicated outlet control structure (OCS), and eventually reaches a receiving water body such as a lake or river. Since the Town is located within the Sturgeon River watershed, the Sturgeon River is likely to be the ultimate receiving water body.

Past reports offer contrasting information about the availability of outflow conveyance infrastructure for Natural Area 2:

- The *Drainage Study* (UMA, 2005) reported the presence of an 800 mm diameter culvert across Highway 28, located to the south of Natural Area 2, and a drainage ditch running east-west along Highway 28.
- The *Stormwater Master Plan* (AE, 2019) also acknowledged an 800 mm culvert at the south end of Natural Area 2, which conveys flows from Natural Area 2 into a ditch system running east-west along Highway 28, and then this continues to a north-south ditch system along Lily Lake Road, ultimately discharging into the Sturgeon River.
- The *Wetland Storage Study* (AE, 2021) indicated that Natural Area 2 currently lacks an outlet. Instead, it proposed four outlet alignment options extending beyond the Town's limits.

More recent information from the Town (project communication, 13th of March 2024) indicates that a large culvert does exist near the middle of the south edge of the existing Natural Area 2, connecting the wetland to the southside of Highway 28. This culvert allows excess flows from the Natural Area 2 across Highway 28 during large snowmelt and rainfall events, to prevent highway flooding.

However, the Town noted that there is no existing drainage path on either side of Highway 28 due to the elevation of the ditches and surrounding lands. Therefore, the only means of dewatering Natural Area 2 (and the interconnected area south of Highway 28) currently is through evaporation and ground absorption.

For the proposed SWMFs, gravity-based dewatering will require the construction or upgrades to an existing a drainage ditch towards the Sturgeon River or its tributary. This will require coordination with Sturgeon County and other target groups since the drainage will continue beyond the Town's boundary.

The SWMF options proposed in this report currently assume dewatering via a gravity-flow ditch or similar system, to maintain comparability with the options presented in the *Wetland Storage Study* (2021). An alternate dewatering opportunity, through irrigation reuse of treated stormwater, is explored in **Sections 3.2.4** and **3.2.5**.

Detailed information regarding potential outlet ditch alignments, or other alternate discharge options will need to be confirmed before detailed design, since the facility sizing may need to be modified accordingly.

3.2.4 Other Pollutants

The *Stormwater Management Guidelines for the Province of Alberta (1999)* also describe other pollutants in stormwater runoff including nutrients, microorganisms, and salts.

Nutrients such as nitrogen and phosphorous are found in high concentrations in stormwater and can lead to eutrophication. Eutrophication is a process where aquatic ecosystems receive excess nutrients, resulting in harmful algal blooms, and reduced dissolved oxygen levels, thereby affecting aquatic life.

Stormwater may also contain microorganisms such as E-coli and fecal coliform in elevated levels due to cross-connected sanitary systems or from animal/bird waste.

The reduction of microorganism concentrations is important before stormwater reuse for irrigation is considered (*Alberta Health Public Health Guidelines for Water Reuse and Stormwater Use 2021*). Reducing nitrogen and phosphorous, which are essential nutrients for pathogens, will also help prevent pathogen regrowth after secondary treatment.

3.2.5 ALTERNATE DISCHARGE AND REUSE OPPORTUNITIES

Stormwater reuse for irrigation is a potential application for water volume management in SWMFs, which also provides an independent water source for local irrigation separate from potable water sources. Stormwater runoff stored in a SWMF can be reused for irrigation if consistent flows and water quality can be provided through secondary treatment (as described in **Section 3.2.4**). In conventional storm pond facilities, this is achieved through resource-intensive mechanical processes such as UV disinfection.

MAGNA has previously undertaken and successfully completed projects involving stormwater secondary treatment through passive, nature-based infrastructure and irrigation reuse for water volume management, such as the *Dawson's Landing Storm Pond 2A* located in the City of Chestermere.

Pond 2A uses a set of treatment cells – a horizontal surface flow wetland and a vertical flow biofilter to provide secondary treatment and produces high-quality irrigation water, which is then pumped to a nearby farmer's field.

The use of irrigation reuse has been particularly impactful to the community of Dawson's Landing and Chestermere. No gravity-based outflow options currently exist for Pond 2A, and the irrigation reuse has become the primary means of dewatering the facility. This dewatering is essential to restore storage capacity of the facility for runoff from future rainfall events.

Additionally, high-quality stormwater from Pond 2A is also supporting local farmers as it provides them with an alternative to expensive potable water, contributing to both crop quality and financial security.

More details about Pond 2A are included in **Appendix B**.

Figure 3.1: Water from Pond 2A Storm Park Irrigated Nearby Farmer's Fields

4.0 HYDROLOGIC ANALYSIS

Based on the design parameters described in **Section 3**, a PCSWMM model was developed to estimate the storage volumes required for runoff generated within the Natural Area 2 catchments. The City of Edmonton (2022) 1:100-year, 24-hour Huff distribution storm was used as the design event.

4.1 Drainage Areas

4.1.1 Existing Conditions Catchments

The existing catchment area for Natural Area 2 (**Figure 4.1** on Page 12) is estimated as ±83 ha (**Table 4.1**).

Table 4.1: Existing Catchment Area Characteristics

Catchment ID	Description	Area (ha)	Imperviousness (%)
C-D1	Mostly residential with few commercial areas, including a conveyance system consisting of storm sewer pipes and manholes towards Natural Area 2.	15.63	**50**
C-D2	Mostly residential, including a conveyance system consisting of culverts and ditches towards Natural Area 2.	16.31	**50**
C-D3	Mostly residential; overland flow towards Natural Area 2.	14.20	**50**
C-U1	Undeveloped area; overland flow towards Natural Area 2.	28.95	**20**
C-NA	Natural Area 2; estimated water surface area assumed as 100% impervious.	7.78	**20**

4.1.2 Future Conditions Catchments

The future catchment area for Natural Area 2 is estimated as ±94 ha (**Table 4.2**), and shown on **Figure 4.2** (on Page 13).

Table 4.2: Future Catchment Area Characteristics

Catchment ID	Description	Area (ha)	Imperviousness (%)
C-D1	Mostly residential with few commercial areas, including a conveyance system consisting of storm sewer pipes and manholes towards Natural Area 2.	15.63	**50**
C-D2	Mostly residential, including a conveyance system consisting of culverts and ditches towards Natural Area 2.	16.31	**50**
C-D3	Mostly residential; overland flow towards Natural Area 2.	14.20	**50**
C-D4	Mostly residential with few commercial areas. To be serviced by future major and minor (conveyance) systems towards Natural Area 2.	40.00	**50**
C-NA	Natural Area 2; estimated water surface area assumed as 100% impervious.	7.78	**20**

4.1.3 Inflow Boundary Conditions

No inflows from adjacent catchment areas are expected to contribute to Natural Area 2.

4.1.4 Outflow Boundary Conditions

The allowable peak release rate from the proposed SWMF was set as 6 L/s/ha based on the *Town of Bon Accord Stormwater Master Plan* (AE, 2019).

4.2 Runoff Volumes

4.2.1 Existing Conditions Catchments

A PCSWMM model analysis was conducted to determine the total runoff generated during a 1:100-year, 24-hour design storm from the existing conditions catchments. The PCSWMM model inputs were based on the design parameters discussed in **Section 3**, and existing catchment conditions are described in **Section 4.1.1**.

The model results indicated that ±33,000 m^3 of runoff will be generated from the developed areas within the existing catchment. However, the existing catchment also comprises of a large undeveloped area and Natural Area 2. The combined runoff volume from all areas (developed, undeveloped, and Natural Area 2) determined through the model was ±50,000 m^3.

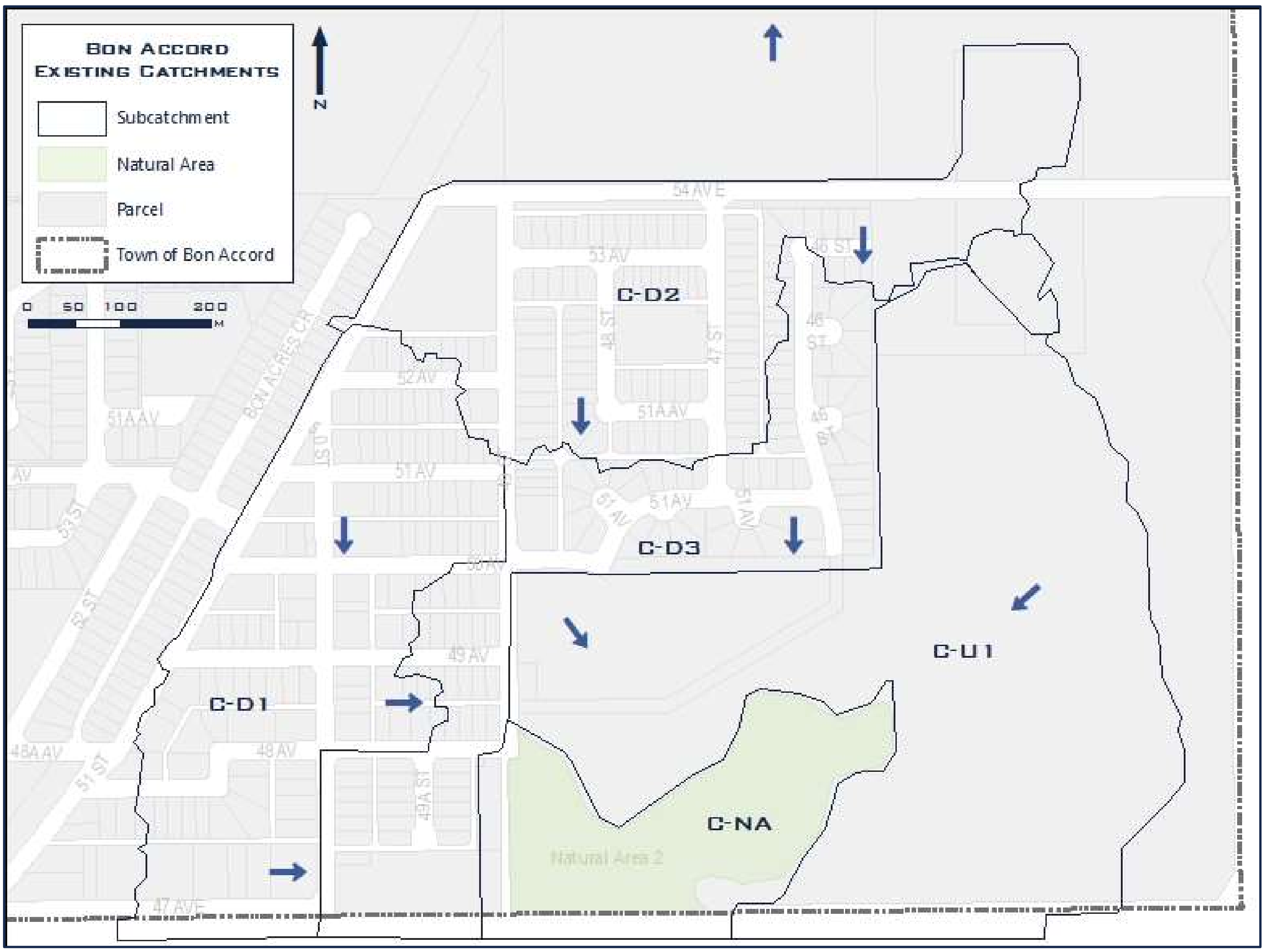

Figure 4.1: Existing Catchment Areas

4.2.2 FUTURE CONDITIONS CATCHMENTS

The total runoff volume generated from the future conditions catchments was estimated as ±67,000 m^3 through the PCSWMM model. As described in **Section 4.1.2**, the future catchments are expected to be fully developed except for Natural Area 2.

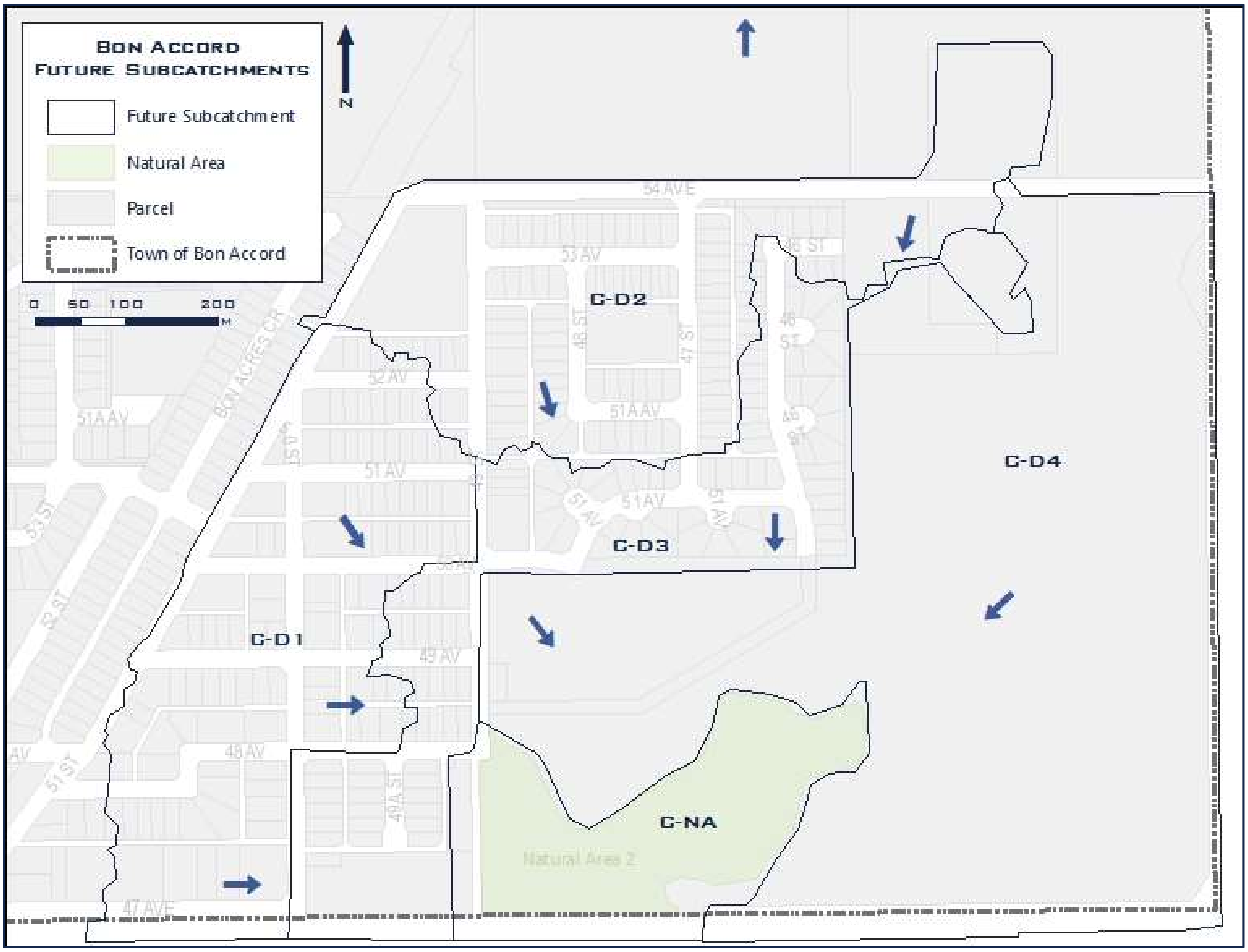

Figure 4.2: Future Catchment Areas

Based on the runoff volumes estimated for both the existing and future catchment conditions, it was estimated that a single SWMF within the Natural Area 2 footprint can sufficiently store the total runoff volume in both scenarios. Therefore, it is proposed that a single SWMF be sized at this time to manage the requirements of both the existing and future catchment conditions. This avoids the need for constructing a separate, smaller SWMF at a later time exclusively for the future development areas. The O&M requirements will also be limited to one SWMF site, which may be preferable to the Town.

5.0 FACILITY DESIGN

A stormwater management facility is defined as an engineered pond or basin designed to accumulate runoff from its contributing catchment areas during storm and snowmelt events and release the collected water at a controlled rate to reduce downstream flooding. Some SWMFs also help improve water quality, primarily through the capture of suspended sediments by gravitational settling.

Three SWMF options are being considered for this feasibility study:

1. **Option 1:** Traditional Storm Pond (also called Wet Ponds)
2. **Option 2:** Storm Park with Enhanced Treatment
3. **Option 3:** Storm Park

An overview of each option, including benefits and risks, has been included in the following sub-sections.

5.1 Option 1: Traditional Storm Pond

5.1.1 Storage Capacity

Traditional storm ponds are large retention basins with a permanent water level (also called normal water level or NWL). During storms or snowmelt events, runoff from the catchment enters the pond, raising its water level above the NWL.

The maximum volume of water that can be contained within a storm pond is based on its high-water level (HWL), which is determined during design. The depth of water between the pond bottom and the NWL is called the "dead storage zone", and the depth between the NWL and HWL is called the "active storage zone". As the storm subsides, the water collected in the active storage zone gradually drains out through an outlet structure, returning the pond water level to the NWL.

5.1.2 Water Quality

Water quality is improved in a wet pond by gravitational settling of sediments. Typically, a sediment forebay is also provided near each inlet – a sediment forebay is a deeper region within the wet pond which captures coarse sediment particles from the runoff within a small area in the pond. Some storm ponds also utilize an Oil-Grit separator (OGS), a multi-chambered manhole that captures coarse sediment and debris from stormwater before it enters the storm pond.

5.1.3 Sizing and Location

The total area and depth required for a SWMF is estimated through storage-routing analysis and PCSWMM model simulation for the design storm event. The analysis yields a depth-area relationship, which can be used to estimate the total storage volumes available.

For this traditional storm pond option, the depth-area relationship curve (given in **Table 5.1**) was derived based on the layout and sizing criteria presented in the *Wetland Storage Study* (AE, 2021) to ensure comparability between the considered options. **Figure 5.1** shows the total footprint area of the facility at NWL and HWL, also reproduced from the *Wetland Storage Study* (AE, 2021).

Table 5.1: Traditional Storm Pond (Option 1) Depth-Area Rating

Elevation (m)	Depth (m)	Area (m^2)	Total Volume (m^3)	Active Volume (m^3)	Water Level
693.00	0.00	30,000	-	-	Bottom
694.50	1.50	32,500	46,875	-	
695.50	2.50	40,000	83,125	-	Normal Water Level (NWL)
696.50	3.50	47,500	126,875	43,750	
697.00	4.00	51,250	151,563	68,438	High Water Level (HWL)
697.50	4.50	55,000	178,125	95,000	Freeboard (FB)

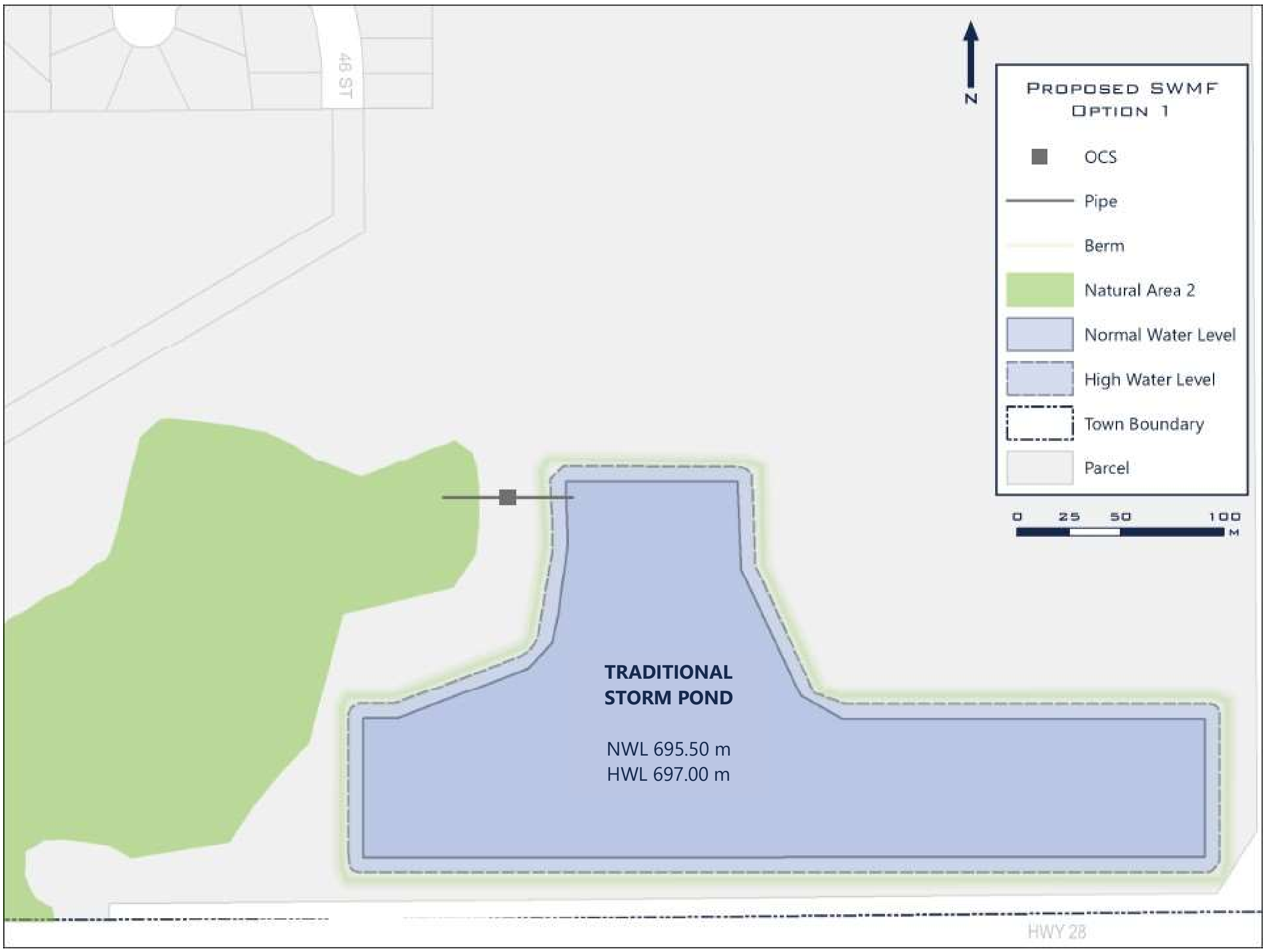

Figure 5.1: Traditional Storm Pond Site Plan
Data Source: Associated Engineering, 2019

5.2 Option 2: Storm Park with Enhanced Treatment

Storm Parks are an emerging class of naturalized SWMFs focused on balancing stormwater quality and quantity management functions with ecological services and placemaking priorities. Storm Parks combines traditional wet pond elements with natural wetland features and park amenities to enhance community integration and provide site-specific, fit-for-use applications such as park space, environment conservation, and system resiliency.

Figure 5.2: Nautilus Pond® Concept

A typical Storm Park consists of the following elements:

- **Nautilus Pond®:** proprietary stormwater clarifier that provides sediment removal.
- **Main Pond:** provides storage for sediment-free stormwater and allows for flexible operating regimes.
- **Treatment Wetland Cells:** provide additional enhanced treatment for nutrient removal, enabling stormwater reuse.
- **Wetland Benches:** offer ecological value and allow for an aesthetic transition between the Main Pond and adjacent natural areas.
- **Recirculation Pump:** for circulating water from the Main Pond into the Treatment Wetland and Wetland Benches

Figure 5.4 (on Page 18) shows a simplified sketch of a Storm Park alongside a traditional storm pond. All the elements of a Storm Park fit within the same footprint area as a traditional pond.

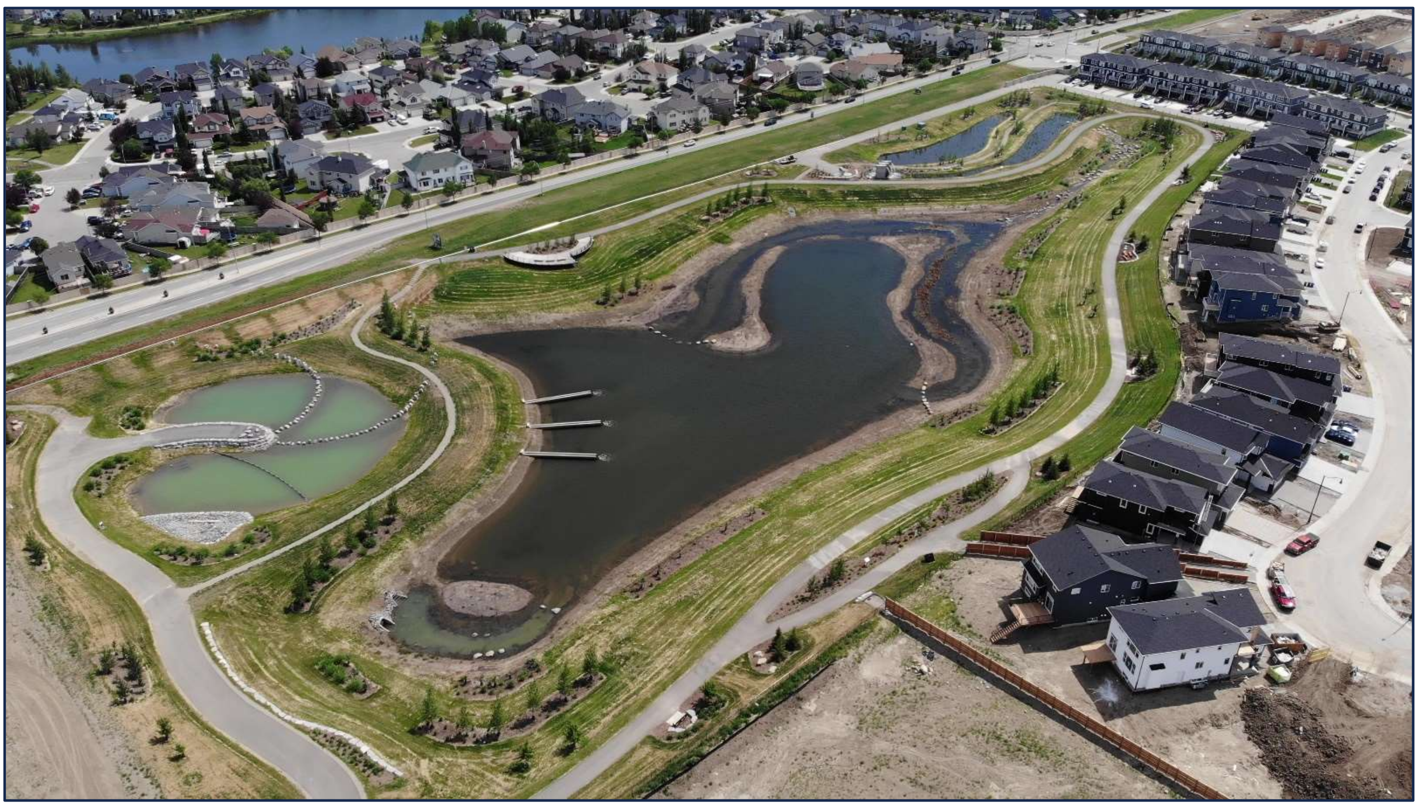

Figure 5.3: Dawson's Landing Pond 2A Storm Park in Chestermere, AB

5.2.1 Storage Capacity

The Main Pond is the primary storage element, modified from traditional wet ponds to allow flexible water volume management. In addition to the traditional "dead" and "active" storage zones, the additional "dynamic" storage zone in the Main Pond allows for flexible water volume management.

The depth of water between the Main Pond bottom and the lower normal water level (LNWL) is the dead storage zone, the depth between the LNWL and the upper normal water level (UNWL) is called the dynamic storage zone, and the depth between the UNWL and HWL is called the active storage zone. While the water stored in the active storage zone drains through the outlet control structure by gravity, the water stored in the dynamic storage zone is recirculated through the Treatment Wetland cells, the wetland bench and the natural areas through the recirculation pumps. Water stored in the dynamic zone may also be reused for irrigation after being treated through the Treatment Wetland cells.

5.2.2 Water Quality

The Nautilus Pond® is a specialized sediment clarifier that functions similar to a sediment forebay and can reliably remove sediment particles as small as 20 μm and avoid its subsequent resuspension. As a result, all sediment removal objectives are achieved within the Nautilus Pond® prior to stormwater reaching the Main Pond.

Beyond primary treatment for sediment removal, a Storm Park provides secondary treatment through the Treatment Wetland cells consisting of a Vertical Flow Biofilter (VFB) and a Horizontal Surface Flow Wetland (HSFW). The Treatment Cells receive pumped flow from the dynamic storage zone in the Main Pond and provide nature-based secondary treatment for pollutants that cannot typically be removed by a wet pond alone (i.e., nitrogen, phosphorus, and microorganisms). The removal of pathogenic microorganisms is essential before stormwater can be reused for irrigation (*Alberta Health Public Health Guidelines for Water Reuse and Stormwater Use 2021)*. The reduction of nitrogen and phosphorous is also important to reduce pathogen regrowth.

Downstream of the Treatment Cells, the treated stormwater may be recirculated through the wetland benches and/or reused for irrigation.

A Storm Park combines traditional wet pond elements with natural wetland features and park amenities to enhance community integration and provide site-specific, fit-for-use applications such as park space, environmental conservation, and system resiliency.

5.2.3 Naturalization

To provide environmental, community, and aesthetic value to the facility, Wetland Benches are specifically designed along the sides of the Main Pond to merge its footprint into the retained portions of Natural Area 2.

Outflow from the Treatment Wetlands pass through the retained Natural Area 2 and Wetland Benches via a network of pools and ledges, creating a diverse and resilient wetland landscape within the facility. This continuous flow of treated water helps maintain the wetland vegetation and increases the flow path length of the pond, while also providing specialized habitat for wildlife such as birds and amphibians.

During storms, the Wetland Benches will become temporarily submerged to allow for additional stormwater storage capacity. However, any water inundating the Wetlands will have first passed through the Nautilus Pond®, protecting it against ingress and deposition of significant quantities of sediment. Once the storm subsides, the facility water level will return to normal levels, protecting the Wetlands from extended inundation, and maintaining its ecological health.

5.2.4 SIZING AND LOCATION

The depth-area relation curve for the proposed Storm Park is given in **Table 5.2** (on Page 19), and represents the combined storage effects from a Nautilus Pond® and Main Pond.

Figure 5.4: Storm Park vs. Traditional Storm Pond

Table 5.2: Storm Park Depth-Area Rating

Elevation (m)	Depth (m)	Area (m^2)	Total Volume (m^3)	Active Volume (m^3)	Water Level
691.70	0.00	5,000	-	-	Bottom
693.20	1.50	8,000	9,750	-	
693.70	2.00	10,558	14,390		Lower Normal Water Level (LNWL)
694.20	2.50	14,516	20,658	-	Normal Water Level (NWL)
694.70	3.00	17,798	28,737	-	Upper Normal Water Level (UNWL)
695.20	3.50	20,784	38,382	9,646	
696.20	4.50	26,367	61,958	33,221	
696.70	5.00	29,978	76,044	47,307	
697.00	5.30	32,098	85,355	56,619	High Water Level (HWL)
697.50	5.80	35,281	102,200	73,463	Freeboard (FB)

Figure 5.5 shows the proposed Storm Park layout within the Natural Area 2 footprint. Where possible, existing vegetation will be retained or enhanced with additional planting. Consistent low-flow pump recirculation will also support wetland establishment. Wetland Benches will be between the Main Pond UNWL (694.70 m) and HWL (697.00 m).

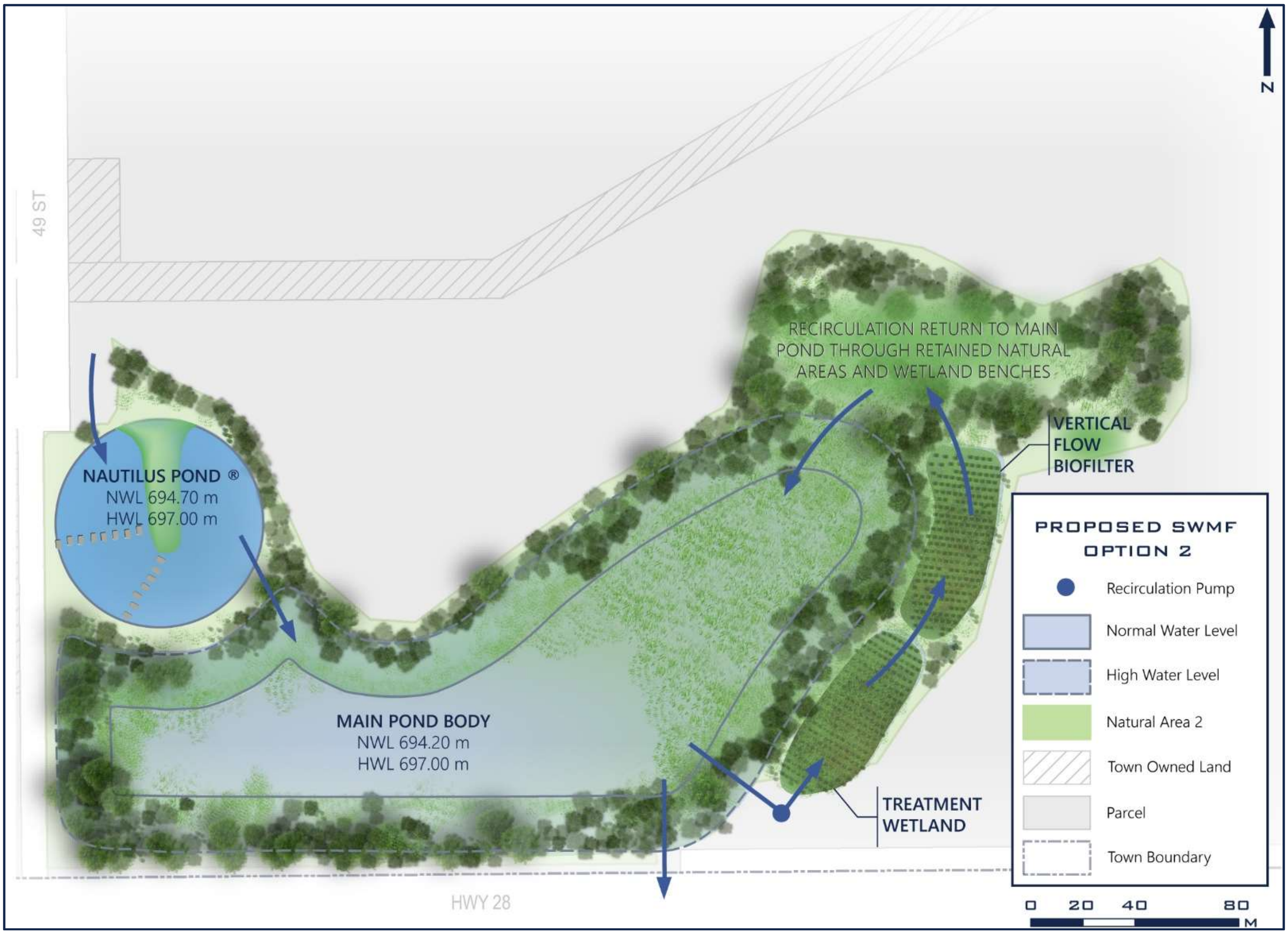

Figure 5.5: Proposed Storm Park (with Treatment Cells) Site Plan

Note: The proposed facility currently aligns with the existing Natural Area 2 boundary but can be modified as needed by the Town.

5.3 Option 3: Storm Park

The third option considered is a Storm Park without the recirculation and secondary treatment, shown in **Figure 5.6**. The other features for Option 3 are similar to Option 2, excluding the recirculation pumps and the Treatment Wetland Cells.

In the absence of the Treatment Wetland Cells, targeted pollutant removal such as nitrogen and phosphorous, and microorganisms may not be achieved in significant amounts.

Figure 5.6: Storm Park (without Treatment Cells) Site Plan

Note: The proposed facility currently aligns with the existing Natural Area 2 boundary but can be modified as needed by the Town.

5.4 Benefits and Other Considerations

This subsection details the benefits and risks associated with each proposed option.

5.4.1 Option 1: Traditional Storm Pond

Benefits

- **Design and construction**:
  - Relatively standard design and construction process.
- **Regulatory requirements**:
  - Fulfills the required stormwater peak flow attenuation and volume management needs.
  - Fulfills the basic stormwater quality needs through sediment removal.

Other Considerations

- **Complex pond maintenance**:
  - Wet ponds require regular sediment removal maintenance, which includes dewatering the facility and dredging the deposited sediments. The storage and sediment removal capacity of wet ponds will be reduced if regular sediment dredging maintenance is not performed. Dredging is typically performed in the winter months when no stormwater inflows are expected into the facility.
  - Intensive maintenance of the grassed side slopes, including regular mowing and landscaping, is required to prevent invasive weeds and grazing birds and animals.
- **Complex OGS unit maintenance and inefficiencies**:
  - OGS units have limited sediment storage capacity and require frequent sediment cleaning (typically once every year), which involves confined space entry for maintenance workers.
  - OGS units can become overwhelmed during heavy storm events when a large volume of runoff is entering the pond, leading to inefficient treatment.
- **No Naturalization**:
  - Traditional wet ponds cannot be cohesively tied into the retained natural/wetland areas due to their conventional design and sediment removal maintenance requirements.
- **Space requirements**:
  - Traditional wet ponds typically need a large bottom and water surface area to minimize areas of shallow depths to prevent the growth of unwanted vegetation.
- **Secondary treatment potential**:
  - No targeted secondary treatments for pollutants such as nutrients are possible.
- **Stormwater reuse potential**:
  - The main reason for not being able to use traditional stormwater for re-use is the low water quality, however, the quick drawdown period from HWL to NWL also reduces opportunities for low-flow feedwater support to naturalized wetland areas.

5.4.2 Option 2: Storm Park with Enhanced Treatment

Benefits

- **Construction**:
  - A perceived benefit of the Storm Park facility is related to the comparable if not lower construction costs and footprint when compared to a traditional wet pond.
- **Regulatory requirements**:
  - The Main Pond fulfills all the required stormwater peak flow attenuation and volume management needs.

- The Nautilus Pond® completes all sediment removal requirements before stormwater reaches the Main Pond.
- **Retained or reconstructed wetland amenities**:
    - Certain portions of the existing Natural Area 2 can be retained or reconstructed as wetland benches as part of the integrated Storm Park facility, thereby maintaining the environmental value of the site.
    - Wetland benches provide aesthetic and environmental benefits through the fostering of resilient native vegetation, supporting wildlife, and seamlessly integrating from constructed areas to the retained natural area features.
    - Wetland Benches restore and preserve ecological habitat for variety of wildlife, including creating quality habitat for migrating waterfowl, native animals, and other species.
- **Simplified sediment removal maintenance**:
    - While a traditional pond requires frequent dredging of the forebay and the entire facility, in the Storm Park, only the Nautilus Pond® needs to be regularly dredged, resulting in a smaller area of maintenance.
    - The Nautilus Pond® is perched above the Main Pond NWL and can be drained by gravity into the Main Pond for maintenance.
    - It is anticipated that accumulated sediment may reside within the Nautilus Pond® for a 5 to 10-year period, and if managed regularly, eliminates the need for Main Pond dredging entirely.
- **Secondary treatment and reuse potential**:
    - Secondary pollutants such as nutrients are removed through the Treatment Wetlands.
    - Treated stormwater can be recirculated through retained areas of Natural Area 2 and wetland benches, thereby maintaining existing wetland features.
    - Treated stormwater may also be used for irrigation within the Town, providing an alternate dewatering option for the facility.

OTHER CONSIDERATIONS

- **Design**:
    - A storm park requires a slightly more nuanced design approach than a traditional wet pond to ensure the effective integration of its various elements.
- **Treatment Wetland and Wetland Benches**:
    - Special attention is required to the establishment and maintenance of the Treatment Wetland cells and Wetland Bench areas during construction. For example, sediment and erosion control measures will be required, and extended inundation should be avoided during the first year of operation to support plant establishment.
    - Once established, these wetland systems will become self-sufficient and require minimal maintenance.
    - Treatment Wetlands are known to be in operation for 20+ years without loss of function, therefore, this system is anticipated to perform as intended for multiple decades post establishment.
- **Energy requirements**:
    - A low horsepower recirculation pump (1-10 hp) is used to recirculate the resident water in the Main Pond into the Treatment Wetlands and wetland benches, if required.
    - The pump system would be designed as a well-casing pump assembly system with a pitless adapter, to simplify its construction, operation, and maintenance.

5.4.3 Option 3: Storm Park

Benefits

- **Construction**:
  - Construction needs and costs are mostly similar to a traditional wet pond.
  - A Storm Park also fits within the same footprint as a traditional wet pond.
- **Regulatory requirements**:
  - The Main Pond fulfills all the required stormwater peak flow attenuation and volume management needs.
  - The Nautilus Pond® completes all sediment removal requirements before the stormwater reaches the Main Pond.
- **Retained or reconstructed wetland amenities**:
  - Certain portions of the existing Natural Area 2 can be retained or reconstructed as wetland benches to supplement the Storm Park facility, thereby maintaining the environmental value of the site.
  - Wetland benches provide aesthetic and environmental benefits through the fostering of resilient native vegetation, supporting wildlife, and seamlessly connecting the edges of the constructed SWMF to the retained natural area features.
  - Wetland Benches restore and preserve ecological habitat for variety of wildlife, including creating quality habitat for migrating waterfowl, native animals, and other species.
- **Simplified sediment removal maintenance**:
  - While a traditional pond requires frequent dredging of the forebay and the entire facility, in a Storm Park, only the Nautilus Pond® needs to be regularly dredged, resulting in a smaller area of maintenance.
  - The Nautilus Pond® is perched above the Main Pond NWL and can be drained by gravity into the Main Pond for maintenance.
  - It is anticipated that accumulated sediment may reside within the Nautilus Pond® for a 5 to 10-year period, and if managed regularly, eliminates the need for Main Pond dredging entirely.

Other Considerations

- **Design**:
  - A storm park requires a slightly more nuanced design approach than a traditional wet pond to ensure the effective integration of its various elements.
- **No secondary treatment and reuse potential**:
  - Secondary pollutants such as nutrients cannot be removed in a targeted manner without the Treatment Wetland Cells.
  - No treated stormwater will be available for irrigation within the Town.
- **Wetland Benches**:
  - Special attention is required to the establishment and maintenance of the Wetland Bench areas during construction. For example, sediment and erosion control measures will be required, and extended inundation should be avoided during the first year of operation to support plant establishment.
  - Once established, these wetland systems will become self-sufficient and require minimal maintenance.

6.0 COSTS OVERVIEW

6.1 Capital Costs

Table 6.1 summarizes the expected capital costs for Options 1, 2, and 3. The cost for Option 1 was reproduced from the *Wetland Storage Study* (AE 2021); costs for Option 2 and 3 are high-level estimates by MAGNA with an accuracy of ±50%.

Table 6.1: Capital Costs Comparison

No.	Description	Option 1[1]	Option 2[2]	Option 3[2]
1	Earthworks		$513,000	$513,000
2	Liner		$370,000	$370,000
3	Nautilus Pond®		$519,000	$519,000
4	Outlet Control Structure		$250,000	$250,000
5	Deep Utilities		$1,200,000	$1,200,000
6	Landscaping and Surface Improvements		$630,000	$630,000
7	Secondary Treatment		$843,000	$0
8	Pumps and Electricals		$550,000	$0
9	Inlet Realignment and Miscellaneous		$500,000	$500,000
	SUB-TOTAL		**$5,375,000**	**$3,982,000**
	TOTAL	**9,705,000[1]**	**-**	**-**

1. Wetland Storage Study (AE 2021) reported the total construction cost as $10,676,000 including 50% contingency and 15% design fees. Reported here without design fees.
2. Costs based on similar completed and ongoing MAGNA Storm Park projects. Does not include contingency or design fees.

6.2 Wetland Disturbance and Facility Location

The costs associated with disturbing the Natural Area 2 wetland depends on several factors including its classification and regulatory requirements.

Any wetland disturbance will need to align with the *Alberta Wetland Mitigation Directive* (2018). Some of the permits and approvals process include an evaluation of the Natural Area 2 by a wetland specialist, and subsequent engagement regarding minimization, reclamation, or replacement, associated compensations for replacement and monitoring, and potential credits for reconstruction. The replacement fees for a natural wetland (without replacement credits) are approximately $20,000 - $160,000 per hectare, depending on the value category of the wetland. **Table 6.2** summarizes the estimated land acquisition / wetland disturbance costs for Options 1, 2, and 3.

Table 6.2: Land Acquisition / Wetland Disturbance Costs Comparison

No.	Description	Option 1[1]	Option 2[2]	Option 3[2]
1	Land Acquisition (outside the Natural Area 2 footprint)	$1,500,000	-	-
2	Wetland Disturbance / Replacement	-[3]	$640,000	$640,000

1. Land costs for a traditional storm pond from the Wetland Storage Study (AE 2021) based on $250,000 per hectare.
2. Assumes $160,000 per hectare and 4 ha wetland disturbance. Does not consider classification of existing wetland, or potential reconstruction credits.
3. No wetland disturbance costs were reported by the Wetland Storage Study (AE 2021); however, it is likely that some disturbance fees will be charged because the Town's stormwater is still routed through the wetland in this option.

MAGNA has previously undertaken and successfully completed projects involving wetland reconstruction and integration into SWMFs for credit, such as the *Livingston Phase 26 Storm Pond E* located in northeast Calgary. The Pond E facility was specifically designed as a combined storm pond and constructed wetland (*i.e.,* a storm park) facility to replace a portion of an existing large wetland through successful coordination with stakeholders including the City of Calgary and the Province under formal *Water Act* and *Environmental Protection and Enhancement Act (EPEA)* applications. More details regarding Pond E are included in **Appendix B**.

6.3 Discharge Location

The proposed designs assume gravity-based discharge of the facility towards Sturgeon River is feasible (see **Section 3.2.3**). If the facility cannot discharge via gravity (*e.g.,* through a highway ditch system), alternative outfall options must be explored. One potential solution is to dewater the facility by reusing treated stormwater for irrigation (see **Section 3.2.4**), which is possible with Option 2, but not with Option 3. MAGNA has previously undertaken and successfully completed projects that rely on stormwater reuse for irrigation as their primary dewatering mechanism, such as the *Dawson's Landing Storm Pond 2A* located in Chestermere.

Pond 2A cleans resident water in the Main Pond by pumping it through the VFB and HSFW to provide secondary treatment, which is then pumped to a nearby farmer's field. This irrigation reuse has been particularly impactful to the community of Dawson's Landing and Chestermere, as well as the local farmers. It has provided the facility a means of stormwater volume control in the absence of a gravity-based outlet option, and also provided the local farmers with alternative sources to expensive potable water, contributing to both crop quality and financial security. More details about Pond 2A are included in **Appendix B**.

The costs associated with the construction of a new drainage ditch towards the Sturgeon River are currently not included in this assessment. The alternative option, irrigation reuse, will also require additional pumps and electrical infrastructure, whose costs are not currently included. Irrigation reuse will require ongoing maintenance and power supply, whereas the gravity discharge option is a passive dewatering option without significant ongoing maintenance (as compared to the irrigation system).

7.0 COMPARATIVE ANALYSIS

To support decision-making, an in-house comparative analysis was conducted. The purpose of this analysis is to provide the Town with a framework that supports the overall evaluation of the three treatment options, while making room for prioritization of certain criteria over others. Using information gathered in background research, understanding of the site risks and opportunities, and various discussions with the Town, MAGNA weighted the criteria in **Table 7.1** below (and reviewed with Town staff prior to writing this report).

7.1 Criteria Weighting

In this table, a weight score of three (3) signifies the most important criteria, and one (1) is least important.

Table 7.1: Comparative Analysis Criteria Weighting

Criteria		Description	Score	Notes
Engineering & Planning Optimization	Footprint Size	SWMF size and integration with overall site.	**3**	The SWMF size should be limited to the existing Natural Area 2 footprint.
	Water Quality (Regulatory Compliance)	Optimization of discharge water quality to downstream receiving waters, in excess of regulatory requirements.	**1**	The discharge must meet the requirements set out in the design standards.
	Site Servicing	Access for maintenance crews and ease of servicing the facility.	**2**	The servicing for the facility should be generally simple.
Social	Public Perception / Aesthetic	Consideration for the public's perception and aesthetic of the SWMF and overall marketability and integration with overall City vision.	**3**	Based on the "Community" goal, where Bon Accord wants to "continue to develop enhanced public communication strategies to ensure that residents are well informed of community events, programs, and services".
	Water Reuse Opportunities	Consideration for stormwater reuse opportunities within the SWMF and overall site (active or passive).	**2**	Based on the "Economy" goal. Stormwater reuse opportunities may provide economic benefit to the town.
	Climate Change Resiliency	Consideration for accommodating climate impacts (larger design storm events) within the SWMF.	**1**	According to the "Infrastructure" goal, the town is committed to improving infrastructure in a fiscally responsible manner, which includes designing for climate resiliency.
Economic	Capital Costs / Engineering Costs	Consideration and optimization of the cost of construction, design, and construction management of the SWMF.	**3**	Costs should be minimized to reduce the economic impact on the Town.
	O&M Costs	Consideration of cost of maintenance of the SWMF.	**3**	

7.2 Comparative Analysis Results

Each option was scored in **Table 7.2** (on the next page) with three (3) signifying the most favourable, and one (1) the least. Each score was then multiplied by the weighting to achieve an overall ranking.

Table 7.2: Comparative Analysis Summary

Criteria		Weighting Score	Option 1	Option 2	Option 3
Engineering & Planning Optimization	Footprint Size	**3**	1	3	3
	Water Quality (Regulatory Compliance)	**1**	2	3	2
	Site Servicing	**2**	2	1	2
Social	Public Perception / Aesthetic	**3**	2	3	3
	Water Reuse Opportunities	**2**	1	3	1
	Climate Change Resiliency	**1**	2	2	2
Economic	Capital Costs / Engineering Costs	**3**	1	2	3
	O&M Costs	**3**	3	2	3
Weighted Total (higher score indicates more favourable)			**31**	**43**	**46**

Note, the higher the score, the more favourable the option. However, if the Town's priorities are different or have changed, the weightings can be realigned to better suit the Town's needs.

7.3 Recommendation

The comparative analysis indicates that Options 2 and 3 are the best choices for the Town based on project objectives and Town goals and priorities.

It should be noted that the main differences between Options 2 and 3, besides cost, are primarily around water reuse opportunities. Option 2 provides recirculation and secondary treatment, which enables stormwater reuse for irrigation. Irrigation reuse may be an alternative means of discharge from the facility in the absence of a gravity-based outlet such as an underground storm pipe or ditch.

Option 3 does not provide secondary treatment and therefore, stormwater cannot be reused for irrigation. In this case, the only means of discharge from the facility is through a gravity-based storm pipe or ditch.

8.0 PHASING

The Storm Park options (Options 2 and 3) are the most suitable choices for retrofitting Natural Area 2 and addressing the Town's stormwater management requirements. To ensure an effective balance between stormwater needs and overall construction and maintenance costs, MAGNA is proposing the Storm Park facility be constructed in three phases. Note, this phasing is applicable to both Options 2 and 3.

Table 8.1 summarizes each phase and its associated costs and objectives. Note that these phasing costs are based on subtotals for the corresponding elements listed in **Table 6.1**, and do not include any contingency or design fees.

Table 8.1: Proposed Phasing Plan and Objectives

Phase	Elements	Objectives	Sub-Total Cost[1] ($)
1	Nautilus Pond® and conveyance systems tie-in	• **Discharge Quality**: Enhance the quality of stormwater discharge from the Town into Natural Area 2 and further downstream to comply with legislative requirements. • **Conveyance**: Ensure efficient tie-in of conveyance systems into the Nautilus Pond®.	$1,019,000
2	Main Pond, outlet control structure, and underground utilities	• **Discharge**: Establish a clear means for discharge from Natural Area 2, allowing runoff to exit and flow toward the Sturgeon River. • **Storage Capacity**: Improve the storage capacity within Natural Area 2 to efficiently receive and capture runoff from the catchment.	$2,333,000
3	Wetland benches and rejuvenation	• **Environmental and Aesthetic Value**: Retrofit the facility to provide both environmental benefits and aesthetic appeal of wetlands.	$630,000
	Pumps and treatment wetland cells (only Option 2)	• **Water Reuse Opportunities**: Provide water reuse options (such as irrigation) through secondary treatment methods (i.e., treatment wetland cells).	$1,393,000

*1. Subtotal costs from **Section 6.1**, does not include contingency or design fees.*

8.1 Phase 1

The first phase will include the tie-in of the Town's conveyance systems to the Nautilus Pond®, construction of the Nautilus Pond®, and underground infrastructure to direct the Nautilus Pond® outflow to Natural Area 2 (and future Main Pond). Aligning the conveyance systems will redirect inflow through the Nautilus Pond®, which will provide sediment removal and complete the statutory stormwater quality requirements. This will stop the flow of sediments into Natural Area 2 that are currently negatively impacting this area.

The estimated Phase 2 construction cost is $1,019,000. This estimate is the sum of subtotal costs for Nautilus Pond® and inlet realignment and miscellaneous elements described in **Section 6.1**.

Figure 8.1 shows the Phase 1 elements and approximate boundaries for SWMF Option 2 (note that the phasing approach for Option 3 is identical to Option 2, except for the installation of pumps and treatment wetland cells in Phase 3).

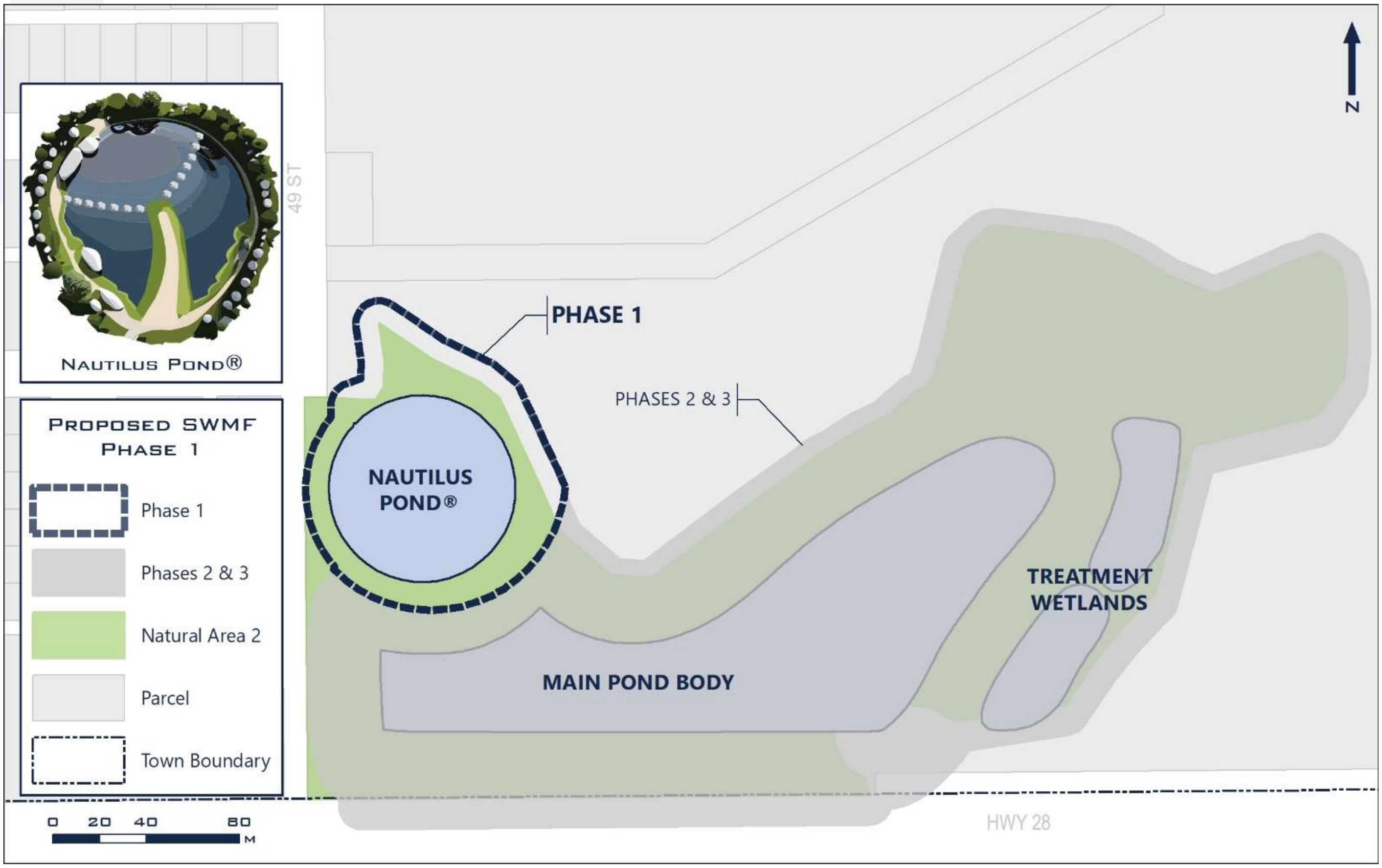

Figure 8.1: Proposed SWMF Phase 1

8.2 Phase 2

The second phase will include the construction of the Main Pond, the OCS, and other underground infrastructures. These elements will provide additional storage capacity for runoff from the Town and discharge the collected stormwater towards the Sturgeon River, respectively. This phase also includes the underground storm infrastructure required to tie-in the Main Pond to existing Nautilus Pond® and future phase elements (such as pipes, manholes, and pump standpipes).

The estimated Phase 2 construction cost is $2,333,000. This estimate is the sum of subtotal costs for earthworks, liner, underground utilities, and OCS elements described in **Section 6.1**.

Figure 8.2 shows the Phase 2 elements and approximate boundaries for SWMF Option 2 (note that the phasing approach for Option 3 is identical to Option 2, except for the installation of pumps and treatment wetland cells in Phase 3).

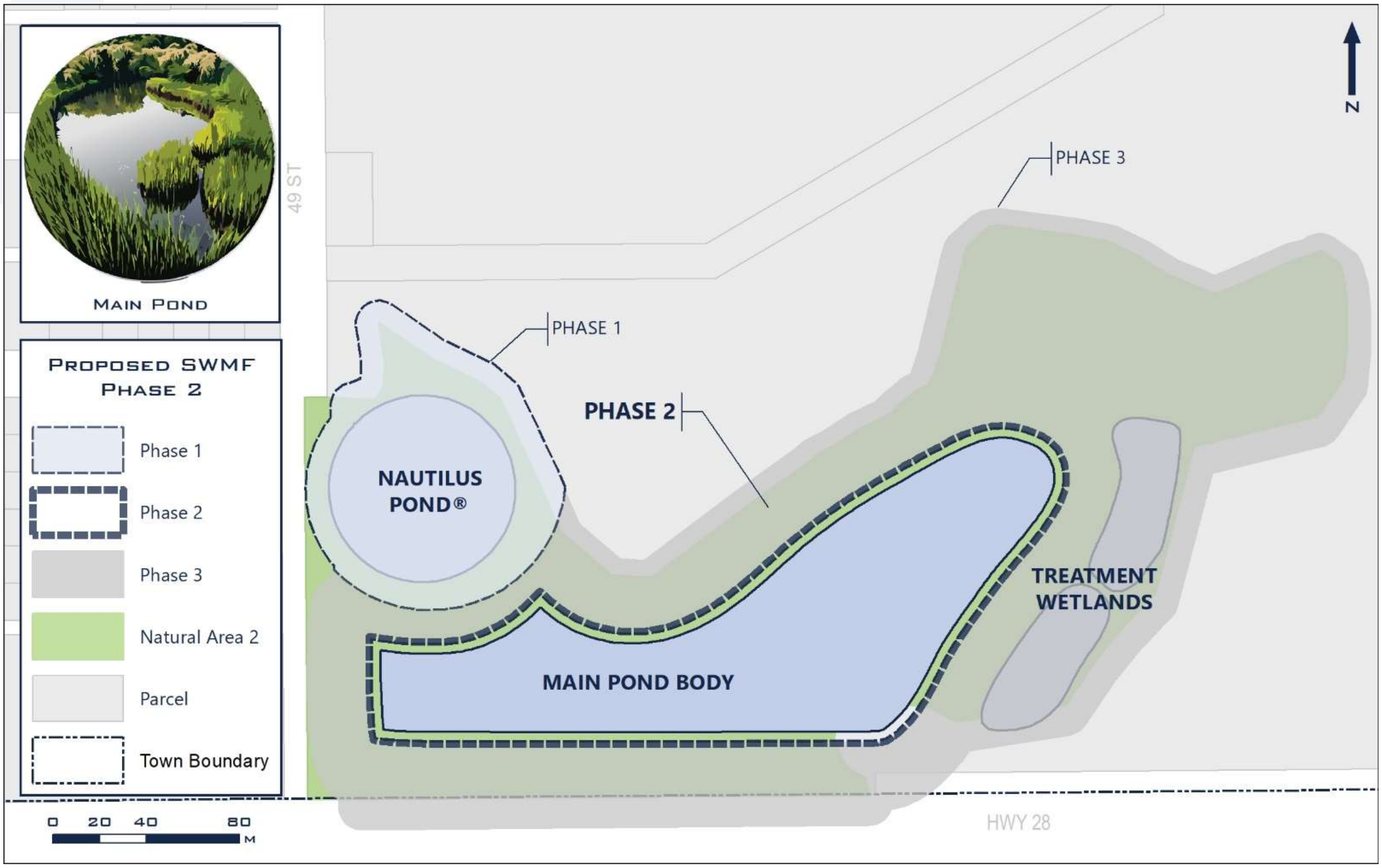

Figure 8.2: Proposed SWMF Phase 2

8.3 Phase 3

Phase 3 will include the construction or reconstruction of the wetland benches along the side slopes of the Main Pond to provide ecological habitat and support vegetation. Portions of the Natural Area retained as-is will also be rejuvenated through the planting of native, resilient vegetation. The recirculation pump and associated electrical, instrumentation, and controls will also be installed simultaneously to pump water from the Main Pond into the wetland regions to support their vegetation with consistent water flow, if Option 2 is chosen.

For Option 2 only, phase 3 will also include the construction of treatment wetland cells for secondary water treatment. Treated water maybe be reused for irrigation or other non-potable purposes or circulated through the wetlands. Targeted secondary treatment through the treatment cells provides improved water quality beyond the existing regulatory requirements for stormwater (*i.e.,* removal of sediments only).

The estimated Phase 3 construction costs for Option 2 and 3 are $2,023,000 and $630,000, respectively. This estimate is the sum of subtotal costs for landscaping and surface works, the pumps and electrical elements, and the secondary treatment elements described in **Section 6.1**.

Figure 8.3 shows the Phase 2 elements and approximate boundaries for SWMF Option 2 (note that the phasing approach for Option 3 is identical to Option 2, except for the installation of pumps and treatment wetland cells in Phase 3).

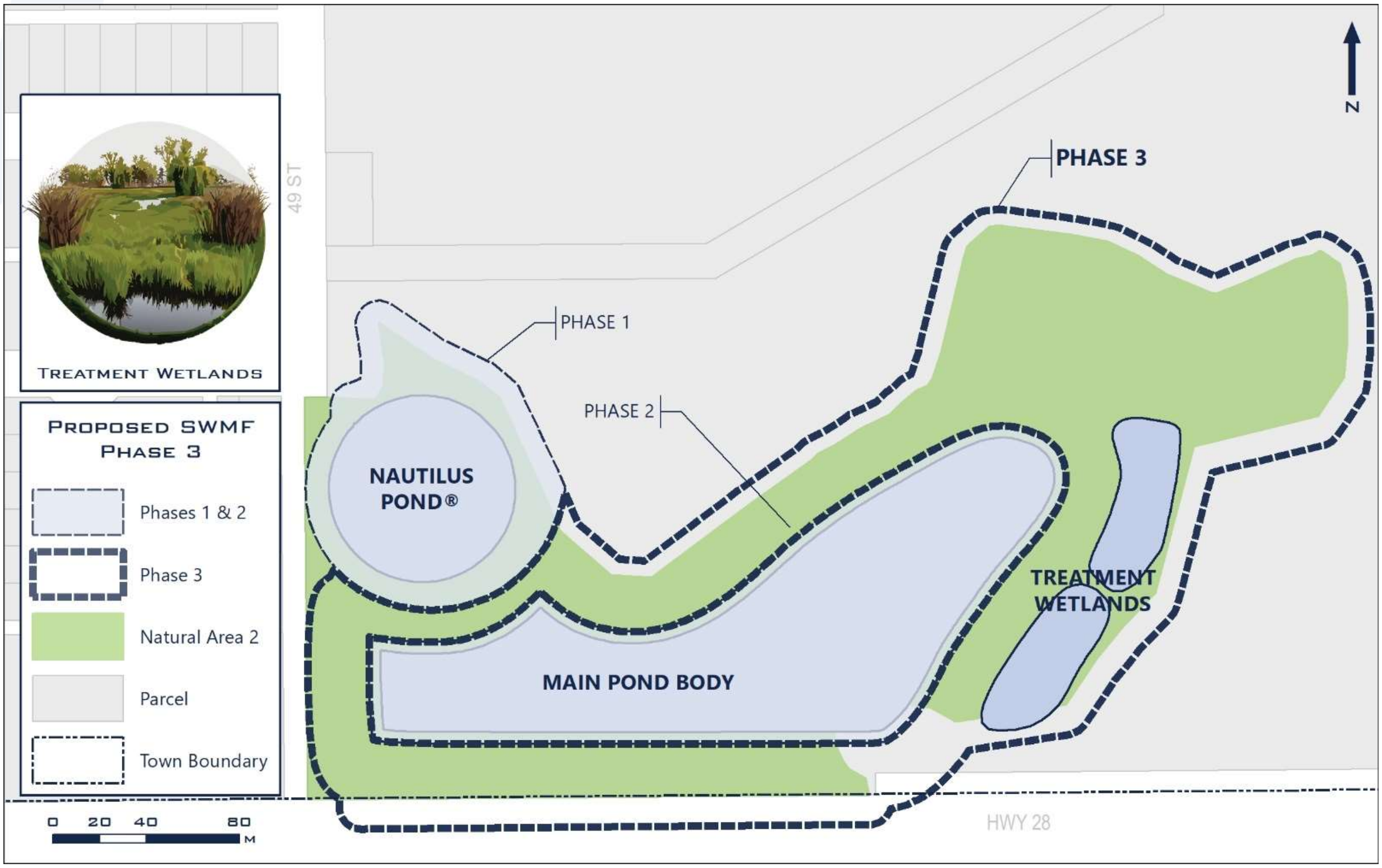

Figure 8.3: Proposed SWMF Phase 3

Through this phased approach, the Town's stormwater management needs can be optimized and balanced with the Town's long-term economic and environmental needs, as well as the sustainability and functionality of the Storm Park facility.

9.0 GRANT FUNDING OPPORTUNITIES

Depending on the option the Town chooses to move forward, there are some potential funding opportunities that should be explored to help fund future project phases.

9.1 Alberta Drought and Flood Protection Program

The Drought and Flood Protection Program (DFPP) is *"a multi-year program to help municipalities and Indigenous communities improve their long-term resilience to drought and flood events."* More specifically, the DFPP will help fund the design and construction of projects that work towards ensuring public safety by protecting public infrastructure from flooding such as, but not limited to:

- Drought and flood proofing or relocation of critical infrastructure.
- Structural measures (i.e. berms, flood walls, bank protection, retention ponds, etc.) intended to protect critical infrastructure and ensure public safety.
- Purchase of property for the purpose of relocation or for access to and/or construction of a project.
- Bio-retention infrastructure designed to increase flood attenuation and reduce the impacts of drought.

More details on full project eligibility will be available in the summer of 2024.

9.2 Alberta Municipal Water/Wastewater Partnership

The Alberta Municipal Water/Wastewater Partnership (AMWWP) provides cost-shared funding to eligible municipalities to help build municipal facilities for water supply and treatment, and wastewater treatment and disposal. Eligible projects can receive up to 75% of project costs (funding is calculated as a percentage of eligible project costs based on the municipality's population when the grant is approved).

Municipalities are invited to contact AMWWP prior to applying to discuss project eligibility.

9.3 FCM Green Municipal Fund

Recently, the Federation of Canadian Municipalities (FCM) changed the funding goals and requirements of the Green Municipal Fund (GMF) to be more focused on *"accelerating a transformation to resilient, net-zero communities."* That said, MAGNA has been informed that FCM will be launching a new funding initiative called Local Leadership in Climate Adaptation that will include grants for municipal projects focused on climate resilience. At this time, the funding criteria are still being developed, but eligible projects *may* include green infrastructure projects focused on stormwater management and flood prevention.

It is expected that this program will be launched in the summer of 2024.

9.4 Investing in Canada Infrastructure Program – Green Infrastructure

Alberta's Investing in Canada's Infrastructure Program (ICIP) funding has been fully allocated; therefore, applications are no longer being accepted at this time.

10.0 NEXT STEPS

The purpose of this *Feasibility Study Report* is to convey the conceptual design philosophy for the proposed nature-based stormwater management facility to the Town. Further revisions to the concept may be considered as per the Town's needs and other regulatory requirements at detailed design. A draft version of this *Feasibility Study Report* was also previously provided to the Town and this final report was revised based on feedback received.

10.1 Risk Identification and Mitigation

Three major uncertainties were identified during this feasibility study, which have the potential to impact project costs, schedule, and quality. MAGNA recommends early and continuous engagement with regulators and other relevant stakeholders to mitigate these risks.

10.1.1 Wetland Disturbance and Facility Location

Any modifications to the Natural Area 2 wetland may be subject to permits and approvals under the *Water Act* and *Public Lands Act*. Alternate facility locations may need to be considered if modifications to Natural Area 2 are not permitted.

MAGNA recommends that a professional biologist and wetland specialist be consulted to advise on the nature, classification, and modifications permitted to the wetland.

10.1.2 Discharge Location

The potential dewatering mechanism for Natural Area 2 and the proposed Storm Park will need to be resolved before next steps and detailed design. Traditionally, a gravity-based discharge (ditch or storm trunk) is the preferred dewatering mechanism for any SWMF. However, irrigation reuse may also be a potential alternative if a gravity-based system is not feasible due to costs or other complications.

The Town's *Wetland Storage Study* (2021) suggested four potential outlet alignment options through adjacent lands outside the Town's boundary into Sturgeon County. Adjacent landowners, the County, and the Province will need to be engaged regarding land acquisition for the outlets and stormwater discharge into water bodies in the County. MAGNA recommends consultation with associated stakeholders to clarify if a gravity-based discharge is possible, and if not, irrigation reuse within the Town may be a potential option.

10.1.3 Conveyance Systems tie-in and Future Upgrades

The *Town of Bon Accord Stormwater Master Plan* (2019) suggested upsizing the Town's existing minor and major conveyance systems to prevent localized flooding within the Town and ensure sufficient capacity towards Natural Area 2 or SWMF. Upgrading the conveyance systems will reduce localized flooding and deliver runoff to the proposed SWMF for treatment and management.

Conveyance systems developed as part of future development will also need to be routed into the proposed SWMF. MAGNA recommends early engagement with landowners and potential future developers to manage this process starting at the early planning stages of any future development.

11.0 CONCLUSION

Stormwater runoff from the majority of the developed areas within the Town of Bon Accord currently discharge towards the existing 'Natural Area 2' located in the southeast portion of the Town. In recent years, the Town has identified issues such as large sediment deposition, decreased stormwater storage capacity, and declining vegetation health within Natural Area 2, as well as flooding in the adjacent developed areas during storm and snowmelt events. MAGNA Engineering Services Inc. was engaged by the Town to conduct a feasibility study and high-level concept design of a stormwater management facility to retrofit the aging Natural Area 2 wetland and increase its stormwater storage and treatment capacities.

Runoff volumes for both existing and future catchment characteristics draining towards Natural Area 2 were estimated using a PCSWMM model, based on the *City of Edmonton Stormwater Management and Design Manual (*2022) and the *Town of Bon Accord Stormwater Master Plan* (AE, 2019). Based on the runoff volumes generated from the existing and future catchment scenarios (50,000 m^3 and 67,000 m^3 respectively), and available area within the Natural Area 2 footprint to locate a SWMF, it is recommended that the Town consider one single SWMF facility for both its current and future stormwater needs to preserve valuable land for future development, and limit maintenance requirements to one facility. Facility sizes were estimated through storage-discharge routing and verified through the PCSWMM model.

Three facility concepts were considered:

1. The first conceptual design option, a traditional storm pond, was modelled with similar characteristics presented in the Town's *Wetland Storage Study* (AE, 2021) to maintain comparability between the area and volume estimates of the presented options.
   - A traditional storm pond receives stormwater runoff, stores it for a few hours or days and slowly releases it downstream. Water quality improvements occur primarily through the gravity-based settling of sediments.
   - Other pollutants such as nitrogen and phosphorous are not reduced in significant amounts.
   - A traditional wet pond also requires a larger normal water level surface area to prevent invasive shallow-water vegetation, as traditional ponds do not support wetland habitats or vegetation.
   - In this case, a traditional storm pond will have at normal water surface area of 4 ha, therefore, at least 4 ha of land to be excavated (from Natural Area 2 or adjacent areas) and lined to become a permanent reservoir.
   - Additional side-slope treatments would also be required to prevent invasive vegetation growth along the edges of the pond.

2. The second conceptual design option presented was a Storm Park.
   - Storm Parks are an emerging class of naturalized stormwater management facilities that balance stormwater quality and quantity management functions with ecological services and placemaking priorities.
   - A Storm Park combines traditional wet pond elements with natural wetland features and park amenities to enhance community integration and provide site-specific, fit-for-use applications such as park space, environment conservation, and system resiliency.
   - A typical Storm Park consists of a proprietary sediment clarifier system called the Nautilus Pond®, a Main Pond for runoff storage, a set of Treatment Wetland Cells including a VFB and a Horizontal Flow Treatment Wetland for secondary treatment and removal of nutrients such as nitrogen and phosphorous, and a Wetland Bench specially designed to support diverse and resilient wetland vegetation through pools and ledges. A low horsepower internal recirculation pump recirculates resident water in the Main Pond through the Treatment Wetland cells and Wetland Bench for vegetation and ecological maintenance.
   - The Main Pond is the primary runoff storage element in a Storm Park and is typically smaller than a traditional pond itself.

- For this study, the normal water surface area of the Main Pond was estimated to be 1.8 ha, which means that only 1.8 ha of land would need to be lined to become a permanent water reservoir.
- The adjacent side-slope areas of the Main Pond are engineered with Wetland Benches to restore and preserve ecological habitat for variety of wildlife, including creating quality habitat for migrating waterfowl, native animals, and other species.
- The Wetland Bench areas will also temporarily flood during storm events to provide additional storage capacity, and quickly drain once the storm subsides to prevent extended inundation.

3. The third conceptual design option presented was a Storm Park without the recirculation pumps and Treatment Wetland cells.
    - Recirculation pumps and treatment wetlands are not included in Option 3.
    - While the Treatment Wetland cells provide valuable secondary treatment and enable non-potable stormwater reuse (such as irrigation), this design option was considered because the Town prefers simplified O&M procedures for their stormwater facilities.
    - The other remaining Storm Park elements are common between options 2 and 3.

Preliminary costs and value-based analyses were conducted and indicated that either option 2 or option 3 might be the most suitable option for the Town. This is due to comparable costs for the three options, while options 2 and 3 offer significantly more environmental and aesthetic value, while retaining and promoting natural spaces and wetland habitats. The Nautilus Pond® in options 2 and 3 also greatly simplifies the sediment removal maintenance process by capturing most of the inflow sediment within a small area. Where traditional wet ponds required periodic dredging of the entire facility to maintain its storage and water treatment capacity, the Nautilus Pond® allows quick and easy sediment removal maintenance since it can be entirely drained to the Main Pond by gravity, and sediment removal can occur from the smaller Nautilus Pond® area.

The comparative analysis indicates that Options 2 or 3 are the best choice for the Town, given the project objectives and Town values and priorities.

To manage the costs associated with a full-build out of the proposed SWMF, a three-phase construction/retrofit approach is proposed for the Storm Park options.

1. The first phase is the construction of a Nautilus Pond® for sediment capture to prevent further sediment deposition in the existing wetland.
2. The second phase is the construction of a Main Pond and underground infrastructure within the facility to provide additional storage.
3. The final step is the reintegration of wetlands and ecological habitat through the inclusion of vegetated benches along the sides and edges of the proposed Main Pond, up to the boundary of the Natural Area. For Option 2 only, this phase will also include the installation of the pumps, associated electricals, and the treatment wetlands.

Several grant funding opportunities were also identified to help the Town offset costs for the design, construction, and maintenance of whichever stormwater management facility option is selected. MAGNA recommends these (and any other) grant funding opportunities be fully explored so that the environmental and aesthetic value needs of the Town can be balanced with its economic priorities.

Three potential risks which may impact project costs, schedule, and quality, were identified during this feasibility study. A clear characterization of the existing Natural Area 2 wetland, facility discharge options and routes, and conveyance systems are required to further develop the proposed concepts for detailed design.

12.0 CLOSURE

This report, titled *Nature-Based Stormwater Feasibility Study,* was prepared by MAGNA Engineering Services Inc. It is intended for the use of the Town of Bon Accord, for which it has been prepared.

The contents of the report represent the best judgment of MAGNA Engineering Services Inc. based on information available at the time of preparation. Any use a third party makes of the report, including reliance on, or decisions made based on it, are the responsibilities of such third parties. MAGNA Engineering Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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If you have any questions about the information provided within this report, or should you wish to review this report with us, please do not hesitate to contact the undersigned.

Sincerely,

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13.0 REFERENCES

Alberta Environmental Protection. 1999. *Stormwater Management Guidelines for the Province of Alberta*. January 1999.

Alberta Environment. 2001. *Municipal Policies and Procedures Manual*. April 2001.

Associated Engineering Alberta Ltd. (AE). 2019. *Stormwater Master Plan*. Report prepared for the Town of Bon Accord. October 2019.

Associated Engineering Alberta Ltd. (AE). 2021. *Wetland Storage Study*. Report prepared for the Town of Bon Accord. September 2021.

EPCOR Water Services Inc. (EPCOR). 2021. *City of Edmonton Design and Construction Standards Volume 3-01: Development Planning Procedure and Framework*. December 2021.

EPCOR Water Services Inc. (EPCOR). 2022. *City of Edmonton Design and Construction Standards Volume 3-02: Stormwater Management and Design Manual*. February 2022.

Government of Alberta. (GoA). 2018. *Alberta Wetland Mitigation Directive*. December 2018.

MAGNA Engineering Services Inc. (MAGNA). 2023. *Stormwater Facility Feasibility Study Background Report*. Report prepared for the Town of Bon Accord. December 2023.

Town of Bon Accord. 2023. *Municipal Development Plan Bylaw 2023-10*. December 2023.

UMA Engineering Ltd. (UMA). 2005. *Drainage Study*. Report prepared for the Town of Bon Accord. September 2005.

APPENDIX

Appendix A: Acronyms

AE	Associated Engineering
AMWWP	Alberta Municipal Water/Wastewater Partnership
DFPP	Drought and Flood Protection Program
FB	Freeboard
FCM	Federation of Canadian Municipalities
GoA	Government of Alberta
GMF	Green Municipal Fund
HWL	High Water Level
HSFW	Horizontal Surface Flow Wetland
ICIP	Investing in Canada's Infrastructure Program
LNWL	Lower Normal Water Level
NWL	Normal Water Level
OCS	Outlet Control Structure
O&M	Operations & Maintenance
SWMF	Stormwater Management Facility
UNWL	Upper Normal Water Level
VFB	Vertical Flow Biofilter

Appendix B: Past and Ongoing MAGNA Storm Park Projects

Dawson's Landing Storm Pond 2A

Chestermere, AB | Qualico Communities | 2019 to 2022 | 90 ha of Serviced Development Area | In Operation

MAGNA was retained to complete the concept design, preliminary design, and detailed design for the Dawson's Landing Storm Pond 2A Stormwater Kidney® (Pond 2A). MAGNA collaborated with Source2Source to execute an innovative **stormwater management facility (SWMF) that functions both as a storm pond and constructed wetland, called a Stormwater Kidney® - the first of its kind in the world**. Pond 2A provides the community with a green infrastructure solution utilizing engineered wetlands and naturalized technology.

- Pond 2A combines traditional storm pond functions with wetland amenities, as well as secondary treatment through a treatment wetland biofilter system.
- The primary stakeholders included the Western Irrigation District, the City of Chestermere, Alberta Environment, and the developer, Qualico Communities.
- Wetland amenities provide ecological, social, and environmental value for the community, and offer diverse habitat for vegetation and wildlife.
- The secondary treatment allows for stormwater to be reused for irrigation, providing flexible water volume management.
- Strict regulations around discharge water quality led to limitations in dewatering infrastructure options. Traditional gravity system (storm pipe or ditch) was not feasible.
- Pond 2A is currently operating with irrigation as the primary means of water volume management in the facility.
- **Figure B.1** shows Pond 2A in operation.

Figure B.1: Pond 2A in operation

Livingston Phase 26 Storm Pond E

Calgary, AB | Brookfield Residential | 2020 to Present | 500 ha of Serviced Development Area | Under Construction

MAGNA was retained to complete the concept design, preliminary design, and detailed design for the Livingston Phase 26 Pond E Stormwater Kidney® (Pond E). MAGNA collaborated with Source2Source to execute an innovative stormwater management facility (SWMF) that functions both as a storm pond and constructed wetland. Pond E provides the community with a green infrastructure solution utilizing engineered wetlands and naturalized technology.

- MAGNA worked closely with the client to ensure the facility could be integrated into the community providing both efficient stormwater treatment and urban green space that preserved the character of the community.
- Pond E provides the regulatory stormwater management functions while also incorporating secondary treatment biofiltration elements, and a large constructed-wetland facility to replace the existing wetland area.
- Stormwater after secondary treatment through the treatment wetland-biofilter elements will also be used to irrigation three local park and school sites, removing the need for expensive potable freshwater.
- The project team completed the work from feasibility study through to detailed design. This project culminated with the completion and submission of the detailed engineering drawings, the Pond Report, and the Wetland Management Plan.

The following figures shows the evolution of Pond E:

- **Figure B.2** shows the wetland areas that existed at the project location.
- **Figure B.4** shows the proposed Pond E concept design.
- **Figure B.4** shows the Pond E concept design overlaid on the wetland (WP27) it will replace, including future ponds and phasing plans.

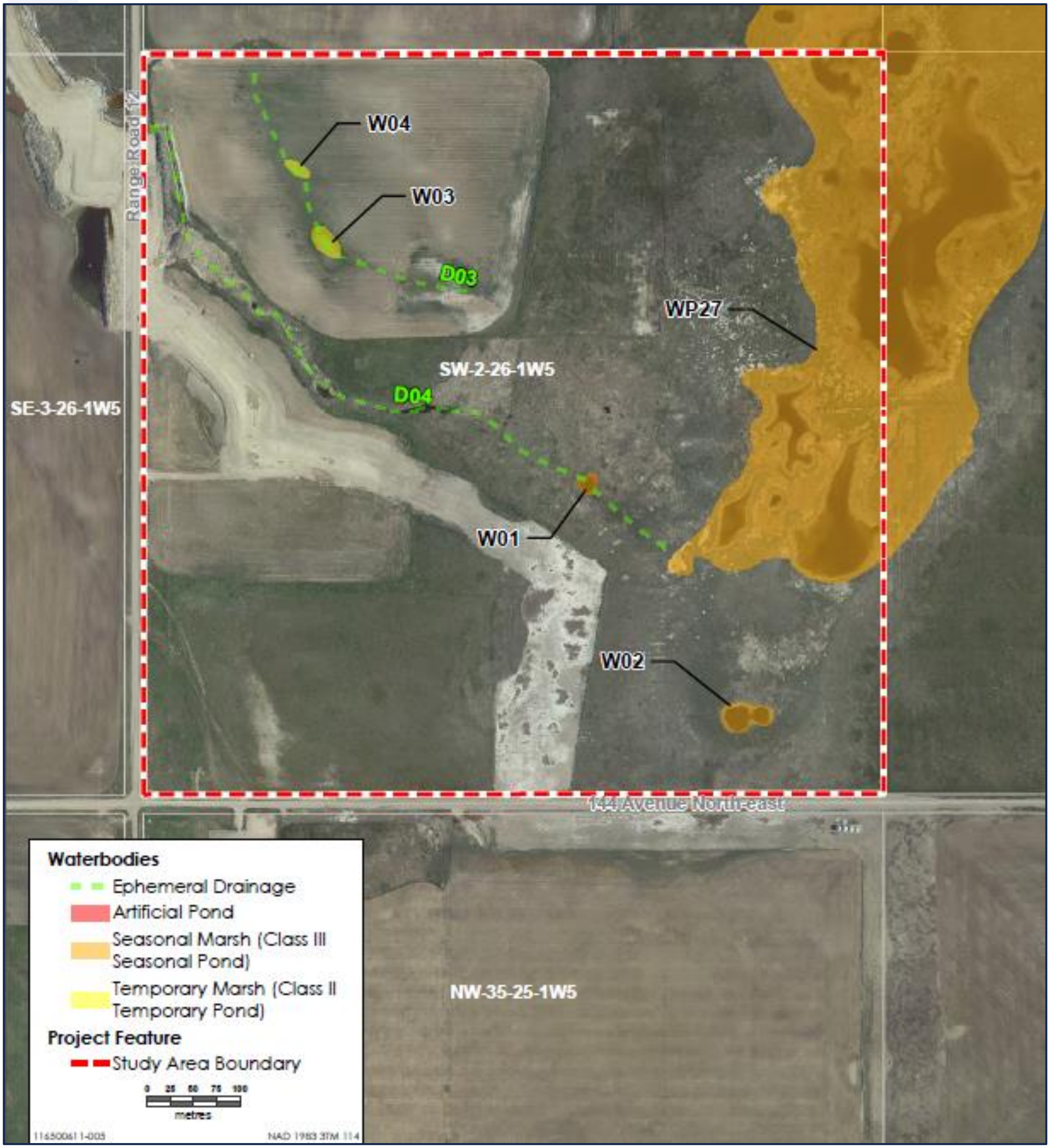

Figure B.2: Existing wetlands in the Pond E project location.

Figure from Livingston Community C BIA, January 2020, Stantec Consulting Ltd.

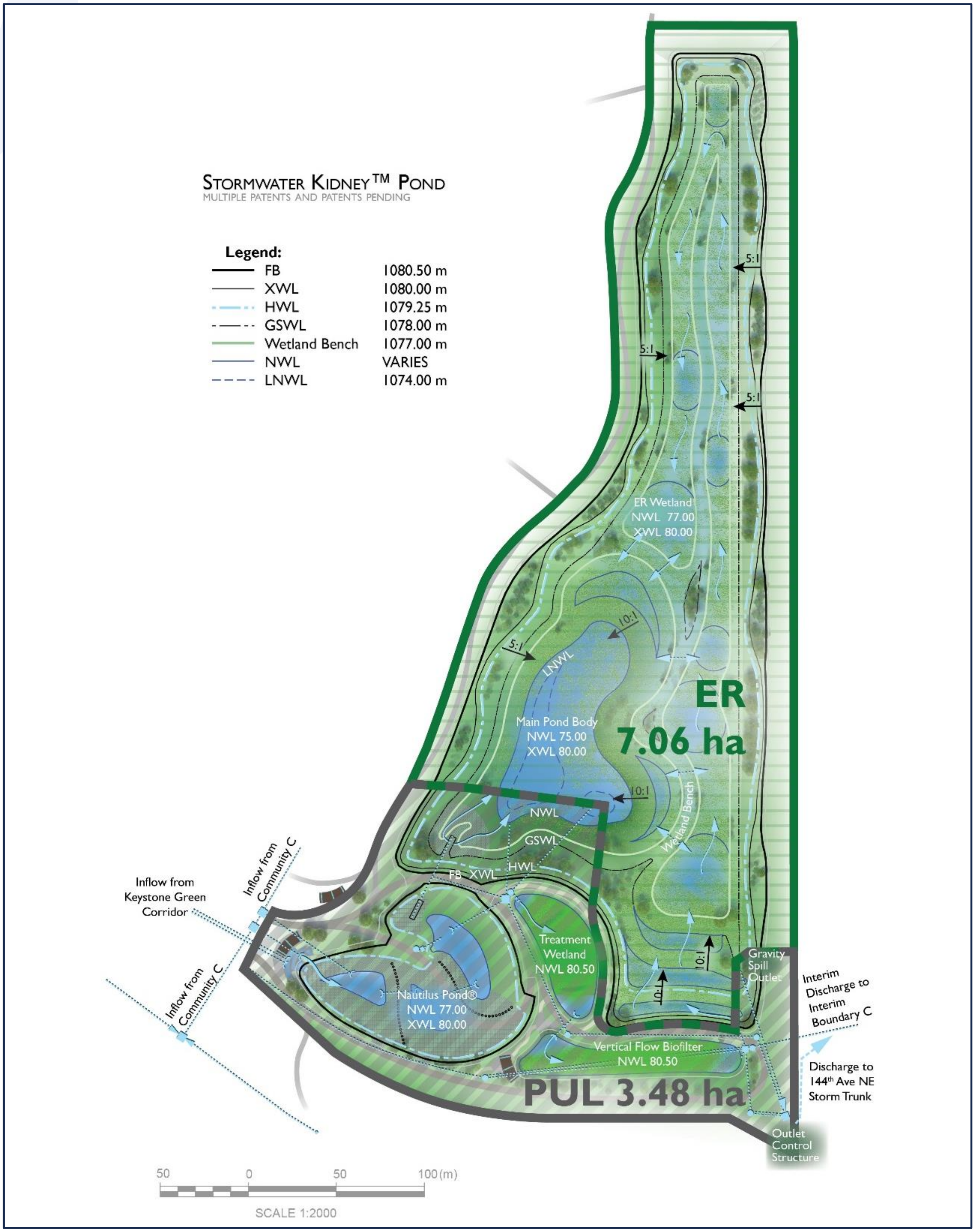

Figure B.3: Pond E Concept Design

Figure from Livingston Phase 26 Storm Pond E Pond Report, MAGNA Engineering Services Inc.

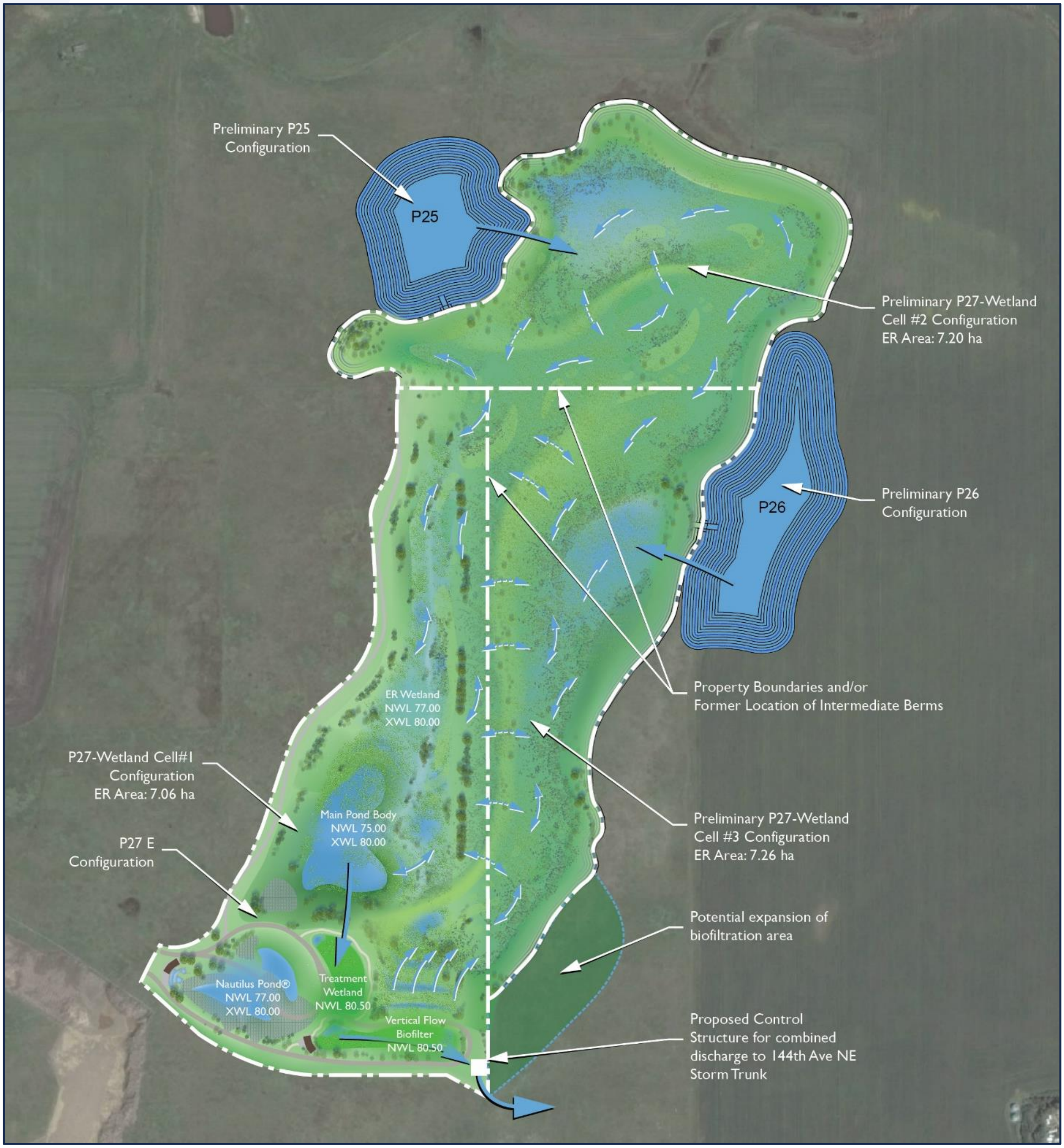

Figure B.4: Pond E (P27E) Concept Overlaid on Existing Wetland (WP27) Footprint and Future (P25E, P26E) Facilities

Figure from Livingston Phase 26 Storm Pond E Pond Report, MAGNA Engineering Services Inc.

Alpine Lands Storm Park P15

Calgary, AB | Dream Development | 2020 to Present | 125 ha of Serviced Development Area | Pre-Construction

Driven by the developer's (Dream Development) pursuit for a unique stormwater facility, the P15 Storm Park design is focussed on amenity driven spaces while functionally unlocking new opportunities for stormwater management, water reuse, and environmental resiliency. The central theme of this storm park is to integrate interactive park spaces into stormwater utility, while also maintaining key natural wetlands and ravines.

- MAGNA worked closely with the client and led concept workshops to resolve planning, architecture, ecological, and engineering needs.
- Storm Park P15 provides regulatory stormwater management functions, secondary treatment biofiltration, and large park-wetland facility for community engagement and environmental value.
- The project team completed the work from feasibility study through to detailed design, expected to begin construction in 2024.

The following figures shows the evolution of Alpine Storm Park P15:

- **Figure B.5** shows the wetland areas that existed at the project location.
- **Figure B.6** shows the proposed concept design, where certain key features of Wetland 5 including the existing topography and native vegetation of the ravine are retained. Wetland 6 is being recreated in an enhanced manner through a constructed wetland bench.

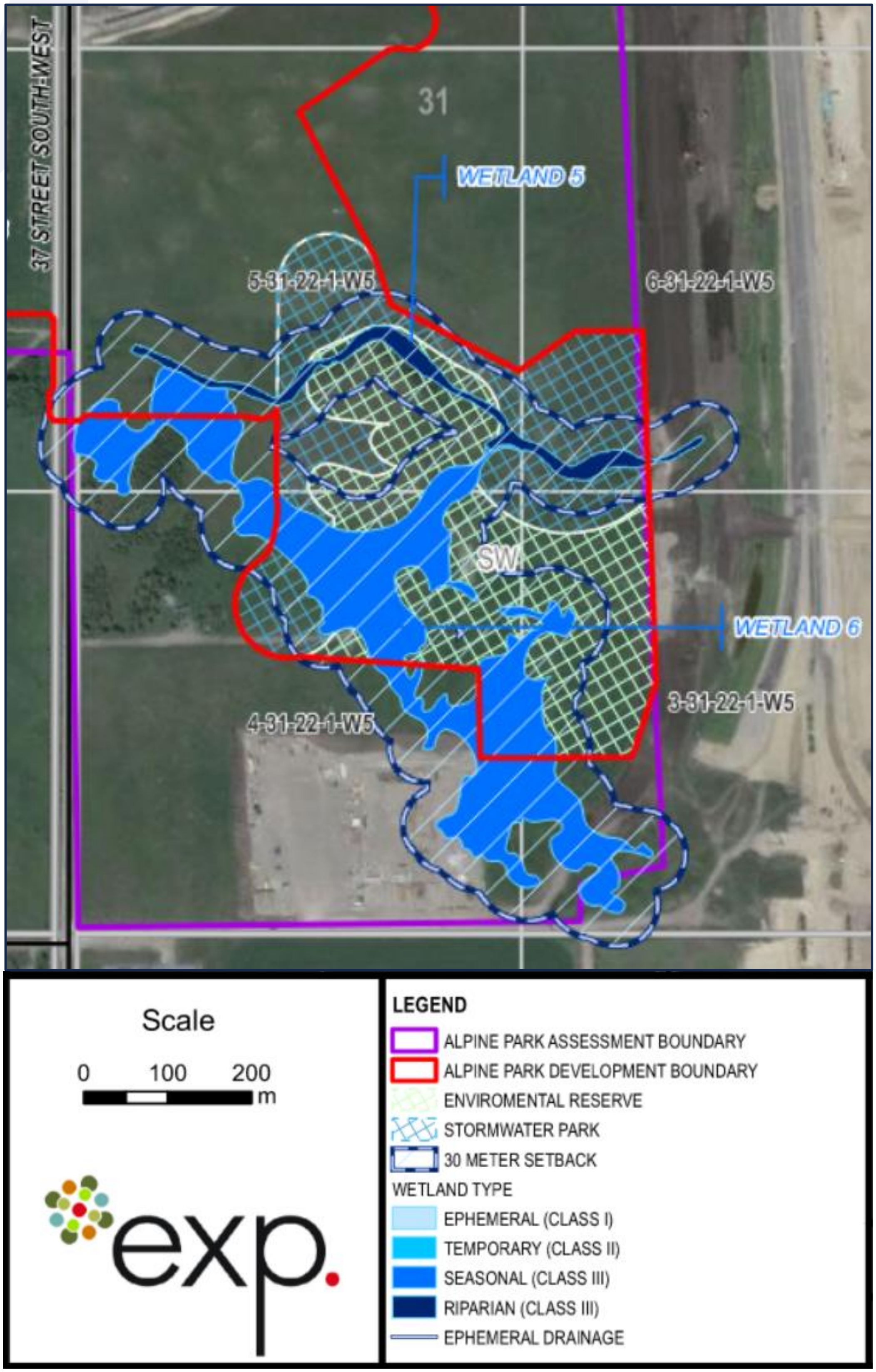

Figure B.5: Existing Wetlands in the Alpine Lands Storm Park P15 Project Location
Figure from BIA for Alpine Park Stage 2; EXP (May 2021)

Figure B.6: Alpine Lands Storm Park P15 Concept Design