SE DESIGN AND CONSULTING INC.

Stormwater Management Plan
Final Report - Issued for Approval

Summer Village of Sunset Point

Sections W26 54-3-5, NW23 54-3-5, and
NE22 54-3-5
Lac Ste. Anne County

Summer Village of Sunset Point
June 2020

The Summer Village of Sunset Point

Stormwater Management Plan

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Executive Summary

SE Design and Consulting Inc. (SE Design) were retained by the Summer Village of Sunset Point (Sunset Point) to conduct a drainage evaluation and develop a Stormwater Management Plan (SWMP) for Sunset Point. Sunset Point is located on the east shore of Lac Ste. Anne in Lac Ste. Anne County (Municipal District No. 13) approximately 60km northwest of Edmonton. Currently, private properties in Sunset Point are being flooded during significant runoff events as there is very little design or continuity for stormwater infrastructure in the Summer Village, and not accommodation of significant external flows from the county. This report by SE Design analyses existing drainage patterns using data from reports, topographical survey and stormwater modelling software. Four key problem areas and the underlying causes are identified, and remediation options are presented.

Drainage plans were developed using a 15m LiDAR DEM surface, aerial photographs, topographic survey and a site visit. Two main catchment areas were found within the project site and flow paths to the lake were identified. Culverts along the flow paths were classified according to their service level and 119 of the 183 surveyed were found to be undersized according to the Lac Ste. Anne municipal servicing standards. The Big Lake Stormwater Management Plan was reviewed and used to set the target release rate for the Sunset Point watershed to 2.5 L/s/ha which is lower than Sunset Point's estimated pre-development release rate.

Based off resident complaints, information from the Village, and internally acquired data, four key problem areas were identified: two culverts that drain the golf course under the railway embankment, the existing dugout that manages water from the golf course, and major drainage courses passing through 49A Avenue and 56 Avenue. Most of the problems can be attributed to undersized culverts and inconsistent flow paths that were not designed to covey major external flows. This is leading to bottlenecks during rainfall events and localized overland flooding.

Hydrological modeling was done using PCSWMM 2019 Professional 2D software. The rainfall runoff rate for the 1:100-year, 24-hour event in the largest catchment (246ha, 0.246), was found to be 17.6L/s/ha; which is higher than regional flood discharge rate estimates, as expected.

Three drainage improvement projects were proposed for construction:

1. An Embankment Drainage System – to rectify the flooding issues on 48 Street due to the external flows from the golf course. Two options were considered for the Embankment Drainage System – ditching along the east side of the embankment and a new culvert crossing to the 48A Avenue south ditch or a stormwater collection system consisting of catchbasins and stormwater pipes. The east ditching option was recommended as it is the most cost-effective for the Summer Village. A 10-meter utility right of way will be acquired from the Alberta Beach Golf Resort to accommodate the proposed large drainage

ditch on the east side of the embankment. The proposed ditch will convey the external runoff to the central point at 48A Avenue, where a large new culvert will allow the flow to cross the embankment into the south ditch of 48 Avenue. The flow path will be improved with ditch and culvert upgrades from this proposed culvert to the lake to better convey the design flow to the lake outlet.

2. A Central Drainage Way – to convey the major drainage course from the north side of 49A Avenue to Lac Ste. Anne. The Central Drainage Way project will include the acquisition of utility rights of way to provide legal access to the drainage flow path so that construction and maintenance can occur. Culverts will be upgraded along 48 Street and 49A Avenue to ensure a continuous flow path. A drainage ditch will be constructed from 49A Avenue north between Lots 7 and 8 and then west along the new utility right of way. Culvert upgrades are recommended for the Sunset Drive recreational trail crossing and the Sunset Drive major culvert crossing to adequately convey the flows to outlet to the lake.
3. 56 Avenue Replacement of Culverts and Ditch Rehabilitation – to accommodate the major external flows from the large external catchment through the neighbourhood and to the lake. Within the existing MR and road right of ways, ditches will be regraded and rehabilitated; and culverts will be upgraded to convey the flows from the large external catchment to the lake. This will reduce flood risks to the residences on 56 Avenue and provide flow continuity along a major drainage path.

The report also made recommendations for stormwater management to accommodate future development in the basin. In particular; preliminary design for overall surface drainage, stormwater management sediment bays and adequate outlets to the lake were provided for two parcels identified by the Summer Village for future residential developments within the Summer Village boundary. Parcel 1 (south) will outlet to the east ditch of Sunset Drive and follow an existing major drainage route to the lake. Parcel 2 (north) will outlet to the Phase II extension of the Central Drainage Way to reach the lake.

SE Design reviewed all existing stormwater infrastructure in Sunset Point including: a complete culvert inventory and assessment, overlying road evaluation, condition rating and recommendations for a maintenance, improvement and replacement scheme. A thorough culvert inspection report is provided for each culvert and as per the culvert replacement scheme, cost estimates are provided as required.

Overall, the cost estimate for the three key drainage resolution projects is **$677,974.** Costs for the drainage projects to accommodate future development are approximately $203,865. The report makes recommendations for the Summer Village to explore cost-sharing strategies with Lac Ste. Anne County and possible municipal grant funding opportunities.

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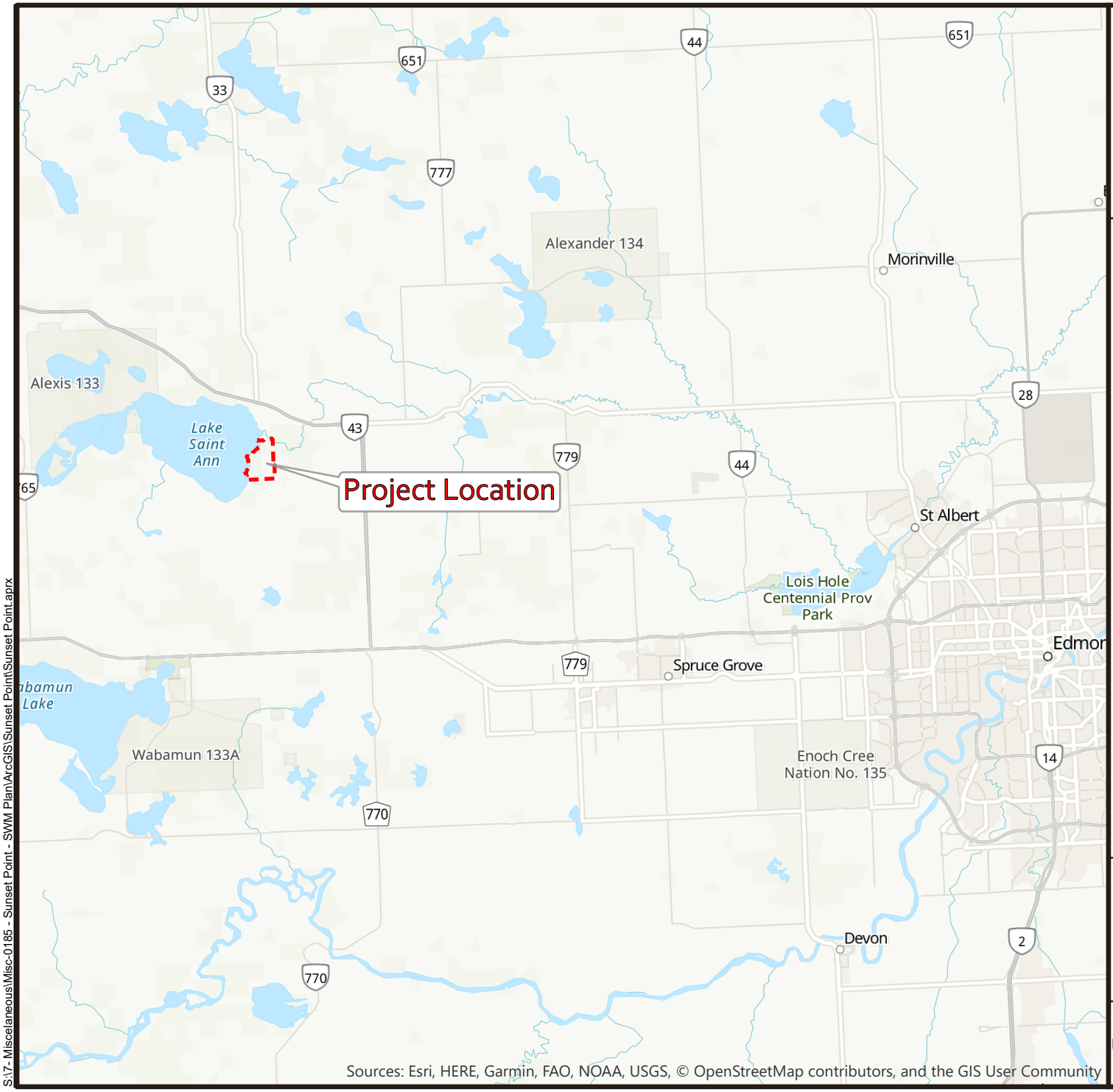
1.0 INTRODUCTION

SE Design and Consulting Inc. (SE Design) were retained by the Summer Village of Sunset Point (Sunset Point) Council to conduct a drainage study and prepare a Stormwater Management Plan (SWMP) for the Summer Village. Sunset Point is situated on the east shore of Lac Ste. Anne in the heart of Lac Ste. Anne County (Municipal District No.13), Alberta. It is located approximately 60km northwest of Edmonton and 16km northwest of the intersection of Highway 16 and Highway 43 (Range Road 23). The project location is shown in ***Figure 1 – Regional Context.*** The region surrounding Lac Ste. Anne, its neighbouring villages and summer villages, and the SWMP project boundary are shown in ***Figure 2 – Lac Ste. Anne Region and Overall Plan Area***.

Lac Ste. Anne County has a rich history due to its fertile agricultural lands, valuable forestry resources and plentiful fish and game. Development along the south shore of Lac Ste. Anne gained momentum in 1912 when the Alberta Northern Rail (ANR) built a railroad from Edmonton to what is now the Village of Alberta Beach. The area was initially developed as a corporate retreat for ANR employees, and eight years later was incorporated as a summer village. Use of the summer village expanded to include other companies and soon the ANR established a regular weekend service to Alberta Beach. Regular rail service further increased the accessibility of the area and enabled the purchase and development of land for private residences and small businesses. Development spread west and north along the shore of Lac Ste. Anne and in January 1959, the Summer Village of Sunset Point was incorporated with 50 residents. According to the 2016 census, Sunset Point currently has 169 permanent residents and 337 private dwellings.

The development process described above is typical for country retreat or resort communities established in the early 20th century. Development begins at the access point and spreads out in such a way to optimize the enjoyment of the focal point or key natural features (in this case, Lac Ste. Anne). This growth mechanism typically leads to a community that is quaint and rustic but deprived of adequate planning and infrastructure design. Stormwater management is often rudimentary and lacking regional scope. Frequently, drainage courses traverse municipal boundaries and stormwater management is an intermunicipal issue. Consequently, summer villages such as Sunset Point tend to present unique drainage issues and stormwater management challenges.



Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Project Boundary

Figure 1

Regional Context

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Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

Municipal Boundary

- Sunset Point
- Alberta Beach
- Val Quentin
- Yellowstone
- Ross Haven
- Alexis Nakota Sioux Nation
- Castle Island
- Project Boundary
- Roadways

Scale: 1:50,000

General Notes:
1. 2018 Aerial photograph provided by Lac Ste. Anne County
2. 2019 Cadastral shown

Figure 2
Lac Ste. Anne Region and Overall Plan Area

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1.1 Project Scope

Landowner complaints as well as several historical and recurring drainage issues within the project area, has led the Summer Village to instigate this SWMP. This report summarizes the findings of a thorough drainage analysis and evaluation, which is focused on identifying the existing drainage conditions and the short-term actions necessary to rectify the major drainage issues. The goal of this project is to resolve some of the key drainage issues and provide the stormwater management infrastructure and framework to have functionable stormwater management system in the future. This report presents preliminary design concepts for discussion and approval purposes. Detailed design is required prior to implementation or construction.

The main objectives of this SWMP are to:

- Review the existing reports, standards, land use maps, natural features, documented complaints and drainage issues within the plan boundary.
- Inventory the existing drainage infrastructure.
- Identify both regional and local drainage patterns and delineate existing flow routes.
- Quantify peak flow rates for design runoff events.
- Evaluate the existing infrastructure and identify issues.
- Propose corrective measures to resolve drainage issues.
- Provide drainage recommendations for future developments.
- Provide preliminary construction estimates.
- Assess opportunities for grant funding and cost sharing.

1.2 Geographic Characteristics

The summer village occupies an area of 1.06 km^2 (106Ha. or 261Ac.) and has the following existing land use distribution:

- 35% Institutional (The Sunset Point Christian Camp)
- 27% Residential (majority is single detached dwellings)
- 20% Undeveloped
- 13% Roads
- 5% Municipal Reserves, Utility R/W, and Railway R/W

The existing and proposed land use concept was detailed in the Municipal Development Plan (MDP) [1] and can be seen in ***Figure 3 – 2007 MDP Land Use Concept.*** There are currently no commercial or industrial developments within the Summer Village. Figure 3 also identifies the naming convention for the key landmarks and geographical features referenced in this report

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Project Boundary
- Sunset Point

Basemap

- Lake Boundary
- Cadastral Lines

Land Use

- Residential
- Future Residential
- Institutional
- Roadway
- Future Roadway
- Sanitary R/W
- Drainage R/W
- Railway R/W
- Environmental Reserve
- Municipal Reserve
- Golf Course
- RV Park
- Lagoon
- Lagoon Buffer

Scale: 1:10,000

General Notes:
1. 2019 Cadastral shown

Figure 3
2007 MDP Land Use Concept

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Lac Ste. Anne
Silver Beach Subdivision
Alberta Beach Golf Resort
The Sunset Point Christian Camp
Woodland Subdivision
Lakeview Place Subdivision
Castle Island
TRSSC Lagoon
Project Boundary
Sturgeon River
Railway Embankment (Existing Recreational Trail)
Ste. Anne Trail (Range Road 31A)
Sunset Drive
48 Street
48A Avenue
49A Avenue
49 Street
54 Avenue
56 Avenue
Lakeview Place
Lakeview Drive
44 Avenue
45 Avenue
47 Avenue
44 Street
43 Street

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The main street in Sunset Point is Sunset Drive which has a north-south orientation adjacent to the shore of Lac Ste. Anne. North of the village, Sunset Drive becomes Ste. Anne Trail, while south of the village Sunset Drive becomes 50th Avenue which passes through the Village of Alberta Beach and the Summer Village of Val Quentin, and once again becomes Ste. Anne Trail when it exists the summer villages into Lac Ste. Anne County.

Sunset Point is accessed either by travelling from Highway 43 to Ste. Anne Trail and entering Sunset Drive (Range Road 31A) at the north side of the summer village, or by taking Secondary Highway 663 to Range Road 32 or Ste. Anne Trail and entering the summer village from the south. Sunset Point is bound to the west by the shore of Lac Ste. Anne and to the south by residential developments in the Village of Alberta Beach. To the southeast Sunset Point is neighboured by the Alberta Beach Golf Resort which includes an 18-hole, par 72 golf course as well as an RV Park. Approximately 1 km east of the golf resort is the TriVillage Regional Sewer Service Commission (TRSSC) Lagoon, which provides sanitary sewage treatment for Sunset Point, Alberta Beach and Val Quentin. To the northeast, it is neighboured by an existing country residential subdivision, Lakeview Place, and to the north is municipal land which includes some residential dwellings, agricultural areas and undeveloped land. The Summer Village of Castle Island is located 0.8km northwest of the Sunset Point boundary.

Lac Ste. Anne is the prominent natural feature within the region, with an area of 54.5km^2 and a 687km^2 watershed. The lake is an open (exorheic) lake that is the second lake in the upper watershed of the Sturgeon River. The river flows into the lake from the southwest and exits the lake just north of Sunset Point, proceeding eastward. The Sturgeon River is part of the North Saskatchewan River Sub-Basin and is a major tributary of the North Saskatchewan River. The Sturgeon River has a subwatershed area of approximately 3,317km^2. The major industrial activities in the subwatershed include oil and gas extraction and aggregate mining. The primary land use in the subwatershed is urban development and agriculture. The area is low-lying and poorly draining, and as a result is susceptible to flooding and drainage issues. Lac Ste. Anne County declared a state of agricultural emergency during the growing season of 2018 and 2019 due to the surplus of precipitation and saturated soils which led to overland flooding.

The Summer Village of Sunset Point lies within the Boreal Plain Ecozone and Boreal Transition Ecoregion. The ecoregion has characteristics of both the Western Alberta Uplands to the west, Aspen Parkland to the east and south, and Mid-Boreal Uplands to the north. The boreal transition ecoregion marks the northern limit of arable agriculture and the southern limit of closed boreal forest. The predominant vegetation includes a closed cover of tall quaking aspen intermixed with balsam poplar, white spruce and balsam fir and a thick understory of mixed herbs and tall shrubs. Poorly drained sites are usually covered with sedges, willow, some black spruce, and tamarack. The region features a topography of hummocky to

kettled plains and is characterized by a mix of farmland, forests and many small ponds and sloughs occupying shallow depressions.

Most of the surface soils are tills (either sandy clay loam, clay loam or silty clay loam) [1], described generally as poorly draining dark grey chernozemic soils or dark grey-grey luvisols [1]. For all landforms, depression areas were poorly or very poorly drained. The Land Suitability Rating System (LSRS) for spring grains indicated that there were slight restrictions or limitations to growth as a result of temperature (insufficient heat units for optimal growth) and landscape slopes (significant enough to incur risk of soil erosion), but in some areas, very severe to unsuitable limitations as a result of poor drainage (excess water in soils limits production).

Figure 4 – Natural Features shows the natural characteristics of the study area as per the 2019 aerial photograph overlaid by the basemap and wetland boundaries obtained from the Alberta Merged Wetland Inventory and seasonally flooded areas delineated from the aerial image. Although there are only three wetlands within the existing Sunset Point boundary, there are numerous wetlands and large wetland complexes within the future municipal boundary.

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Project Boundary
- Sunset Point
- Wetlands

General Notes:

1. 2019 Aerial photograph provided by Lac Ste. Anne County
2. 2019 Cadastral shown

Figure 4

Natural Features

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2.0 DRAINAGE EVALUATION

This section details the methodology and findings of the drainage evaluation, including the existing catchments, flow routes and outlets.

2.1 Drainage Evaluation Methodology

The following activities were undertaken for the preliminary drainage evaluation:

- Cadastral basemap obtained and spatial data files created (CAD/GIS).
- 15m LiDAR obtained and digital elevation model (DEM) created.
- Aerial photographs obtained from Lac Ste. Anne. County, underlaid DEM and basemap.
- Topographic survey of existing drainage infrastructure conducted and processed.
- Catchment and flow paths delineated utilizing PCSWMM Catchment Delineation Tool.
- Site visit conducted to confirm drainage patterns, photograph problem areas, meet impacted landowners and verify flow paths.
- Adjusted catchments and flow paths based on field observations, aerial photography and reported problem areas.

2.2 Drainage Characteristics of the Sunset Point Watershed

The preliminary drainage evaluation identified and delineated the drainage characteristics of the Sunset Point watershed. **Figure 5 – Regional Drainage Patterns** shows two regional drainage catchments that intersect the Sunset Point municipal boundary, a north (1) and south (2) catchment. The two catchments have contours showing relatively flat terrain gently sloping from east to west towards Lac Ste. Anne. North of the watershed boundary, the terrain is more steeply sloped towards the Sturgeon River. The regional drainage catchments have been further divided into subcatchments based on the flow paths, major culvert crossings and outlets to Lac Ste. Anne. Subcatchments, flow paths and outlets are shown in **Figure 6 – Existing Drainage Features.**

The nine identified outlets and corresponding flow paths are labelled *A* to *I* and branches of the major flow paths are identified with roman numerals (A(i), A(ii), B(i), etc.). The areas contributing to each outlet are summarized below:

Outlet	A	B	C	D	E	F	G	H	I	Average
Area (ha)	3.4	10.6	4.8	80.2	4.9	23.1	4.3	25.6	245.8	44.7
Area (ac)	8.4	26.2	11.9	198.1	12.1	57.1	10.7	63.3	607.3	110.6

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Catchment Boundary
- Summer Village Boundary
- Major Drainage Course
- Minor Drainage Course
- 543 Major Contour
- Minor Contour
- 1 / 287 Ha. Catchment Callout

Elevations Table		
Minimum Elevation	Maximum Elevation	Color
723	725	
725	727	
727	729	
729	731	
731	733	
733	735	
735	737	
737	739	
739	741	
741	743	
743	745	
745	747	
747	749	
749	751	
751	753	
753	755	
755	757	
757	759	
759	761	
761	763	
763	765	
765	767	

Scale 1:12,500

General Notes:

1. 2019 Cadastral Shown
2. 2018 Aerial Photograph provided by Lac Ste. Anne County
3. Elevations, Contours, Catchments, and Flow paths Generated with AltaLis (2010) 15m DEM Lidar

Figure 5
Regional Drainage Patterns

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Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Summer Village Boundary
- Existing Minor Drainage Course
- Existing Major Drainage Course
- Existing Storm Subcatchment
- Existing Major Outlet
- Existing Minor Outlet
- 1 / 31.4ha. — Subcatchment Label
- Existing Wetlands and Seasonally Flooded Areas

Scale 1:10,000

General Notes:

1. 2019 Cadastral Shown
2. 2018 Aerial Photograph provided by Lac Ste. Anne County
3. Catchments, and Flow paths Generated with AltaLis (2010) 15m DEM Lidar

Figure 6
Existing Drainage Features

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Culverts along the flow paths have also been named according to their respective outlets (A01, A02, B01, etc.) Outlets, flow paths and culverts are shown in **Appendix A, Figures A-1 to A-14**. On each figure, a data table lists the culverts shown and provides a summary of key culvert attributes such as size, slope, length, material and installation year.

The culverts are shown with a flow arrow to indicate the direction the culvert is graded, with the arrowhead pointing towards the lower end. Flow paths are also shown with a flow arrow. Culverts with flow arrows pointed in the opposite direction of their respective flow paths are back-graded (i.e. water must flow through it from the low end to the high end). These culverts also have a negative slope in the culvert data table. Back-graded culverts often cause localized ponding or flooding at their inlets and can become a bottleneck point in the flowpath.

Culverts have been colour-coded to indicate their service level. The GMSS specifies that culverts shall be designed to accommodate the 1:25-year service level with maximum surcharging to the height of the road subgrade. For this report, the service level of a culvert is defined as the largest rainfall event that can be conveyed by a culvert when fully flowing with no surcharging (ie. flowing at capacity). This definition provides a factor of safety for existing culvert analysis and culvert design. The service level of a culvert is a function of the effective culvert size and slope; inlet and outlet conditions; and the size and land use of the contributing area. The service level of the culverts in this study area have been determined by combining field data with event-based hydrological modelling using the software program PCSWMM.

The service-level colour scheme identified 1:5-year (orange), 1:10-year (yellow), 1:25-year (green) and 1:100-year (bright green) service levels. Culverts that were unable to convey the flow from any design events were identified as “Inadequate” and shown in red. Culverts that had very small contributing areas were identified as having “Negligible Flow” and shown in grey. The service level standard for culverts and ditches in the County of Ste. Anne is a 1:25-year event [1]. Thus, the culverts shown in green are currently meeting the standard service level while culverts shown in yellow, orange and red have increasing degrees of non-compliance with the county standard.

The GMSS specifies the minimum pipe sizing (diameters) for culverts as follows:

Residential Approach	500mm
Industrial Approach	500mm
Roadway Centreline	600mm

The GMSS also specifies that ditch grades are to be a minimum of 0.5% and that the culvert grade should not be less than the ditch grades at the inlet and outlet. Within the study area, 184 culverts were surveyed. 156 of the culverts are residential approach culverts or equivalent. According to the standard, 119 of these culverts are undersized. There are no industrial approaches in the Summer Village and no industrial activities in the future land use plan. Twenty-six of the surveyed culverts crossed roadway centrelines.

2.3 Review of Relevant Documents

Several relevant planning, environmental, and drainage reports for Sunset Point, the Lac Ste. Anne watershed and the Sturgeon River Subwatershed were reviewed for this drainage evaluation. These reports were reviewed for key drainage issues, hydrologic variables and future stormwater management plans. Relevant policies, standards, legislation and bylaws have also been reviewed to determine the required legal framework and approvals for stormwater management in the area. Existing stormwater management plans, area structure plans (ASP's) and intermunicipal development policies were reviewed to develop the stormwater planning framework.

Some of the critical documents reviewed were:

1. Summer Village of Sunset Point – Resolution of Water/Drainage Issues [5]
2. The Lac Ste. Anne County General Municipal Servicing Standards (GMSS) [4]
3. The Big Lake Stormwater Management Plan [6]

The Stewart, Weir & Co. Ltd. (Stewart Weir) report entitled *Summer Village of Sunset Point – Resolution of Water/Drainage Issues* and the accompanying two drawing sets were reviewed with the following goals:

1. To investigate previously identified drainage issues in the summer village.
2. To determine if the report's recommendations/solutions were constructed or implemented.
3. If constructed/implemented, evaluate if the systems/solutions are performing as per design.

The review of the Stewart Weir report and drawings revealed that the previously identified drainage issues in the summer village are nearly identical to the existing drainage issues identified by SE Design. The review suggests that the recommendations/solutions were either not implemented or are not functioning as intended, and the drainage issues have not been resolved.

Lac Ste. Anne County issued their General Municipal Servicing Standards (GMSS) in January 2008 and most recently amended the standards in 2017. Section F describes the standards for Stormwater Management Systems in the county. For major drainage systems, including roads, gutters, lot drainage and detention facilities, the design standard is 1:100-year rainfall event. Section G describes the requirements for roadside ditching and culverts to be designed to the 1:25-year rainfall event, and other drainage design standards.

For future developments in the project area, the post-development runoff rate must be limited such that it does not exceed the pre-development runoff rate. Review of various stormwater management reports for the region has revealed that the majority reference the Big Lake Stormwater Management Plan for the pre-development flow rate and the release rate for future developments. The Big Lake Stormwater Management Plan was an immense study for the Sturgeon River Basin (approximately 3,500 km^2).

The study went to incredible lengths to develop a long-term stormwater management plan for the Big Lake Drainage Basin from Lac Ste. Anne to the North Saskatchewan River. The project was directed by the Big Lake Basin Taskforce, involved eight municipalities and multiple regulatory agencies. A technical committee was created to advise the Taskforce and Associated Engineering with Sameng Inc. were retained to investigate the drainage issues and recommend stormwater drainage guidelines for the basin.

To define the Big Lake Basin's pre-development runoff rates, the technical committee conducted a regional flood-frequency analysis of streamflow data within the basin and within similar adjacent basins. The following table (Table 7.1 from the Associated Engineering Summary Report) summarizes the relationship they found between effective drainage basin area and 1:100-year unit flow rate.

Table 1 – Regional Flood Discharge Rates for the 1:100 Year Flood

Effective Drainage Area (km^2)	1:100 Year Unit Flow (L/s/ha)
1	10.3
10	4.6
100	2.1
1000	0.9

The study area for this report falls within the Big Lake Basin Study Area. Consequently, we believe it would be appropriate to adopt some of the key report findings for the analysis of Sunset Point. Since the project area has 9 outlets, it essentially has many small basins, each with a unique time of concentration. The average effective drainage area to each outlet was 45 ha ($0.7km^2$), less than one square kilometer. Consequently, it is expected that these basins will generate more than 10.3L/s/ha during the 1:100-year event. However, it should be noted that rainfall runoff rates for catchments with effective drainage areas less than $1km^2$ are poorly represented by regional analyses, so detailed hydrological modeling is required for accurate flow predictions. The preliminary 1:100-year flow rate estimates utilizing Table 1 are as follows:

Outlet	A	B	C	D	E	F	G	H	I	Average
Area (ha)	3.4	10.6	4.8	80.2	4.9	23.1	4.3	25.6	245.8	70.1
Flow Rate (m^3/s)	0.04	0.11	0.05	0.83	0.05	0.24	0.04	0.26	2.53	0.72

The Big Lake Basin Study found the acceptable post-development release rate to be 2.5L/s/ha for future developments. This proposed release rate was determined by considering several factors. The study area was modelled with several different release rates between 0.1 and 10 L/s/ha.

The following factors were studied within the Sturgeon River Watershed:

1. Long-term impacts on peak streamflow and lake water-level rise.
2. Size and cost of required stormwater management ponds.
3. Drawdown period (days) of stormwater management ponds.
4. Regulatory requirements.

The recommended release rate of 2.5L/s/ha was a compromise between all these factors to balance the downstream impacts of development with the long-term development costs. Since 2.5L/s/ha is less than the estimated pre-development discharge rate for the outlets in Sunset Point (minimum 10.3L/s/ha), it will be adopted as the release rate for future development in the summer village.

3.0 EXISTING DRAINAGE ISSUES

Through review of resident and landowner complaints, correspondence with the Village Council, topographic survey, site reconnaissance and by conducting a baseline drainage evaluation, we have identified four key areas with existing drainage and flooding issues that need to be addressed promptly. The four key areas are shown on **Figure 7 – Key Drainage Problem Areas.**

3.1 External Flows from Alberta Beach Golf Resort

The railway right of way along the east side of Sunset Point acts as the eastern municipal boundary separating the Summer Village from the Alberta Beach Golf Resort. The 15m (50ft) right of way contains the old railbed embankment, which has an average top width of 8m. It is currently owned by the Summer Village and utilized as a recreational walking and cycling trail. The embankment has ditches on both sides that range in depth from 1-2.5m. On the east side of the embankment, the ditch is poorly-defined. A wide strip of trees and dense shrubbery overlaps the area between the ditch and the golf course. The embankment acts as a berm, and retains water along the east side, leaving the strip of trees continually flooded, with standing water at depths greater than 60cm (2ft) in some locations.

The runoff from the golf course can cross the embankment at two locations, culverts RE01 and RE02. The south crossing, culvert RE01, crosses the embankment approximately 180m south of the 48A Avenue centreline and drains to an existing dugout, as shown in **Appendix A, Figure A-13.** The culvert has a 400mm diameter, 11m length and is back-graded at a 1.1% slope. With a contributing area of 29 hectares, culvert RE01 does not have the capacity to convey the required flow rate. The inadequate service level can be attributed to the large contributing area, the culvert being undersized, and the culvert being back-graded. The inadequacy of RE01 is compounding the ponding on the east side of the railway embankment.

The north railway embankment crossing, culvert RE02, crosses the embankment 125m northeast of the 48A Avenue centreline (behind Lot 51, Block 15) and drains to the ditch on the west side of the embankment, as shown in **Appendix A, Figure A-14.** The existing culvert RE02 is 600mm in size, has 31 hectares of contributing area and is graded from east to west at a slope of 1.8%. With such a large contributing area, the service level of the culvert is inadequate in all scenarios studied. The RE02 culvert inlet (east invert) is too high to allow the standing water in the east ditch to drain across the embankment, so it is directly contributing to the embankment ponding and seepage issues.

The most significant drainage issue related to the external runoff from the golf course is that the downstream flow paths were not designed to convey this large external flow, they were likely only designed to convey internally-generated runoff from the Summer Village. In some cases, the external flow doubles or triples the area contributing to a flow path.

Description of Problem Areas

Number	Description
1	External Flow From Golf Course - Railway Embankment Ponding and Flooding of 48 Street Residences
2	Existing Dugout (Wetland 1) - Golf Course Stormwater Management Pond and Flooding of 48A Avenue Residences
3	49A Avenue Drainage and Accomodating Flow Path F(i)
4	54 Avenue Flooding - Inadequate Culverts

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Drianage Problem Area
- Sunset Point

General Notes:

1. 2019 Aerial photograph provided by Lac Ste. Anne County
2. 2019 Cadastral shown

Figure 7
Key Drainage Problem Areas

Scale: 1:10,000

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The subdivision adjacent to the railway embankment (Woodland Subdivision) has residences along the east side of 48 Street which back onto the railway right of way. These residences experience routine flooding and their rear yards are continuously saturated. The lots are significantly lower than the embankment and some are meters lower than the embankment ditches. With continual standing water along the east side of the embankment and such a large difference in elevation head, it is likely that there is significant seepage through the embankment entering the 48 Street lots and contributing to the flooding and drainage issues. The north culvert crossing the embankment, RE02 (at the back of Lot 51, Block 15) was intended to convey runoff from the east ditch to the west ditch, then the embankment's west ditch would direct the flow south to the 48A Avenue south ditch where it could be effectively conveyed west to the lake. Resident complaints and field observations have indicated that the culvert and ditch system is not performing as intended.

Culvert RE02 is undersized and unable to convey the necessary flow rate. What flow is conveyed by RE02 exits the culvert at velocities greater than 2.2m/s during the runoff events studied. This is a high exit velocity and based on field observations we believe that the water is flowing too quickly from this culvert and is not effectively redirecting to flow south along the embankment's west ditch bottom, but rather appears to be flowing straight (west), overtopping the ditch bank and flowing directly into the adjacent residential lots on 48 Street. This overtopping flow, combined with the embankment seepage, is exacerbating the 48 Street flooding issues. Photos of the railway embankment and the rear lots of the 48 Street residences can be found in **Appendix C, Photos 1-9.**

To address their lot drainage issues, most of the affected landowners have installed property line swales to improve the drainage from the back-of-lots to the 48 Street east ditch. The Outlet F flow paths along 48 Street and 49A Avenue are shown in **Appendix A Figure A-7**. Although the property line swales provide some relief for lot drainage, they inadvertently cause downstream flooding issues by diverting large quantities of runoff to a system that was not sized to accommodate the additional external flows. Photos of the property line swales are shown in **Appendix C, Photos 11-15.**

3.2 Existing Dugout: Golf Course Stormwater Management Pond and Flooding of 48A Avenue Residences

Flow that is conveyed by culvert RE01 enters the existing dugout which was historically used as a borrow pit and stormwater management pond for the golf course. The dugout is on private land and is not managed by the Summer Village. **Appendix C, Photo 10** shows the exiting dugout. Field investigators were unable to locate:

1. An outlet structure (to control the pond water level and release rate).
2. A constructed outlet (a pipe to convey water from the pond to the ultimate outlet, Lac Ste. Anne).
3. An emergency overflow channel.

With no constructed outlet and no control structure, the dugout tends to overtop during the spring melt and floods a portion of the yards on the south side of 48A Avenue (Lots 54-56, Block 14). The large external flows from the Alberta Beach Golf Resort exacerbate the dugout flooding situation. At the existing overflow elevation, the dugout spillover appears to flow west though a rough ditch along the existing power line right of way (Plan 5543 HW), although a significant area is flooded prior to reaching this overflow elevation.

3.3 49A Avenue Drainage and Flow Path F(i)

Many of the existing ditches and culverts along 48 Street and 49A Avenue are being overwhelmed by the external drainage from the golf course that is diverted through the Woodland subdivision. The residents routinely report flooding in the neighbourhood, particularly during the spring melt. The 49A Avenue flow path is shown in **Appendix A, Figure A-6.** Although some culverts and crossings are adequate, there is no consistency along the flow-path, which is leading to bottleneck points at culverts F13, F03-F07.

The F11-F12 culvert crossing consists of two 600mm culvert and meets the required service level. All downstream culverts must have the equivalent or greater capacity to adequately convey the flow. Hence, F07a-F07b (one 400mm culvert and one 600mm culvert, respectively) and F05-F06 (two 400mm culverts) are inadequate bottleneck points and are likely significantly contributing to flooding issues along this flow path. Culvert crossing F03-F04 (two 600mm culverts) have a 10-year service level due to low grades and are also causing a bottleneck at the 49A Avenue crossing during runoff events exceeding 10-years.

On the north side of 49A Avenue, the flow path proceeds through a ditch along the Lot 7-8 property line to the rear of the lots. This ditch is poorly maintained (long grass, dead vegetal debris); thus, it is operating at a service level much lower than its capacity. Upon speaking with the adjacent homeowner, the ditch is often flooded. Site photos of the Lot 7/8 ditch are shown in **Appendix C, Photos 17 and 18**.

At the rear property line, the flow path turns west toward Lac Ste Anne along a ditch that spans from Lot 7 to Lot 6 and into the 5R reserve lot (Block 11). The ditch is poorly graded and maintained. Residents from Lots 7 and 6 report the ditch floods their rear-yards in the spring and has 4-6” of standing water persisting throughout the year. Upon further field investigation, it was determined that the ditch has an overflow elevation that inhibits the westerly flow through the reserve lot to the lake, which is contributing to the standing water along the ditch. Site photos of the rear lot ditch are shown in **Appendix C, Photos 19-22.**

There is currently no drainage right of way to protect these ditches or allow the Summer Village to legally maintain the portions on private property. Presently, permission to access and maintain the ditch is at the discretion of the landowners.

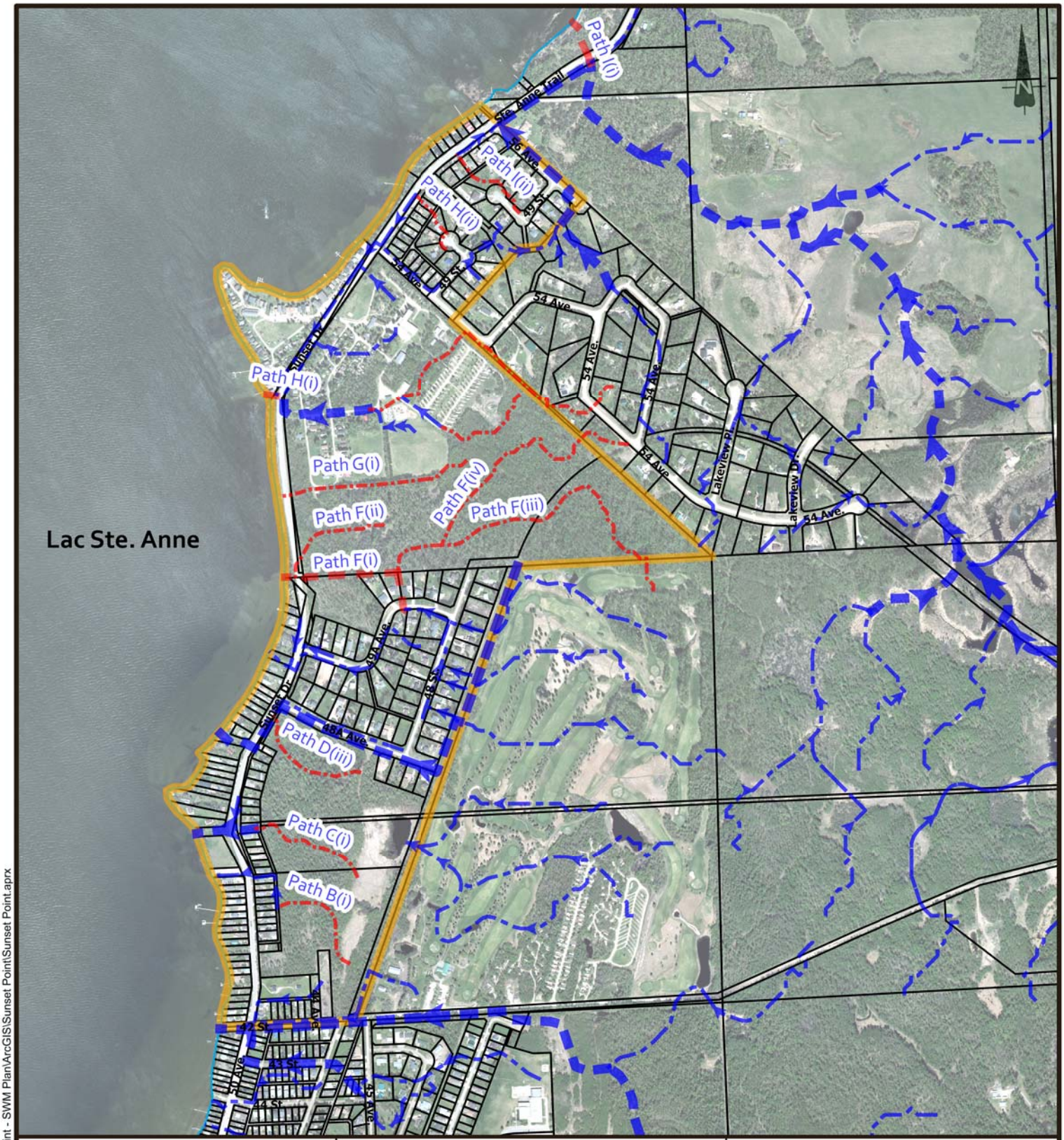
3.4 56 Avenue Major Flow Path

On the north side of 56 Avenue, along the north edge of the existing Summer Village boundary there are two culverts (I02 and I03) that have 400mm diameters, 1% and 0.8% slopes, and span nearly 110m. With 16 ha of contributing area, these culverts simply do not have the capacity required to convey the flow in the north ditch. These culverts span such a long distance because the road has a high point in this segment (a hill), and ditch flow is impractical. Consequently; this area experiences flooding during large runoff events and during the spring snowmelt. Upstream of these culverts is culvert I04 crossing 56 Avenue, which has an adequate service level, and culvert I05 (adjacent to the northeast corner of Lot 21, Block 2) which is inadequate. Culvert I05 causes a bottleneck along the Flow Path I(i) and reportedly causes localized flooding in the rear-yard of Lot 21. 56 Avenue, Flow Path I(i) and the associated culverts are shown in ***Appendix A, Figure A-11***. Site photos of the components of Major Flow Path I(i) through 56 Avenue are shown in **Appendix C, Photos 28-33.**

3.5 Accommodating Outlets and Flow Paths

It is very important for the Summer Village to have access to the lake outlets and drainage routes for maintenance and protection purposes. This is especially critical in areas where future growth and development is planned, and the quantity of runoff is expected to increase. Appropriate zonings to accommodate flow paths and outlets include municipal reserves, public utility lots or rights of way (drainage/utility/roadway). Some major flow paths and lake outlets are presently not appropriately accommodated, as shown in ***Figure 8 – Unaccommodated Flow Paths***. Of the nine outlets to Lac Ste. Anne studied, the majority have been situated within road right of ways. There are three exceptions:

- Major Outlet F drains a large area of the Christian Camp as well as the Woodland Subdivision and it will drain a Future Development Area to the east of the Christian Camp. Due to the present location of the culvert crossing Sunset Drive, the flow path to the lake appears to pass through a privately-owned lot rather than within the road right of way which lies just south of the flow path.
- Major Outlet H drains a large area of the Christian Camp along with areas as far north as 54 Avenue but based on the current location of the culvert crossing Sunset Drive (D01) it appears that the flow path to the lake is through a privately-owned lot rather than within the road right of way which lies just south of the flow path.
- Major Outlet I could not be located. It appears that the flow path enters a wetland on the east side of Ste. Anne Trail, but a culvert crossing could not be located, so it is unclear whether this flow path has been accommodated.



Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

Minor Flow Paths
- Accomodated
- Unaccomodated

Major Flow Paths
- Accomodated
- Unaccomodated

General Notes:
1. 2019 Aerial photograph provided by Lac Ste. Anne County
2. 2019 Cadastral shown

Figure 8
Unaccommodated Flow Paths

Scale: 1:12,000

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Major Flow Paths should typically also be accommodated in a drainage swale or ditch and contained within appropriate land use zone. In Sunset Point, the majority of the major flow routes are accommodated by roadway rights of way. As previously described in Section 3.3, Flow Path F(i) is one major flow path that is not presently accommodated with appropriate land use zoning.

Minor Flow Paths are typically accommodated through site grading and managed within roadway ditches. The majority of the unaccommodated minor flow paths shown in Figure 8 fall within undeveloped parcels of land. These minor flow paths are not of concern at this time but should be addressed at the time of development and site-specific stormwater management planning. However, two existing minor flow paths do present some interest for further investigation, should complaints of poor drainage or flooding arise.

- Minor Flow Paths H(ii) and I(ii) drain a portion of the two 49 Street cul-de-sacs and flow northwest from the tip of the cul-de-sacs directly through privately-owned properties (Lot 19 Block 4 Plan 4635TR and Lot 22 Block 2 Plan 142 2685, respectively). After flowing through these lots there is an opportunity to divert the flow either north or south along the rear-lot lanes; but this does not appear to be utilized. As shown in **Figure A-11**, Path I(ii) is further conveyed northwest through culvert I08 which crosses the lane and outlets to privately-owned Lot 3 (Block 2, Plan 621TR) and flows through the lot to culvert I07 then proceeds to Sunset Drive. Path H(ii) does not have culverts directing the flow toward Sunset Drive, but the LiDAR indicates that the flow would be in that direction approximately through Lot 3 (Block 4, Plan2060MC These minor flow paths would typically be of little concern; however, as they both drain a portion of roadway, they will be part of the major drainage system during a large runoff event. Further investigation along these two flow paths is recommended.

4.0 HYDROLOGICAL MODELING

The software PCSWMM 2019 Professional 2D (v7.2.2785, SWMM v5.0.013) was used to develop a hydrological model to represent the drainage in Sunset Point. The software was used to evaluate the quantity of runoff generated from the contributing areas during design rainfall runoff events. ***Table 2 – Summary of Adopted Hydrologic Parameters*** lists some of the key parameters and the range of values used in the model. Parameters such as areas, lengths, widths and slopes as well as overland flow transects were extracted from the LiDAR DEM surface data. Other parameters were selected to best reflect the existing conditions as determined by examining the recent aerial photographs, studying land use maps and identifying registered land uses from the cadastral basemap.

Table 2 – Summary of Adopted Hydrologic Parameters.

Parameters	Lower	Upper
Subcatchments		
Impervious (%)	15	85
N Impervious	0.011	0.02
N Pervious	0.15	0.4
Depression Storage, Impervious (mm)	2.0	3.0
Depression Storage, Pervious (mm)	3.5	6.0
Zero Impervious (%)	-	25
Lake/Wetlands		
Impervious (%)	-	100
N. Impervious	-	0.01
Depression Storage, Impervious (mm)	0	-
Green-Ampt Soil Parameters		
Suction Head (mm)	202.54	219.96
Conductivity (mm/hr)	1.02	6.59
Initial Deficit (fraction)	0.262	0.283
Overland Flow Paths (Irregular Cross-Sections)		
Roughness	0.035	0.075
Pipes (Culverts – Circular Cross-Sections)		
Roughness	0.012	0.022

The percent imperviousness for undeveloped land is typically 10-20%, and for rural residential properties it is 10-30%. Hence 15% was adopted for undeveloped land and the golf course, 20% for rural residential areas and 85% for roadways. Depending on their design, golf courses can have high imperviousness due to well-maintained grass and well-watered (saturated) soils. Hence, the runoff coefficient from a golf course can be considerably higher than undeveloped land, reserve or park space. Golf courses can also have significant on-site storage due to landscaping and water features. Hence there is some sensitivity in the model with respect to the golf course parameterization.

The Manning's roughness coefficients (N) and depression storage were selected to represent a range of overland flow surfaces. For permeable surfaces, lawns were assigned lower values, pasture grasses average values and forests the higher values. For impermeable areas, the manning coefficient for asphalt (0.011) was used and a higher value of 0.02 was used for catchments that included rural residential developments. Zero impervious was kept at the default value of 25%.

Within the study area there were numerous wetlands and seasonally flooded areas, especially in the golf course. PCSWMM's storage creator tool was used to generate storage nodes from the DEM to provide an estimate of potential storage. This tool identifies pits in the DEM, then creates and assigns storage curves and storage units. Thirteen storage nodes were identified and created. Total storage depths ranged from 0.5m to 3.5m with an average depth of 1m. Maximum volumes stored during the 1:25-year event ranged from 750m^3 to 5,200m^3, though none of the storages exceeded 44% full for this event.

The Green-Ampt soil parameters used were consistent with organic (peat) very poorly draining soils (similar to clay), sandy loam and fine sandy loam soils that are well drained, (similar to a sandy clay loam), as identified in the Alberta Soils mapping and descriptions. For the predicted open channel flow paths – including natural (irregular) channels and constructed ditches, polygons were used to differentiate the Manning's roughness coefficient in different zones of the channel including the bottoms and banks. The roughness coefficients varied depending on the vegetation in the channel zone observed during site visits or inferred from the aerial photographs. Maintenance of the constructed ditches varied considerably between locations; hence, they were assigned a coefficient of 0.030 (clean and straight but some weeds and stones) to represent average conditions. Natural (irregular) drainage paths were assigned roughness coefficients ranging from pasture grasses with some weeds and stones (0.035) to forested areas with dense underbrush (0.1) while the channel banks were assigned 0.075 for weedy and rough terrain.

4.1 Summary of Basin Characteristics

Statistical analysis of the basin parameters for the hydraulic model and field observations identified the following basin characteristics:

a) Most of the outlets have small contributing areas (≤1km^2) except for outlet I which has a significant offsite area contributing external flows to the major flow path. (2.45 km^2)
b) Channel banks are poorly defined along the major flow paths.
c) The basin has significant storage capacity in offsite/external contributing areas but very little internally.
d) The slope across catchments/overland flow (4.5% average) was moderately high.
e) The slope along the existing drainage paths/natural channels (1.25% average) was high.
f) The slope along the existing culverts and ditches (1.84% average) was high.

These basin characteristics are all indicative of a smaller catchment with a short time of concentration; thus, we expect to model peak flow rates that are larger than anticipated from the regional analysis.

4.2 Event-Based Hydrological Modelling

An event-based modelling approach was adopted for this study, which is considered appropriate when determining peak flow rates and evaluating service levels. The design storms used in the PCSWMM model were SCS Type II distributions, as is recommended for the region. The SCS storm was generated using Environment Canada's short duration Rainfall Intensity-Duration-Frequency Data - Return Period Rainfall Amounts for Edmonton Blatchford Station and 24-hour durations were used for each storm [7]. The data was was collected from 69 years of monitoring between 1914 and 2015. Infiltration was calculated using the modified Green-Ampt method. The PCSWMM model was used to estimate rainfall runoff for the 5, 25 and 100-year return period storms. A thirty-six-hour drawdown period was provided to allow for the largest possible runoff volumes to reach the storage areas. The peak flow rate of runoff generated for each rainfall event is summarized in ***Table 3 – Estimated Rainfall Runoff Rates at Lake Outlets.***

Table 3 – Estimated Peak Rainfall Runoff Rates at Lake Outlets

Outlet	Contributing Area (ha)	1:5-Year Peak Runoff Rate (m^3/s)	1:25-Year Peak Runoff Rate (m^3/s)	1:100-Year Peak Runoff Rate (m^3/s)
A	3.4	0.27	0.39	0.48
B	10.6	0.29	0.45	0.59
C	4.8	0.25	0.39	0.51
D	80.2	0.66	0.94	1.90
E	4.9	0.38	0.79	1.06
F	23.1	0.76	1.39	2.03
G	4.3	0.29	0.44	0.59
H	25.6	1.04	2.09	3.18
I	245.8	2.09	4.32	5.95

The rainfall runoff rates predicted by the PCSWMM model were higher than the rates anticipated from the regional flood discharge rate estimates. This was expected due to the size of the effective drainage areas, since smaller catchments (<1km^2) are poorly represented by regional analyses. Higher runoff rates are also consistent with the basin characteristics described in Section 4.1, which is consistent with a small catchment and short time of concentration. Outlet I has the largest contributing area (2.45km^2). Accordingly, its peak rainfall runoff rate estimated by the model is most similar to the regional runoff estimate. Other peak runoff rates for critical culverts and drainage paths are provided as needed throughout Section 5.0.

5.0 DRAINAGE IMPROVEMENT PLAN

This drainage improvement plan is focused on resolving the key drainage issues identified in Section 3.0 and providing a prioritization scheme for upgrading the existing stormwater management infrastructure. The three proposed major improvement areas shown on ***Figure 9 – Proposed Major Drainage System Improvements*** are:

1. Construction of Embankment Drainage System (Resolving the external flows from the Golf Course)
2. Construction of Central Drainage Way (49A Avenue to Lac Ste. Anne)
3. Replacement of Culverts and Ditch Rehabilitation (54 Avenue)

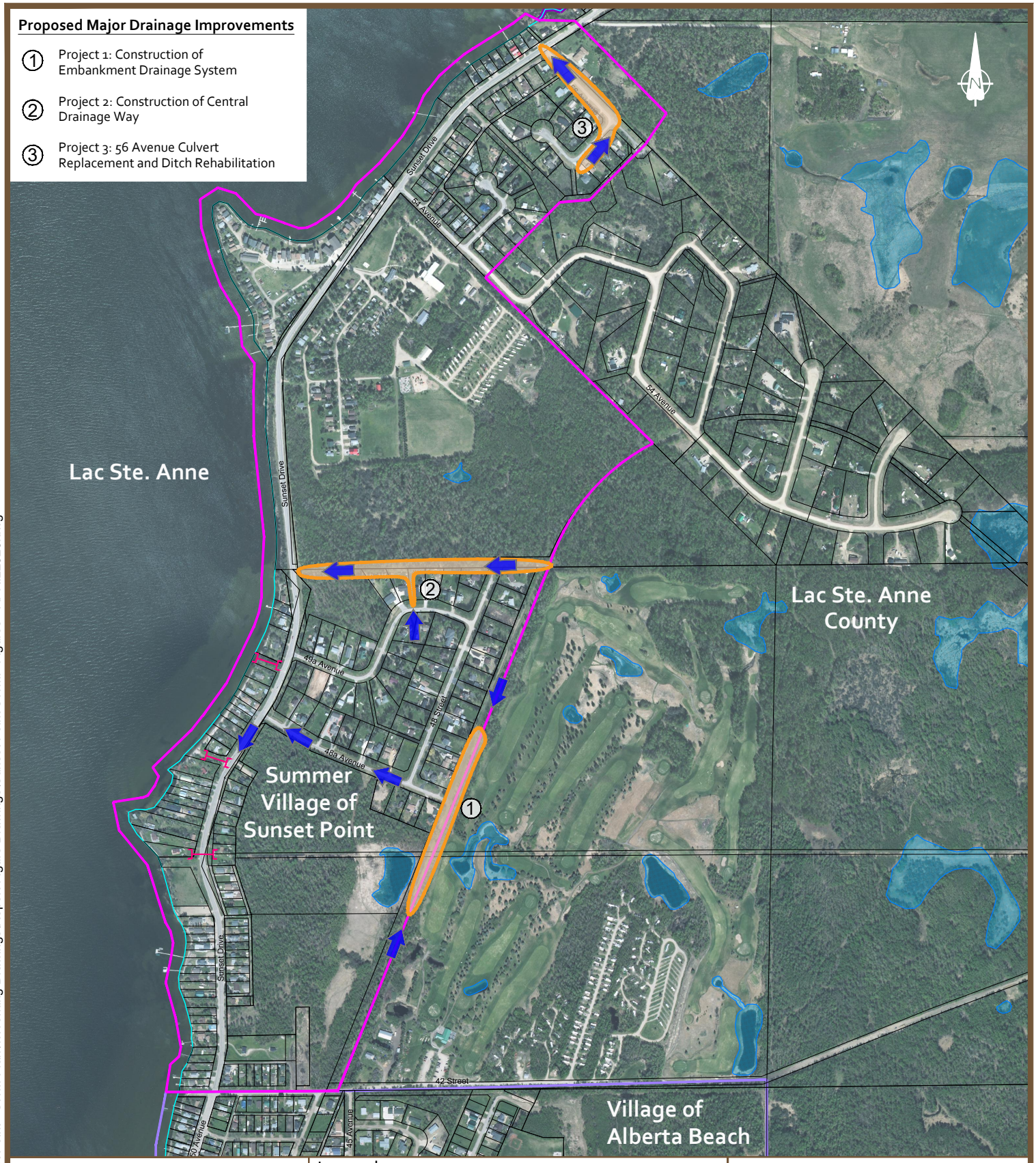
5.1 Project 1 - Construction of Embankment Drainage System

The external flows from the Alberta Beach Golf Resort need to be collected and conveyed across the railway embankment and discharged to a flow path that can accommodate the sizeable flow. This can be achieved by designing and constructing a drainage system with the following specifications:

- Accommodates the 1:25-year rainfall runoff event flow rate.
- Spans at minimum from culvert RE01 (the dugout) to RE02 (rear of 48 Street Lots 50 and 51) to resolve the drainage issues for both the Woodland Subdivision (48 Street, Section 3.1) and the dugout/48A Avenue residences (Section 3.2).
- Collects the runoff from the golf course and redirects the runoff to an appropriate flow path
- Allows the runoff to traverse the Summer Village along an adequate outlet to the lake.

Two design options were considered for the drainage system:

1. **Ditching Along the East Side of the Railway Embankment:**
   a. Remove and dispose of existing culverts RE01 and RE02.
   b. Construct a ditch on the east side of the railway embankment (west side of the Golf Course) that collects and conveys the external flows toward 48A Avenue.
   c. Install a major culvert crossing the embankment that outflows to the south ditch of 48A Avenue.
   d. Install new culverts and regrade the ditch along the 48A Avenue south flow path (Flow Path D(i), Figure A-4) to accommodate the additional flows from the embankment to Major Outlet D. Provide erosion control as needed around culverts and ditches when slopes exceed 2.0%.
2. **Stormwater Collection System on the East Side of the Railway Embankment:**
   The proposed stormwater collection system will be constructed in two phases.
   Phase 1: North of 48A Avenue
   a. Remove and dispose of existing culvert RE02.



Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Sunset Point Boundary
- Albert Beach Boundary
- Seasonally Flooded Area
- Improvement Area
- Existing Outlet Culvert
- Proposed Flow Direction

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 9

Proposed Major Drainage System Improvements

Scale 1:10,000

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b. Install a storm collection system along the bottom of the east ditch of the railway embankment, starting in-line with the south ditch of 48A Avenue and terminating 120m north (near RE02).
c. Install a catchbasin at the north end of the main line and a catchbasin manhole at the south end of the main line. The catchbasins will collect runoff from the bottom of the embankment east ditch. The south catchbasin manhole will also include a control structure to prevent water from crossing the embankment if needed.
d. Install two inlet structures along the golf course property line (east of the embankment), in-line with RE02 and the 48A Avenue south ditch. The inlet structures will be flared end sections with trash grates. Their openings shall face the golf course (east) and be aligned to the direction of the existing flow paths.
e. Connect the inlet structures to the catchbasins on the main storm line.
f. Install an outlet pipe from the south catchbasin manhole to the south ditch of 48A Avenue.
g. Install new culverts along the flow path (Flow Path D(i), Figure A-4) to accommodate the additional flows from the embankment to Major Outlet D.

Phase 2: South of 48A Avenue

h. Remove and dispose of existing culvert RE01.
i. Extend the main storm line along the east ditch of the railway embankment from the existing catchbasin manhole at 48A Avenue south to the location of RE01. This section of line will require an intermediate catchbasin as the standard for maximum storm pipe length is (120m).
j. Install a catchbasin at the south termination point.
k. Install a new inlet structure at the golf course property line (east of the embankment), in-line with RE01. The inlet opening shall face the golf course (east) aligned to the existing flow path.

Comparison of Options

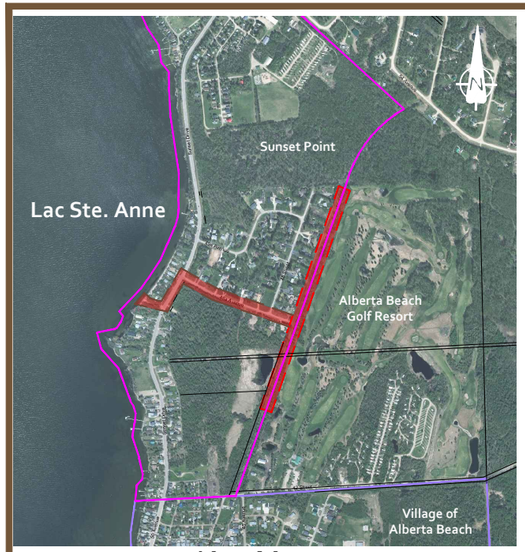
The approximate budget to resolve Problem Area 1 is $400,000. The two options described above are within this budget and both meet the requirements of the identified specifications. To determine which option to recommend, we evaluated the benefits and disbenefits of each. SE Design:

- Conducted preliminary engineering for feasibility and pricing.
- Hydrovaced multiple locations in the embankment to locate existing water line. Soil conditions were observed to be poor and saturated. Hydrovac holes repeatedly sloughed and did not appear to have favourable conditions for trenching.
- Engaged key stakeholders in the decision-making process (the Summer Village and the owner/operator of the Alberta Beach Golf Resort). The Golf Resort owner was hesitant to support Option 1 due to the loss and destruction of trees along the west side of the course. However, once presented with potential benefits of improving the overall course drainage, support and cooperation for Option 1 was obtained.

Option Comparison Summary	**Option 1**	**Option 2**
Resolves the Golf Course and embankment external flow drainage issue	☑	☑
Resolves flooding of the Woodland Subdivision and 48A Avenue south	☑	☑
Restricts flow from embankment	☑	☑
Improves flow path D(i) from the embankment to the lake (culverts, ditches) to meet the 1:25-year service level and convey the offsite golf course flows	☑	☒
Integrates with the existing drainage infrastructure (culverts, ditches)	☑	☒
Water and soil conditions are suitable for proposed construction	☑	☒
Minimizes implementation and construction management costs	☑	☒
Minimizes long-term operations and maintenance costs	☑	☒
Allows for control of flow rate from embankment	☒	☑
Avoids issue of landowner cooperation (land acquisition, access permission)	☒	☑

The above summary shows that for almost the same cost, Option 1 offers significantly greater benefits than Option 2. Two disbenefits were identified for Option 1: flow control and landowner cooperation. Although Option 1 does not allow for flow control, we believe that with the proposed downstream improvements to the D(i) flow path (culvert and ditch improvements); the flow path will be adequate to convey the flow from the golf course without causing adverse flood risk. Additionally, during the design 1:25-year event, the 800mm culvert in the embankment will provide some restriction of the flow from the golf course (as it will have approximately 0.5m head). Landowner cooperation introduces a degree of risk for the project as land acquisition is required for the utility right of way along the east side of the embankment. However, we are confident that with the strong commitment and support that has been obtained from the key stakeholders, this risk has been minimized. SE Design recommends Option 1, an East Ditch along the Railway Embankment and improvement of the D(i) flow path. The components of the proposed embankment drainage system are shown in ***Figure 10 – Project 1: Embankment Drainage System.***

The recommended sizing and grading for the proposed east ditch and culvert replacements along Flow Path D(i) (48A Avenue south ditch and Sunset Drive crossing outlet) are listed in ***Table 4 – Preliminary Ditch Sizing and Grading for Project 1: Embankment Drainage System*** *and* ***Table 5 – Preliminary Culvert Sizing and Grading for Project 1: Embankment Drainage System*** below. The sizing and grading recommendations in **Tables 4 and 5** are preliminary and will be subject to revision during the detailed design; however, these represent minimum size recommendations to accommodate the proposed flows from the embankment, so all alternatives should meet or exceed the required flow capacities. Table 4 shows the worst-case segments for each section of the east ditch, with the smallest longitudinal grades. The longitudinal grades in the ditch were designed to approximate the longitudinal grade on the top of the berm. Contributing areas for the north and south legs of the proposed ditch were determined at the junction point where the two legs merge and cross the embankment.



Key Map
N.T.S

Lac Ste. Anne

Sunset Drive

Install New Culvert *P CSP-D01*

Install New Culvert *P CSP-D02*

Remove Existing Culvert *E CSP-D03*. Replacement to be Determined in Detailed Design

49A Avenue

48A Avenue

Woodland Subdivision

Install New Culvert *P CSP-D04*

Install New Culvert *P CSP-D05*

Install New Culvert *P CSP-D06*

Install New Culvert *P CSP-D07*

48 Street

Remove and Dispose Existing Culvert *E CSP-RE01*

Existing Dugout

Remove and Dispose Existing Culvert *E CSP-RE02*

Railway Embankment

Construct South Leg of East Ditch

Construct North Leg of East Ditch

Install Major Culvert Crossing Embankment from East Ditch to 48A Avenue South Ditch (*P CSP-001*)

Alberta Beach Golf Course

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

Improvement Area Boundaries

- Embankment East Ditch
- 48A Avenue Upgrade
- Sunset Point Boundary
- Alberta Beach Boundary
- Proposed Ditch Improvements
- Existing Culverts
- Proposed Culverts
- Existing Flow Direction
- Proposed Flow Direction

Scale 1:2,500

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 10

Project 1: Embankment Drainage System

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Culvert D03 (E CSP-D03), the existing culvert at the Sunset Drive recreational trail crossing, is recommended for removal as it is currently an obstruction in the flow path and limits the flow rate. Treatment of this crossing to accommodate both the flow path and the trail shall be determined in the detailed design.

Table 4 – Preliminary Ditch Sizing and Grading for Project 1: Embankment Drainage System

				Recommended Ditch Geometry				
Component	**Contributing Area (ha)**	**Peak Flow (m^3/s)**	**Peak Velocity (m/s)**	**Longitudinal Grade (%)**	**Base Width (m)**	**West Backslope (X:1)**	**East Backslope (X:1)**	**Normal Flow Depth (mm)**
P East Ditch N	38.59	0.25	0.50	0.20	0.5	3.0	2.5	343
P East Ditch S	21.25	0.16	0.49	0.25	0.5	3.0	2.5	266

Table 5 – Preliminary Sizing and Grading for Project 1: Embankment Drainage System

Component	**Contributing Area (ha)**	**Peak Flow (m^3/s)**	**Peak Velocity (m/s)**	**Recommended Minimum Pipe Size (mm)**	**Recommended Minimum Slope (%)**
P CSP- 001	66.04	0.93	2.24	800	2.5
P CSP-D07	68.80	0.98	2.85	800	2.0
P CSP-D06	69.09	0.98	2.07	800	0.5
P CSP-D05	69.20	1.01	2.17	800	0.5
P CSP-D04	69.43	1.03	2.56	800	0.5
E CSP-D03	74.16	1.08	TO BE REMOVED – SEE DETAILED DESIGN		
P CSP-D02	76.82	1.19	1.60	1050	0.55
P CSP-D01	79.66	1.19	2.21	1050	0.55

Once the east ditch has been completed, the external runoff from the Golf Course and dugout will be diverted to 48A Avenue, removing most of the flood risk from the residences on 48 Street. With significantly less runoff entering the 48 Street lots, most of the rear yard flooding, and 48 Street drainage issues will be resolved. In addition to the east ditch, removal of RE01 and RE02 will effectively eliminate the large flows crossing the embankment and contributing to the dugout and Woodlands Subdivision. This will resolve the flooding issues regarding the dugout and the rear lots of residences on 48A Avenue, and further reduce the flood risk to the Woodland subdivision.

5.2 Project 2 - Construction of Central Drainage Way

The completion of Phase 1 of the Embankment Drainage System will divert external flows from the Golf Course to an adequate outlet, and significantly reduce the runoff passing through the Woodland Subdivision. This in turn will reduce the flow to 48 Street and 49A Avenue and to the subdivision's north outlet, flow path F(i). This reduction in the quantity of runoff will help relieve some of the flooding experienced by residents along Flow Path F(i); however; as the primary flow path for the subdivision, the other drainage issues and concerns also need to be addressed.

To provide adequate stormwater drainage for the subdivision, the proposed drainage improvements must fulfil several key criteria:

- Provide continuity along the drainage flow path
- Provide legal access to the drainage flow path and infrastructure for the purpose of construction, maintenance and long-term protection.
- Replace or improve the drainage infrastructure to meet the service level requirements
- Reduce flood risk to residents on 49A Avenue

To accomplish these criteria and accommodate major Flow Path F(i), we proposed to construct a central drainage way that can convey stormwater from the Woodland Subdivision and future residential developments to the lake. The proposed Central Drainage Way includes the following drainage improvements, as shown on ***Figure 11 – Project 2: Central Drainage Way.***

1. Acquire a 2.5m corridor of land from both Lots 7 and 8 (Block 11, Plan 772 2500) along the existing ditch that extends the length of the lots from the 49A Avenue road right of way to the rear property line. Subdivide a 5m drainage/utility right of way along this new parcel to provide the Summer Village legal access to the ditch.
2. Acquire a 20m corridor of land from the Sunset Point Christian Camp that extends along the entire north property line of the Woodland Subdivision (the south boundary of the Christian Camp) from the Sunset Drive road right of way east to the existing Lot 1 Plan 972 2687. Subdivide this corridor as a drainage/utility right of way.
3. Regrade the existing north-south drainage ditch (P Ditch-01) within the proposed 5m right of way to provide positive drainage from 49A Avenue to the north property line.
4. Connecting to the improved north-south ditch, construct a new east-west drainage ditch (P Ditch-02) along the south side of the proposed 20m right of way. This new ditch will tie into the existing Sunset Drive west roadside ditch.
5. Remove culvert F02. A new trail crossing should be installed at the intersection of the proposed east-west ditch centreline and the Sunset Drive Recreational Trail. Treatment of this crossing to accommodate both the Central Drainage Way (flow path F(i)) and the trail shall be determined in the detailed design.

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Key Map
N.T.S

Sunset Point Christian Camp

LOT 2A

Existing Sunset Drive Recreational Trail

Proposed Additional Culvert Crossing Sunset Drive (*P CSP-F01b*)

Proposed E-W Drainage Ditch - Phase I (*P Ditch-02*)

Proposed Recreational Trail

Proposed Right of Way

Tie Drainage Ditch to West Ditch of Railway Embankment

Proposed E-W Drainage Ditch - Phase II Extension

Future Residential Development Area

Lac Ste. Anne

Proposed Ditch Improvements (*P Ditch -03*)

Remove and Dispose Existing 600mm Culvert (*E CSP-F02*)

Fill Existing E-W Drainage Ditch

Existing 600mm Culvert (*E CSP-F01a*) @ 3.4% Slope

Tie N-S Ditch to Proposed E-W Drainage Ditch

Regrade Existing N-S Drainage Ditch (*P Ditch-01*)

Tie Proposed Trail to Existing Recreational Trail on Railway Embankment

20.00

5.60

HUDSONS BAY COMPANYS RESERVE

Sunset Drive

49A Avenue

48 Street

Woodland Subdivision

Railway Embankment (Existing Recreational Trail)

Alberta Beach Golf Resort

Legend:

- Improvement Area Boundary
- Summer Village Boundary
- Proposed Right of Way
- Proposed Recreational Trail
- Existing Recreational Trail
- Proposed Drainage Ditch Phase I
- Proposed Drainage Ditch Phase II (Extension)
- Existing Ditch to be Filled
- Proposed Culvert
- Existing Culvert
- Proposed Flow Direction
- Existing Flow Direction

Scale 1:2,000

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 11

Project 2: Central Drainage Way

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6. Rehabilitate culvert F01 (crossing Sunset Drive) as required. Install a second major culvert crossing Sunset Drive so that the combined capacity of F01 and the new culvert (F01b) accommodates the proposed Drainage Parkway flows. F01 shall now be designated F01a, for clarity.
7. Rehabilitate and armour the ditch (P Ditch-03) at the outlet of culvert F01a and F01b as needed to ensure the flow path to the lake is accommodated within the existing road right of way and adequately protected from erosion and scour.

This plan for the Central Drainage Way is simple and feasible. It accommodates the major flow path within the subdivision and minimizes the flood risk to the residents of 49A Avenue. Rehabilitation of the existing east-west drainage management ditch was considered; however, as the existing ditch passes through private property along the rear of Lots 6 and 7, and backwater floods into Lot 8; rehabilitation did not offer the same level of flood protection as relocation. Accordingly, we have proposed to relocate the ditch to the north side of the property line within the proposed right of way.

The right of way width of 20m is proposed to provide space for construction, required drainage ditch, access for maintenance as well as providing space for a multi-use recreational trail opportunity. Although not an essential part of the stormwater management plan, the proposed right of way presents an excellent opportunity to provide pedestrian linkage from the Sunset Drive Recreational Trail to the existing railway embankment recreational trail.

The 20m right of way could be terminated at the Lot 7/8 ditch; however, extension of the right of way to the railway embankment offered 2 advantages. The first is the multi-use recreational trail opportunity. The second is the potential to provide a stormwater outlet for the future development area (Lot 1 Plan 972 2687) as indicated in **Figure 11** and **Figure 14.** Within the newly established right-of-way, the stormwater management outlet for the development could be accommodated by a simple extension of the drainage ditch. This is indicated as the “Proposed E-W Drainage Ditch – Phase II Extension”.

Once the Central Drainage Way is operating as per design, and with the possible additional flow from the future residential development, the existing culvert crossing Sunset Drive (F01) will not meet the 1:25-year service level. An additional culvert should be added at this crossing to meet the flow requirements. The Existing Infrastructure Review provides sizing requirements for the proposed new culvert (P F01b)

North of culvert F01 the road right of way has been widened to include all the land between the road shoulder and the legal bank of the lake. From the drainage evaluation it is unclear whether the flow path veers far enough north to traverse the road right of way, or if it proceeds through the privately-owned lakefront lot. It shall be determined during detailed design if any additional ditching is necessary to ensure that this flow path is within the road right of way to appropriately accommodate and protect the flow path and minimize flood risk to the private property.

Culvert maintenance/replacements/upgrades required to provide continuity along the 48 Street and 49A Avenue flow paths (upstream major flow route) are identified in the Existing Infrastructure Review (refer to Appendix F). ***Table 6 – Preliminary Culvert Sizing and Grading for Project 2: Central Drainage Way*** provides a summary of the preliminary design criteria and minimum sizing for the proposed downstream culvert replacements. Sizing and replacement requirements for all upstream culverts along the F(i) flow path (48 Street and 49A Avenue) are recommended in the Existing Infrastructure Review under Project 2: Phase III Priorities; consequently, these culverts and ditches are not included in **Table 6** and **Table 7**. Peak flows were estimated from the PCSWMM stormwater model, while required culvert slope and sizing was calculated using Manning's Equation. All culverts are assumed to be corrugated steel pipes with a Manning's roughness coefficient (n) of 0.022. Proposed (new) culverts are indicated with the prefix P. The existing culvert E CSP F01 (highlighted in grey) is listed in the table because it will contribute to the combined capacity of the Sunset Drive culvert crossing.

Table 6 – Preliminary Culvert Sizing and Grading for Project 2: Central Drainage Way

Component	Contributing Area (ha)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Recommended Minimum Pipe Size (mm)	Recommended Minimum Slope (%)
E CSP-F02	15.85	0.97	TO BE REMOVED – SEE DETAILED DESIGN		
E CSP F01(a)	22.8	1.42	2.7	600	(existing) 3.4%
P CSP F01b			2.1	800	2.0%

Table 7 – Preliminary Ditch Sizing and Grading for Project 2: Central Drainage Way provides the preliminary design criteria for the proposed north-south drainage ditch between Lots 7 and 8 (P Ditch-01); the east-west drainage ditch adjacent to the subdivision's north property line (P Ditch-02); and the outlet ditch from Sunset Drive to Lac Ste. Anne (P Ditch-03). Peak flows were estimated from the PCSWMM stormwater model, while required ditch sizing was calculated using Manning's Equation for open channel flow in a trapezoidal channel. All ditches are assumed to be lined with vegetation (grass) and well-maintained, so a Manning's roughness coefficient (n) of 0.030 was selected.

Table 7 – Preliminary Ditch Sizing and Grading for Project 2: Central Drainage Way

				Recommended Ditch Geometry			
Component	Contributing Area (ha)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Longitudinal Grade (%)	Base Width (m)	Backslope (X:1)	Normal Flow Depth (mm)
P Ditch-01	9.28	0.64	0.87	0.5	1.0	3.0	355
P Ditch-02	16.99	1.23	0.95	0.5	2.0	4.0	372
P Ditch-03	27.98	1.18	0.88	0.4	2.0	3.0	413

The sizing and grading recommendations in Table 6 and Table 7 are preliminary and will be subject to revision during the detailed design.

5.3 Project 3 – 56 Avenue Culvert Replacements and Ditch Rehabilitation

As identified in Section 3.4, the major drainage route through 56 Avenue (Flow Path I(i)) is not adequately accommodated under current conditions. The contributing area to the flow route is approximately 16 ha and significant external flows are entering a local drainage network that was not designed to accommodate the regional flow patterns and major flow path. To provide an adequate flow route through the neighbourhood the drainage improvements must fulfil several key criteria:

- Provide continuity along the drainage flow path I(i)
- Replace or improve the drainage infrastructure to meet the 1:25-year service level
- Reduce flood risk to residents of the 56 Avenue neighbourhood

The most significant issue is the two existing 400mm culverts (I02 and I03) that cause a severe bottleneck point and flood the north ditch and upstream route. Three options were considered to mitigate the drainage issues associated with these two culverts.

1. Remove and replace the culverts with a single culvert adequately sized to accommodate the 1:25-year rainfall runoff event.
2. Remove and replace the culverts with a stormwater pipe network.
3. Removal of the culverts and regrading the road to remove the high point and have positive drainage along the north ditch.

Option 3 (complete road and ditch regrading) simply isn't feasible with the existing adjacent developments (residences) and would be extremely costly due to requirements for road reconstruction. Option 2 (stormwater system) is prohibitively costly. Option 1 (adequate culvert replacement) is recommended for its cost-effectiveness and simplicity. To accomplish the key criteria for the 56 Avenue drainage improvements, the following activities are recommended, as shown on ***Figure 12 – Project 3: 56 Avenue Culvert Replacements and Ditch Rehabilitation.***

1. Regrade the existing ditch through the drainage right of way (Plan 902 3656) along the rear property line of Lots 20 and 21 (Block 2, Plan 4635TR). Provide positive drainage from the existing flow path northeast along the property line to the 56 Avenue south ditch (P Ditch-04).
2. The existing approach and culvert in the road right of way (Plan 902 3655) adjacent to the northeast corner of Lot 21 shall be treated in accordance with the recommendations of the Existing Infrastructure Review. In its current configuration, it provides some restriction to the external flows entering the subdivision, which is acceptable with the proposed upstream improvements.
3. Improve or rehabilitate this segment of the south ditch of 56 Avenue as needed. This will likely include the trimming or removal of vegetation and shrubs along the ditch bottom.
4. Rehabilitate existing culvert I04 as indicated in the Existing Infrastructure Review to improve conveyance and accommodate the major flow route.

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Improvement Area Boundary
- Summer Village Boundary
- Proposed Ditch Improvement
- Proposed Culvert
- Existing Culvert
- Proposed Flow Direction
- Existing Flow Direction

Scale 1:1500

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 12
Project 3: 56 Avenue Culvert Replacements and Ditch Rehabilitation

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5. Rehabilitate and regrade the existing north ditch of 56 Avenue from culvert I04 outlet to the culvert I02-I03 inlet (P Ditch-05).
6. Remove culverts I02 and I03 and replace with a single larger culvert (P CSP-I02) to provide continuity along the flow path I(i), ensure 1:25-year service level is being met and that proposed culvert meets the minimum size requirements of the Lac Ste. Anne GMSS.
7. Rehabilitate north ditch of 56 Avenue from proposed culvert outlet to Sunset Drive as needed to provide positive drainage (P Ditch-06). Provide erosion control on this ditch (rock check dams), as its existing slope exceeds 2.5%.
8. Evaluate options to provide continuity for Flow Path I downstream of the existing 56 Avenue north ditch. Execute recommended option.

Further study is recommended for Flow Path I downstream of the existing 56 Avenue north ditch to ensure outlet adequacy. Presently, the flow path exits the 56 Avenue ditch and turns north to follow the west ditch of Sunset Drive, crossing the Sunset Point municipal boundary into Lac Ste. Anne County. An approach culvert (I01) located in the County just north of 56 Avenue, does not presently meet the 1:25-year service level. This culvert could become a bottleneck point, causing water to backup into Sunset Point. The approach overflow elevation should be verified during detailed design and the flood hazards caused by the existing culvert and residential approach should be assessed. If the approach overflow elevation is such that it does not cause adverse flood risks to residents of Sunset Point, then no further improvements are required. However, if the flood risks are a concern, there are two options to proceed.

1. Coordinate with the County the removal and replacement of the culvert with an adequate substitute.
2. Bore a new culvert crossing Sunset Drive at the intersection of the 56 Avenue north ditch. This proposed culvert would allow Flow Path I to cross Sunset Drive and outlet to Lac Ste. Anne. There is an existing road right of way at this location extending west from Sunset Drive to the lakeshore that can accommodate the major flow path.

Table 8 – Preliminary Culvert Sizing and Grading for Project 3: 56 Avenue provides the preliminary design criteria for the replacement of problem culverts I02 and I03 and if required, replacement of approach culvert I01. ***Table 9 – Preliminary Ditch Sizing for Project 3: 56 Avenue*** provides the preliminary design criteria for the proposed ditch improvements. It should be noted that these ditches have standard road ditch sections, and longitudinal grades based on LiDAR and preliminary culvert design. All additional culvert replacements or upgrades along this flow path are determined in the Existing Infrastructure Review.

Table 8 – Preliminary Culvert Sizing and Grading for Project 3: 56 Avenue

Component	Contributing Area (ha)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Recommended Minimum Pipe Size (mm)	Recommended Minimum Slope (%)
P CSP-I02	15.7	0.71	1.55	800	1.00%
P CSP-I01	21.8	2.06	1.91	1200	1.25%

Table 9 – Preliminary Ditch Sizing and Grading for Project 3: 56 Avenue

				Recommended Ditch Geometry				
Component	Contributing Area (ha)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Longitudinal Grade (%)	Base Width (m)	Backslopes (X:1)		Normal Flow Depth (mm)
P Ditch-04	15.62	0.72	0.79	0.50	3.00	4:1	3:1	239
P Ditch-05	15.73	0.71	0.78	0.50	3.00	4:1	3:1	237
P Ditch-06	22.52	1.88	2.10	3.64	3.00	4:1	3:1	234

6.0 ACCOMODATING FUTURE DEVELOPMENT

According to the MDP Land Use Map (Figure 3) most of the areas to be developed in the future will be residential developments or roadways. Accommodation of future development in the Summer Village should include the following key drainage considerations:

1. Runoff quantity is to be managed by providing storage in a stormwater management facility to allow for the pre-development 2.5L/s/ha release rate.
2. Runoff quality is to be managed by providing a low-velocity stormwater management facility that achieves sediment removal to the provincial standard of 85% of particles 75 micron or greater.
3. Major drainage courses are to be accommodated in roadside ditches or drainage right of ways that lead to the stormwater management facility.
4. All structures shall have a minimum 0.3m freeboard above the high-water mark of any wetland or stormwater management facility.

Within the existing Summer Village boundary there are two key areas which are planned for residential development. The first area is a sixteen-hectare parcel bound between the golf course, the existing Silver Beach Subdivision and 48A Avenue (Parcel 1) and the second is a six-hectare triangular parcel, just east of the Christian Camp and north of the Woodland Subdivision (Parcel 2). These parcels are shown in ***Figure 13 – Future Residential Development Parcels.***

The development plan for Parcel 1 should follow these recommendations, as shown in ***Figure 14 – Drainage Recommendations for Future Residential Development Parcel 1.***

1. Sediment Bay 1 (SB1) is to be constructed in the northwest corner of the parcel.
2. A drainage ditch is to be constructed along the west extent of Parcel 1 (east of the rear property lines of the existing Silver Beach Subdivision) to divert all flow from minor Flow Paths B(i) and C(i) north to SB1.
    a. Culvert B05 and C02 will be abandoned as they will no longer convey significant flows.
    b. A 6.0m drainage right of way will be subdivided to protect the drainage swale.
3. All drainage within the subdivision is to be routed to SB1 or the proposed drainage swale.
4. Water quality and quantity is to be managed in the proposed SB1 prior to release to Lac Ste. Anne at Outlet D.

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Sunset Point Boundary
- Albert Beach Boundary

Future Residential Development Parcels

① Area = 15.73 Ha.

② Area = 5.98 Ha.

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 13

Future Residential Development Parcels

Scale 1:10,000

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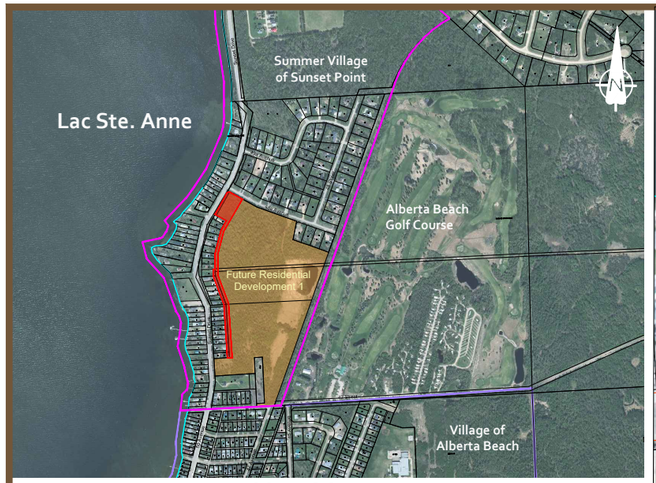

Key Map
N.T.S

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Lac Ste. Anne

Sunset Drive

Existing 600mm CSP (D01) @ 1.3% Slope

Existing 600mm CSP (D02) @ 0.6% Slope

Proposed Drainage Swale

Power Line Right of Way (5543 HW)

Proposed Future Sediment Bay

48A Avenue

Future Residential Development 1

PCL A

Railway Embankment

Existing Dugout

Legend:

- Improvement Area Boundary
- Sunset Point Boundary
- Alberta Beach Boundary
- Proposed Right of Way
- Existing Minor Flow Path
- Proposed Drainage Swale
- Existing Culvert (Critical)
- Existing Culvert (Non-Critical)
- Proposed Flow Direction
- Existing Flow Direction
- Proposed Sediment Bay

Scale 1:2,000

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 14

Drainage Recommendations for Future Residential Development Parcel 1

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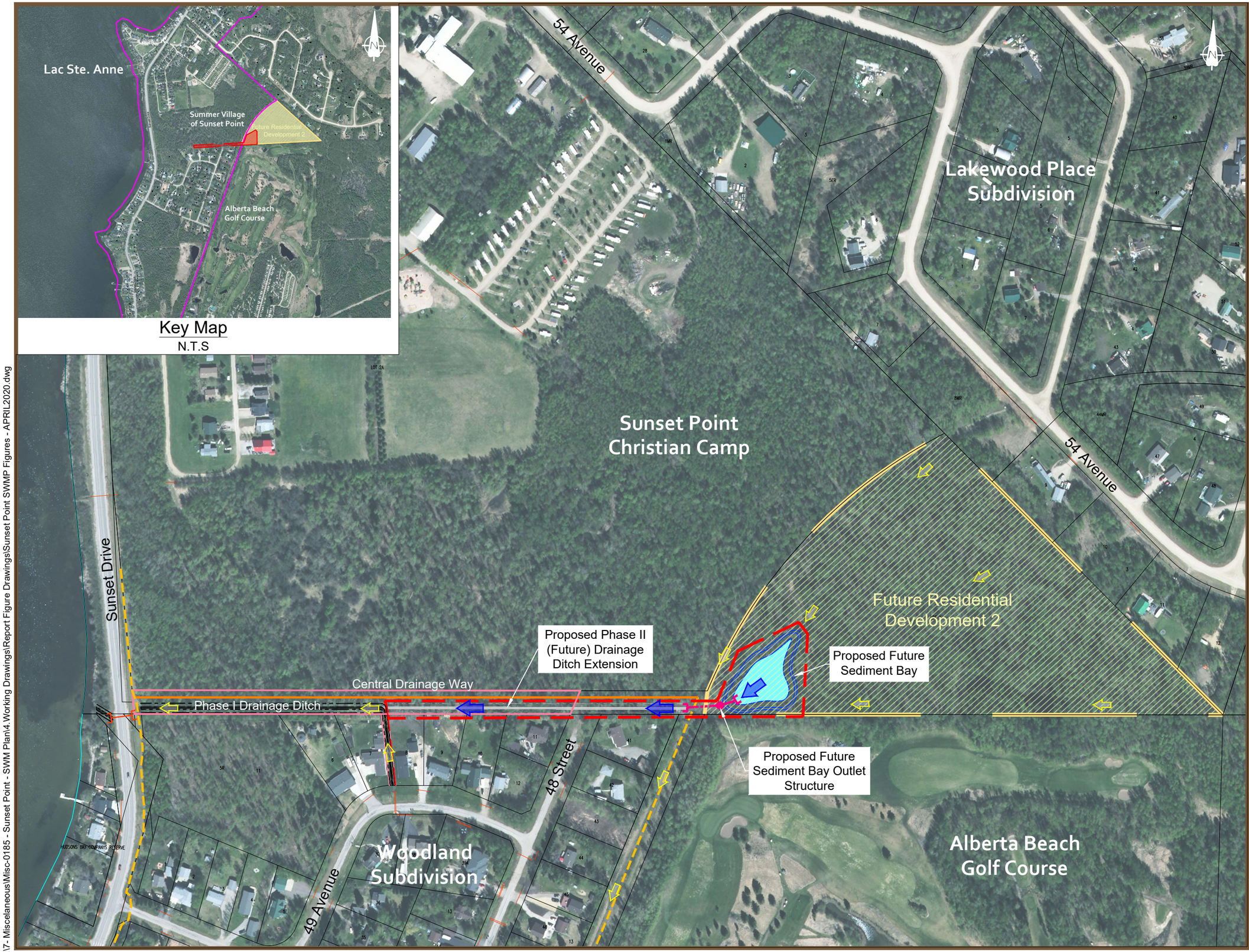
The development plan for Parcel 2 should follow these recommendations, as shown in ***Figure 15 – Drainage Recommendations for Future Residential Development Parcel 2*.**

1. Road access is to be provided by the extension of a road from the intersection of 54 Avenue in Lakeview Place.
2. A minimum 10m wide drainage right of way is to be subdivided along the south boundary of Parcel 1 which will connect with the drainage right of way proposed in Section 5.3.
3. Phase II of the Central Drainage Way is to be constructed east of Phase I, as shown in Figure 11. This will include three key components:
    a. A minimum 10m wide drainage right of way is to be subdivided along the south boundary of the Sunset Point Christian Camp, aligning with the right of way in Phase I at the west and the existing 10m wide section of Plan 972-2687 (future land use designated as roadway) at the east.
    b. Extension of the Central Drainage Way ditch west to the existing recreational trail on the railway embankment.
    c. Extension of the proposed recreational trail west to the existing recreational trail on the railway embankment.
4. Sediment Bay 2 (SB2) is to be constructed in the southwest corner of the parcel.
5. All drainage within the subdivision is to be routed to SB2 in the southwest corner. SB2 will release through an outlet structure and storm pipe crossing the railway embankment and recreational trail and outlet to the proposed Phase II drainage ditch (Central Drainage Way ditch extension).
6. Water quality and quantity is to be managed in the proposed SB2 prior to release to the Central Drainage Way ditch, which as a grassed swale provides more scrubbing prior to reaching Lac Ste. Anne at Outlet F.



Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Improvement Area Boundary
- Summer Village Boundary
- Proposed Right of Way
- Proposed Recreational Trail
- Existing Recreational Trail
- Phase I Drainage Ditch
- Proposed Drainage Ditch Phase II (Extension)
- Proposed Storm Pipe/Culvert
- Existing Culvert (Critical)
- Existing Culvert (Non-Critical)
- Proposed Flow Direction
- Existing Flow Direction
- Proposed Sediment Bay

Scale 1:3,000

General Notes:

1. 2019 Cadastral Shown
2. 2019 Aerial Photograph provided by Lac Ste. Anne County

Figure 15

Drainage Recommendations for Future Residential Development Parcel 2

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7.0 EXISTING INFRASTRUCTURE REVIEW

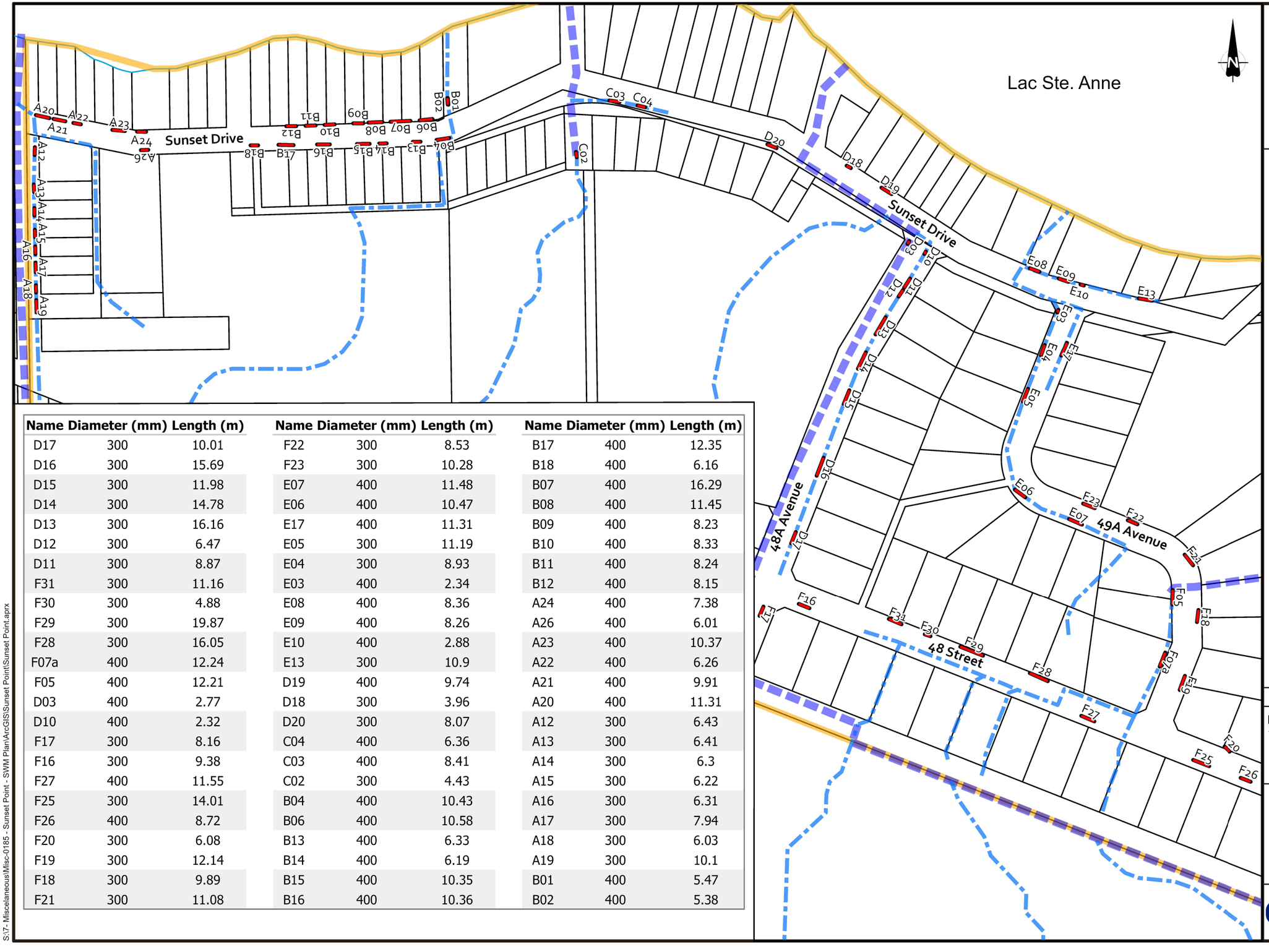
One of the goals of this stormwater management plan was to provide an inventory, rating and replacement scheme for the existing stormwater infrastructure in Sunset Point. This has been accomplished with a stand-alone memorandum entitled ***Existing Infrastructure Review***, which can be found in ***Appendix E.*** As no stormwater sewer systems were found in Sunset Point, the review was focused on culverts, ditches, major watercourses and outlets to the lake. The following characteristics were identified or evaluated for each culvert:

- component age, end treatments, condition and maintenance
- spatial data (size, GPS location, length, slope)
- capacity
- correct flow direction
- prevents flooding or flow rate increase to adjacent lots
- erosion and scour due to drainage
- roadway/approach failures caused by culvert failures

The findings for each culvert are summarized in individual culvert inspection reports, which includes photos of the inlet, outlet and barrel. The first actionable item from the culvert inventory review identified the need to upgrade to the municipal standard. While following the Lac Ste. Anne GMSS minimum culvert sizing requirements, the review proposes that a minimum of two 600mm culverts should be required along major flow routes. ***Figures 16*** and ***17 – Undersized Culverts*** show the existing culverts that do not presently meet the minimum sizing requirements of the municipal standard.

A 26-point rating system was developed to quantify the condition of the infrastructure and score the culverts to help prioritize the infrastructure improvement strategy for the Summer Village. In this system, infrastructure with low scores were considered good while with high scores had substantial concerns. It was recommended that culverts with scores of 10 points or higher should be addressed in a 5-year action plan. The review proposes a replacement scheme with priorities aligned to the key drainage improvement areas outlined in this stormwater management plan, then proceeds to additional areas exhibiting blockages or severe conditions. The review also provides cost estimates of replacements and improvements and a schedule for replacements and improvements

Detailed drawings and specifications adapted from Alberta Infrastructure Highway Geometric Design Guide have been created for the Summer Village to provide guidance and standards for the installation and treatment of culverts. These are included in the appendix of the Existing Infrastructure Review. All recommended works in the Existing Infrastructure Review should be completed to these standards or greater. The infrastructure review provides a substantial amount of information that has been presented in a way that is approachable and useful. The review will be an invaluable tool for the planning and implementation of the infrastructure improvement strategy for the Summer Village of Sunset Point.



Name	Diameter (mm)	Length (m)	Name	Diameter (mm)	Length (m)	Name	Diameter (mm)	Length (m)
D17	300	10.01	F22	300	8.53	B17	400	12.35
D16	300	15.69	F23	300	10.28	B18	400	6.16
D15	300	11.98	E07	400	11.48	B07	400	16.29
D14	300	14.78	E06	400	10.47	B08	400	11.45
D13	300	16.16	E17	400	11.31	B09	400	8.23
D12	300	6.47	E05	300	11.19	B10	400	8.33
D11	300	8.87	E04	300	8.93	B11	400	8.24
F31	300	11.16	E03	400	2.34	B12	400	8.15
F30	300	4.88	E08	400	8.36	A24	400	7.38
F29	300	19.87	E09	400	8.26	A26	400	6.01
F28	300	16.05	E10	400	2.88	A23	400	10.37
F07a	400	12.24	E13	300	10.9	A22	400	6.26
F05	400	12.21	D19	400	9.74	A21	400	9.91
D03	400	2.77	D18	300	3.96	A20	400	11.31
D10	400	2.32	D20	300	8.07	A12	300	6.43
F17	300	8.16	C04	400	6.36	A13	300	6.41
F16	300	9.38	C03	400	8.41	A14	300	6.3
F27	400	11.55	C02	300	4.43	A15	300	6.22
F25	300	14.01	B04	400	10.43	A16	300	6.31
F26	400	8.72	B06	400	10.58	A17	300	7.94
F20	300	6.08	B13	400	6.33	A18	300	6.03
F19	300	12.14	B14	400	6.19	A19	300	10.1
F18	300	9.89	B15	400	10.35	B01	400	5.47
F21	300	11.08	B16	400	10.36	B02	400	5.38

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Culverts <500mm Ø
- Minor Flow Paths
- Major Flow Paths
- Sunset Point

Scale: 1:3,000

Note:
1. Minimum residential culvert sizing in the Lac Ste. Anne County GMSS is 500mm.

Figure 16

Undersized Culverts - 1/2

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Name	Diameter (mm)	Length (m)
H09	400	9.11
H28	400	7.47
H27	400	5.15
H29	400	6.05
H31	400	7.49
H19	400	8.32
H17	400	28.51
H16	400	10.48
H15	400	8.16
H14	400	11.07
H13	400	8.35
I18	300	7.49
I17	400	7.25
I19	400	7
I10	200	6.14
I09	400	7.58
I16	400	7.59
I15	400	7.57
I02	400	109.81
I13	400	7.01
I07	400	11.76
I11	300	10.25

Name	Diameter (mm)	Length (m)
I08	400	7.73
I24	400	7.4
I20	400	2.88
I21	400	7.54
I22	400	7.4
I23	400	7.39
H30	400	7.55
H25	400	7.49
H24	400	7.42
H20	400	7.93
H21	400	12.29
H22	400	7.57
H23	300	6.14
H12	400	13.16
H33	400	11.25
H32	400	6.46
H03	400	6.34
H05	400	9.01
H07	400	39.59
H08	400	12.52
I03	400	105.08

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Culverts <500mm Ø
- Minor Flow Paths
- Major Flow Paths
- Sunset Point

Scale: 1:3,000

Note:
1. Minimum residential culvert sizing in the Lac Ste. Anne County GMSS is 500mm.

Figure 17

Undersized Culverts - 2/2

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8.0 PRELIMINARY COST ESTIMATES

A preliminary cost estimate for the recommended drainage improvements is provided in Appendix B. The estimate includes costs for land acquisition and compensation, construction, engineering fees and contingencies. A preliminary construction estimate has been provided for each of the three major drainage projects and the drainage recommendations for the Future Residential Development Areas. The preliminary cost estimates are summarized in ***Table 10***.

Table 10 – Summary of Preliminary Cost Estimates

Project	Preliminary Cost Estimate
Drainage Improvement Projects	
Project 1 – Embankment Drainage System – East Ditch and 48A Avenue Culverts	$271,131
– 48A Avenue Culverts and Ditches Upgrade	$127,717
Project 2 – Central Drainage Way	$127,350
Project 3 – 56 Avenue Replacement of Culverts and Ditch Rehabilitation	$151,775
DRAINAGE IMPROVEMENT PROJECTS SUBTOTAL	**$677,974**
Stormwater Management for Future Developments	
Parcel 1 (South) – High-Level Stormwater Management	$114,615
Parcel 2 (North) – High-Level Stormwater Management	$89,250
FUTURE STORMWATER MANAGEMENT SUBTOTAL	**$203,865**
OVERALL PROJECT TOTAL	**$881,839**

8.1 FUNDING OPPORTUNITIES

The three key drainage improvements are required because of the need to convey external flows entering the Summer Village from the Lac Ste Anne County lands situated to the east. Hence, it is the County's water that is causing most of the significant drainage problems. In situations such as these, it is recommended to seek all possible cost-sharing opportunities with the County.

The federal and provincial governments offer several cost-sharing and grant funding opportunities to assist small communities with infrastructure upgrades and flood mitigation projects. Some examples are:

1. Investing in Canada Plan – Provided by Infrastructure Canada
2. Federal Gas Tax Fund (GTF) 2020-2021
3. Alberta Water Management and Erosion Control Program (AWMEC) – Natural Resources Services of Alberta Environment and Parks (AEP).
4. Alberta Community Resilience Program (ACRP) – Provided by AEP – this project may not qualify for this grant due to possible Wetland disturbance.

Funding opportunities should be further investigated at the time of detailed design.

9.0 CLOSURE

We trust that this report meets your present requirements. We have identified the drainage patterns, rainfall-runoff event flows and key drainage issues in the Summer Village of Alberta Beach. Improvement plans were presented to resolve each of the key issues. Conceptual plans of the drainage solutions have been presented for discussion and review. It is recommended to proceed to the detailed design phase as soon as possible to initiate the approvals process. Should any large changes in the land use or flooded areas occur within the study area, the results of this report and conceptual design should be reviewed and adjusted accordingly.

This document was prepared by SE Design and Consulting Inc. in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of the Summer Village of Sunset Point. The findings of this report should be utilized to address the specific drainage issues relating to the Sunset Point Stormwater Management Plan as outlined herein.

REFERENCES

[1] Scheffer Andrew Ltd., "Summer Village of Sunset Point Municipal Development Plan (MDP), Bylaw 261," April 2007.

[2] A. A. a. Forestry, "Alberta Soil Information Viewer for the Agricultural Region of Alberta Soil Inventory Database (AGRASID)," https://soil.agric.gov.ab.ca/agrasidviewer/, Version 4.1.

[3] F. a. R. D. Agriculture and Agri-Food Canada and Alberta Agriculture, "Soil Group Map of Alberta," https://www1.agric.gov.ab.ca/soils/soils.nsf/soilgroupmap, Revised May 5, 2015.

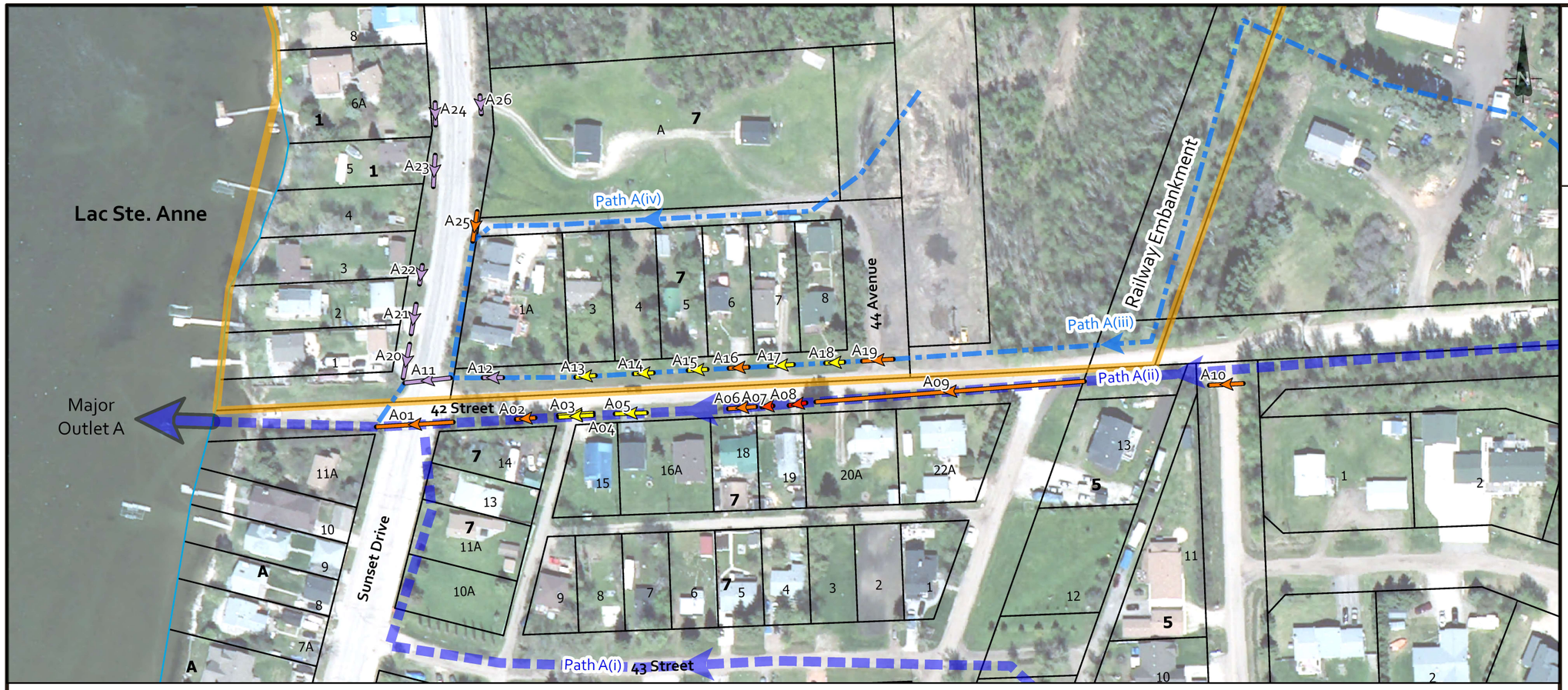
[4] "General Municipal Servicing Standards (GMSS)," Lac Ste. Anne County, January 2008.

[5] Stewart, Weir & Co. Ltd., "Summer Village of Sunset Point - Resolution of Water/Drainage Issues," April 2009.

[6] Associated Engineering, "Big Lake Basin Stormwater Management Plan - Summary Report," Big Lake Basin Task Force, Parkland County, Alberta, May 2004.

[7] Government of Canada, "Engineering Climate Datasets," Environment and Natural Resources, 27 February 2019. [Online]. Available: https://drive.google.com/drive/folders/18U5LJX5FMVuUfhySlN5bOaFB9faVtnKS. [Accessed 2019].

APPENDIX A:
Existing Drainage Features and Infrastructure



Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
A01	600	25.2	3.3	1960	85.39	0.835	0.22	3.80	1.64
A02	800	6.23	0.6	1960	71.67	0.955	0.63	1.52	0.69
A03	600	11.4	2.2	1960	71.67	0.420	0.54	0.78	0.84
A04	600	11.24	1.5	1960	71.67	0.420	0.54	0.78	0.84
A05	600	10.27	1.7	1960	71.54	0.575	0.47	1.22	1.17
A06	600	9	4.8	1960	71.01	0.622	0.79	0.79	1.02
A07	600	3.69	3.8	1960	71.01	0.481	0.71	0.68	1.36
A08	600	5.63	3.6	1960	71.01	0.523	0.68	0.77	1.18
A09	600	87.96	0.7	1960	71.01	0.412	0.31	1.33	1.30
A10	800	11.13	5.6	1960	70.92	1.007	1.85	0.54	0.63
A11	600	15.06	1.9	1960	3.50	0.390	0.49	0.80	0.00
A12	300	6.43	1.6	1953	1.53	0.121	0.15	0.81	0.00
A13	300	6.41	1.7	1960	1.53	0.129	0.07	1.84	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
A14	300	6.3	1.9	1960	1.53	0.146	0.08	1.82	0.00
A15	300	6.22	2.1	1960	1.39	0.136	0.08	1.70	0.00
A16	300	6.31	1.6	1960	1.39	0.151	0.07	2.16	0.02
A17	300	7.94	6.1	1960	1.39	0.127	0.14	0.91	0.06
A18	300	6.03	2.8	1960	1.22	0.136	0.10	1.36	0.03
A19	300	10.1	2.5	1960	1.22	0.123	0.09	1.37	0.03
A20	400	11.31	0.4	1960	0.14	0.044	0.08	0.55	0.00
A21	400	9.91	0.8	1960	0.13	0.040	0.11	0.36	0.00
A22	400	6.26	-0.8	1960	0.11	0.035	0.11	0.32	0.00
A23	400	10.37	2.3	2009	0.05	0.017	0.19	0.09	0.00
A24	400	7.38	1.1	1960	0.03	0.009	0.13	0.07	0.00
A25	500	9.89	0.5	1957	1.77	0.284	0.16	1.77	0.00
A26	400	6.01	2.2	1960	1.35	0.211	0.18	1.17	0.00

Scale: 1:1,500

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-1
Outlet A Flow Paths

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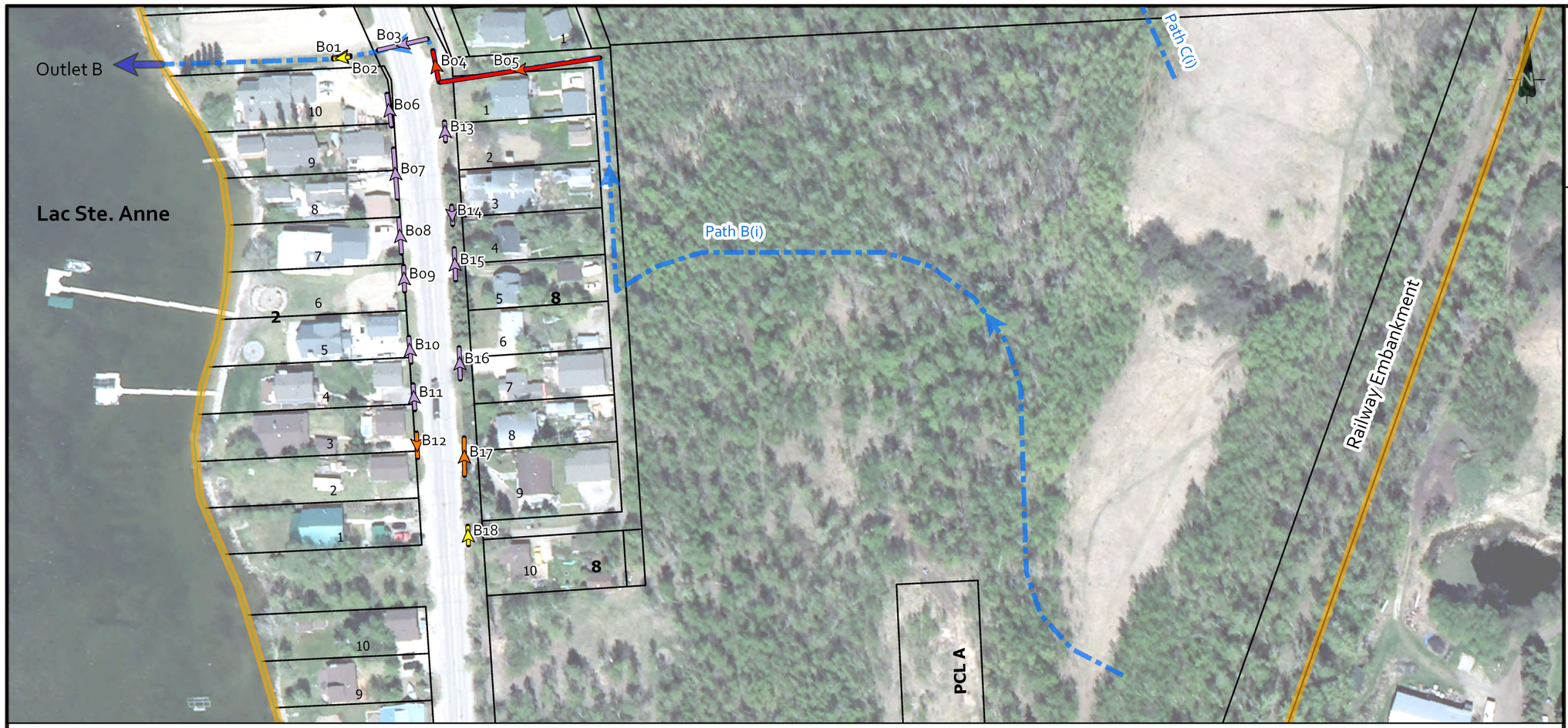

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Minor Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
B01	400	5.47	0.7	1960	10.81	0.185	0.11	1.68	0.00
B02	400	5.38	0.9	1960	10.81	0.185	0.11	1.68	0.00
B03	600	16.56	2.6	1960	10.54	0.334	0.59	0.57	0.00
B04	400	10.43	0.5	1960	10.11	0.222	0.09	2.47	0.12
B05	500	52.76	0.7	1960	10.11	0.222	0.09	2.47	0.12
B06	400	10.58	1	1960	0.16	0.086	0.13	0.66	0.00
B07	400	16.29	1.1	1960	0.16	0.089	0.13	0.68	0.00
B08	400	11.45	0.7	1960	0.10	0.073	0.10	0.73	0.00
B09	400	8.23	1.8	1960	0.10	0.074	0.17	0.44	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
B10	400	8.33	0.5	1960	0.10	0.051	0.09	0.57	0.00
B11	400	8.24	0.7	1960	0.06	0.053	0.11	0.48	0.00
B12	400	8.15	0.1	1960	0.03	0.053	0.04	1.32	0.00
B13	400	6.33	1.4	1960	0.25	0.078	0.15	0.52	0.00
B14	400	6.19	3.6	1960	0.67	0.053	0.23	0.23	0.00
B15	400	10.35	1.4	1960	0.67	0.072	0.14	0.51	0.00
B16	400	10.36	1.1	1960	0.39	0.039	0.13	0.30	0.00
B17	400	12.35	0.2	1960	0.39	0.081	0.05	1.62	0.00
B18	400	6.16	0.3	1960	0.34	0.089	0.07	1.27	0.00

Scale: 1:1,500

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-2

Outlet B Flow Path

SE DESIGN AND CONSULTING INC.

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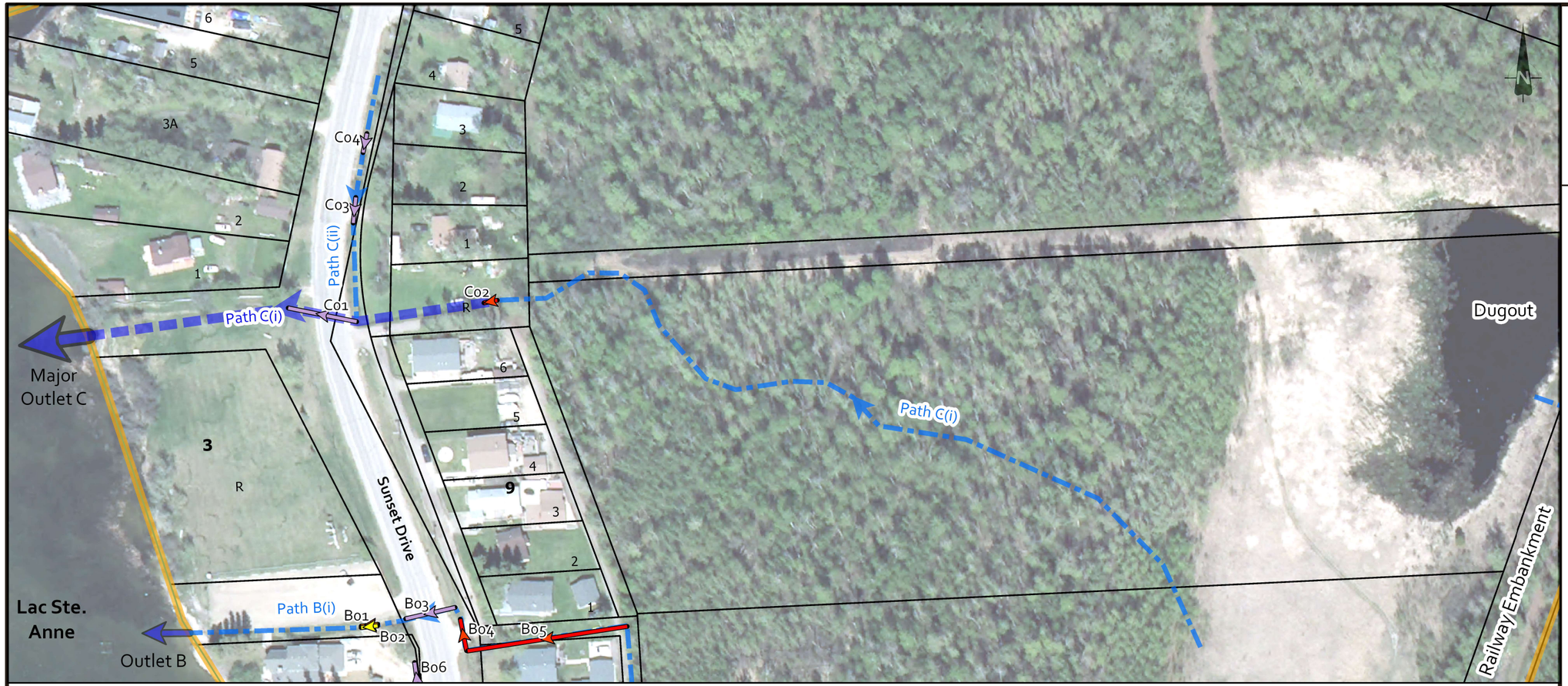

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
B01	400	5.47	0.7	1960	10.81	0.185	0.11	1.68	0.00
B02	400	5.38	0.9	1960	10.81	0.185	0.11	1.68	0.00
B03	600	16.56	2.6	1960	10.54	0.334	0.59	0.57	0.00
B04	400	10.43	0.5	1960	10.11	0.222	0.09	2.47	0.12
B05	500	52.76	0.7	1960	10.11	0.222	0.09	2.47	0.12
B06	400	10.58	1	1960	0.16	0.086	0.13	0.66	0.00
B13	400	6.33	1.4	1960	0.25	0.078	0.15	0.52	0.00
C01	600	22.81	2.3	1960	2.75	0.365	0.55	0.66	0.00
C02	300	4.43	-0.2	1960	2.43	0.138	0.03	4.60	0.19
C03	400	8.41	2	1960	0.09	0.032	0.17	0.19	0.00
C04	400	6.36	-0.6	1960	0.09	0.032	0.10	0.32	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Minor Outlets
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:1,500

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-3
Outlet C Flow Paths

SE DESIGN AND CONSULTING INC.

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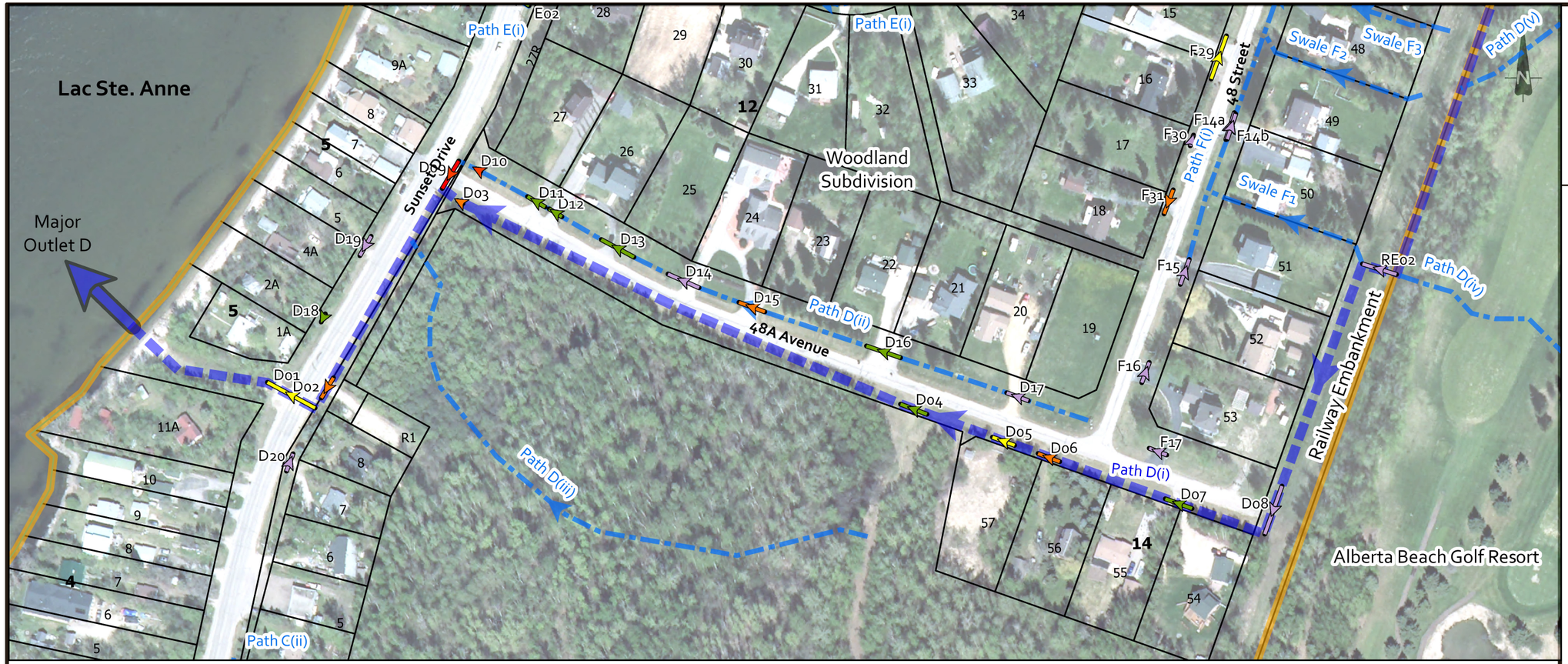

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
D01	600	23.54	1.3	1960	79.66	0.514	0.41	1.25	0.36
D02	600	10.2	0.6	1960	76.82	0.416	0.28	1.49	0.46
D03	400	2.77	0.4	1977	74.16	0.127	0.07	1.81	1.76
D04	600	12.29	1.7	1977	69.43	0.490	0.47	1.04	0.00
D05	600	10.26	1.2	1977	69.20	0.489	0.39	1.25	0.00
D06	600	10.09	0.5	1977	69.09	0.433	0.26	1.67	0.15
D07	600	12.35	1.6	1977	68.79	0.486	0.46	1.06	0.00
D08	600	22.22	0.9	1977	2.56	0.051	0.34	0.15	0.00
D09	600	13.96	0.6	1977	2.50	0.193	0.27	0.71	0.52
D10	400	2.32	1.2	1977	1.73	0.039	0.13	0.30	1.81
D11	300	8.87	1.4	1977	1.73	0.080	0.07	1.14	0.02
D12	300	6.47	2.5	1977	1.73	0.080	0.09	0.89	0.02
D13	300	16.16	2.6	1977	1.58	0.087	0.09	0.97	0.04
D14	300	14.78	1.8	1977	1.26	0.091	0.08	1.14	0.00
D15	300	11.98	0.7	1977	1.26	0.107	0.05	2.14	0.01
D16	300	15.69	1.6	1977	0.82	0.088	0.07	1.26	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
D17	300	10.01	2.2	1977	0.34	0.092	0.08	1.15	0.00
D18	300	3.96	0.5	1960	0.18	0.045	0.04	1.13	0.00
D19	400	9.74	2.4	1960	0.11	0.033	0.19	0.17	0.00
D20	300	8.07	3.1	1960	0.06	0.019	0.10	0.19	0.00
E02	600	15.49	1	1977	3.88	0.359	0.36	1.00	0.00
F13	600	12.25	0.6	1977	2.47	0.320	0.27	1.19	0.00
F14a	500	12.31	0.9	1977	1.42	0.191	0.21	0.91	0.00
F14b	500	11.58	0	1977	1.42	0.191	0.21	0.91	0.00
F15	600	11.52	2.7	1977	0.81	0.208	0.60	0.35	0.00
F16	300	9.38	0.7	1977	0.17	0.040	0.05	0.80	0.00
F17	300	8.16	2.8	1977	0.17	0.056	0.10	0.56	0.00
F29	300	19.87	0.8	1977	0.78	0.061	0.05	1.22	0.00
F30	300	4.88	0.4	1977	0.24	0.032	0.04	0.80	0.00
F31	300	11.16	0.4	1977	0.07	0.064	0.04	1.60	0.00
RE02	500	15.52	1.8	1977	38.76	0.269	0.30	0.90	0.00

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-4
Outlet D Flow Paths

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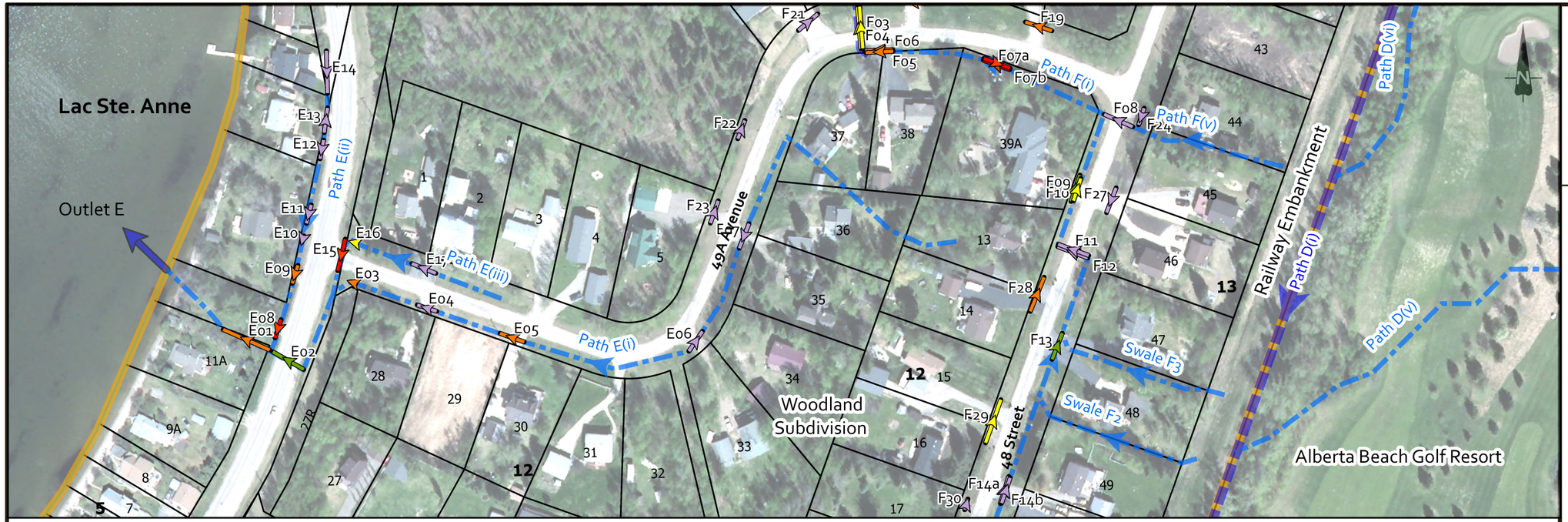

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
D09	600	13.96	0.6	1977	2.50	0.193	0.27	0.71	0.52
E01	500	22.14	1.1	1977	3.98	0.314	0.23	1.37	0.03
E02	600	15.49	1	1977	3.88	0.359	0.36	1.00	0.00
E03	400	2.34	0.9	1977	1.33	0.156	0.11	1.42	0.06
E04	300	8.93	3.6	1977	1.04	0.130	0.11	1.18	0.00
E05	300	11.19	1.1	1977	0.80	0.110	0.06	1.83	0.00
E06	400	10.47	1.5	1977	0.12	0.037	0.15	0.25	0.00
E07	400	11.48	1.6	1977	0.52	0.021	0.15	0.14	0.00
E08	400	8.36	0.1	1977	0.10	0.102	0.04	2.55	0.00
E09	400	8.26	0.1	1977	0.08	0.068	0.04	1.70	0.00
E10	400	2.88	5.2	1977	0.04	0.053	0.28	0.19	0.00
E11	600	8.36	2.2	1977	0.04	0.045	0.53	0.08	0.00
E12	600	8.34	1	1977	0.01	0.024	0.36	0.07	0.00
E13	300	10.9	0.5	1977	0.03	0.025	0.04	0.63	0.00
E14	600	18.46	0.8	1977	0.03	0.012	0.33	0.04	0.00
E15	600	14.11	-0.1	1977	2.48	0.302	0.10	3.02	0.00
E16	500	1.96	5.1	1977	0.94	0.138	0.50	0.28	0.10
E17	400	11.31	3.2	1977	0.73	0.120	0.22	0.55	0.00
F03	600	18.23	0.5	1977	9.22	0.335	0.24	1.40	0.00
F04	600	18.23	0.4	1977	9.22	0.335	0.24	1.40	0.00
F05	400	12.21	0.8	1977	8.58	0.456	0.33	1.38	0.02
F06	600	11.94	1.6	1977	8.58	0.456	0.33	1.38	0.02

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
F07a	400	12.24	0.2	1977	8.36	0.588	0.18	3.27	0.20
F07b	600	12.23	0.3	1977	8.36	0.588	0.18	3.27	0.00
F08	600	13.56	0.8	1977	3.22	0.266	0.33	0.81	0.00
F09	600	12.09	0.3	1977	8.12	0.257	0.21	1.22	0.00
F10	600	10.19	1.9	1977	8.12	0.257	0.21	1.22	0.00
F11	600	14.16	1	1977	6.42	0.204	0.36	0.57	0.00
F12	600	13.99	1.2	1977	2.47	0.167	0.40	0.42	0.00
F13	600	12.25	0.6	1977	2.47	0.320	0.27	1.19	0.00
F14a	500	12.31	0.9	1977	1.42	0.191	0.21	0.91	0.00
F14b	500	11.58	0	1977	1.42	0.191	0.21	0.91	0.00
F18	300	9.89	0.3	1977	0.54	0.064	0.03	2.13	0.00
F19	300	12.14	0.9	1977	0.54	0.091	0.05	1.82	0.00
F21	300	11.08	3	1977	0.30	0.020	0.10	0.20	0.00
F22	300	8.53	1.4	1977	0.09	0.012	0.07	0.17	0.00
F23	300	10.28	1.9	1977	0.06	0.001	0.08	0.01	0.00
F24	500	7.6	3.3	1977	3.22	0.255	0.40	0.64	0.00
F25	300	14.01	3.9	1977	2.92	0.131	0.11	1.19	0.11
F27	400	11.55	2	1977	3.79	0.084	0.17	0.49	0.00
F28	300	16.05	0.6	1977	1.35	0.076	0.04	1.90	0.02
F29	300	19.87	0.8	1977	0.78	0.061	0.05	1.22	0.00
F30	300	4.88	0.4	1977	0.24	0.032	0.04	0.80	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Minor Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-5

Outlet E Flow Paths

SE DESIGN AND CONSULTING INC.

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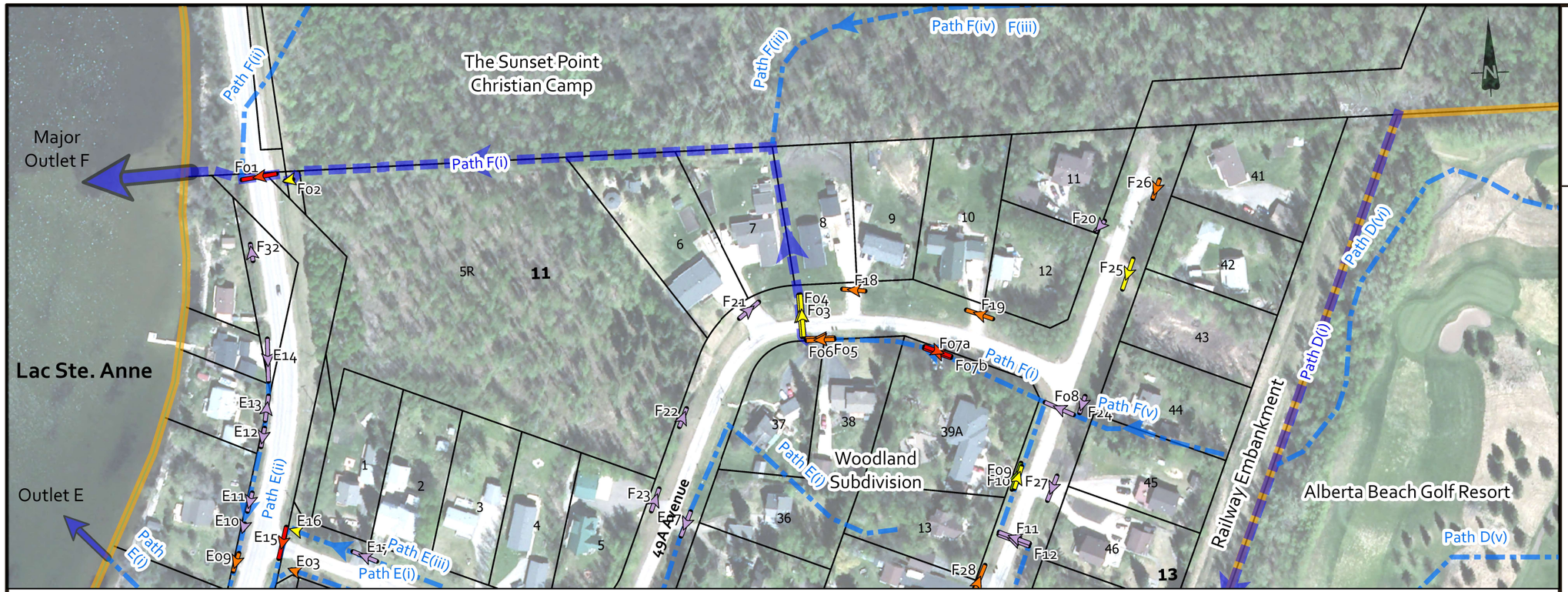

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
E03	400	2.34	0.9	1977	1.33	0.156	0.11	1.42	0.06
E04	300	8.93	3.6	1977	1.04	0.130	0.11	1.18	0.00
E07	400	11.48	1.6	1977	0.52	0.021	0.15	0.14	0.00
E09	400	8.26	0.1	1977	0.08	0.068	0.04	1.70	0.00
E10	400	2.88	5.2	1977	0.04	0.053	0.28	0.19	0.00
E11	600	8.36	2.2	1977	0.04	0.045	0.53	0.08	0.00
E12	600	8.34	1	1977	0.01	0.024	0.36	0.07	0.00
E13	300	10.9	0.5	1977	0.03	0.025	0.04	0.63	0.00
E14	600	18.46	0.8	1977	0.03	0.012	0.33	0.04	0.00
E15	600	14.11	-0.1	1977	2.48	0.302	0.10	3.02	0.00
E16	500	1.96	5.1	1977	0.94	0.138	0.50	0.28	0.10
E17	400	11.31	3.2	1977	0.73	0.120	0.22	0.55	0.00
F01	600	15.26	3.4	1977	22.19	0.597	0.67	0.89	0.78
F02	600	3.45	1.2	1977	18.41	0.505	0.39	1.29	0.77
F03	600	18.23	0.5	1977	9.22	0.335	0.24	1.40	0.00
F04	600	18.23	0.4	1977	9.22	0.335	0.24	1.40	0.00
F05	400	12.21	0.8	1977	8.58	0.456	0.33	1.38	0.02
F06	600	11.94	1.6	1977	8.58	0.456	0.33	1.38	0.02
F07a	400	12.24	0.2	1977	8.36	0.588	0.18	3.27	0.20

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
F07b	600	12.23	0.3	1977	8.36	0.588	0.18	3.27	0.00
F08	600	13.56	0.8	1977	3.22	0.266	0.33	0.81	0.00
F09	600	12.09	0.3	1977	8.12	0.257	0.21	1.22	0.00
F10	600	10.19	1.9	1977	8.12	0.257	0.21	1.22	0.00
F11	600	14.16	1	1977	6.42	0.204	0.36	0.57	0.00
F12	600	13.99	1.2	1977	2.47	0.167	0.40	0.42	0.00
F18	300	9.89	0.3	1977	0.54	0.064	0.03	2.13	0.00
F19	300	12.14	0.9	1977	0.54	0.091	0.05	1.82	0.00
F20	300	6.08	1.6	1977	0.21	0.065	0.07	0.93	0.00
F21	300	11.08	3	1977	0.30	0.020	0.10	0.20	0.00
F22	300	8.53	1.4	1977	0.09	0.012	0.07	0.17	0.00
F23	300	10.28	1.9	1977	0.06	0.001	0.08	0.01	0.00
F24	500	7.6	3.3	1977	3.22	0.255	0.40	0.64	0.00
F25	300	14.01	3.9	1977	2.92	0.131	0.11	1.19	0.11
F26	400	8.72	1.8	1977	2.69	0.217	0.16	1.36	0.00
F27	400	11.55	2	1977	3.79	0.084	0.17	0.49	0.00
F28	300	16.05	0.6	1977	1.35	0.076	0.04	1.90	0.02
F32	600	7.35	0.8	1977	0.02	0.006	0.33	0.02	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Minor Outlets
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-6

Outlet F Flow Paths

SE DESIGN AND CONSULTING INC.

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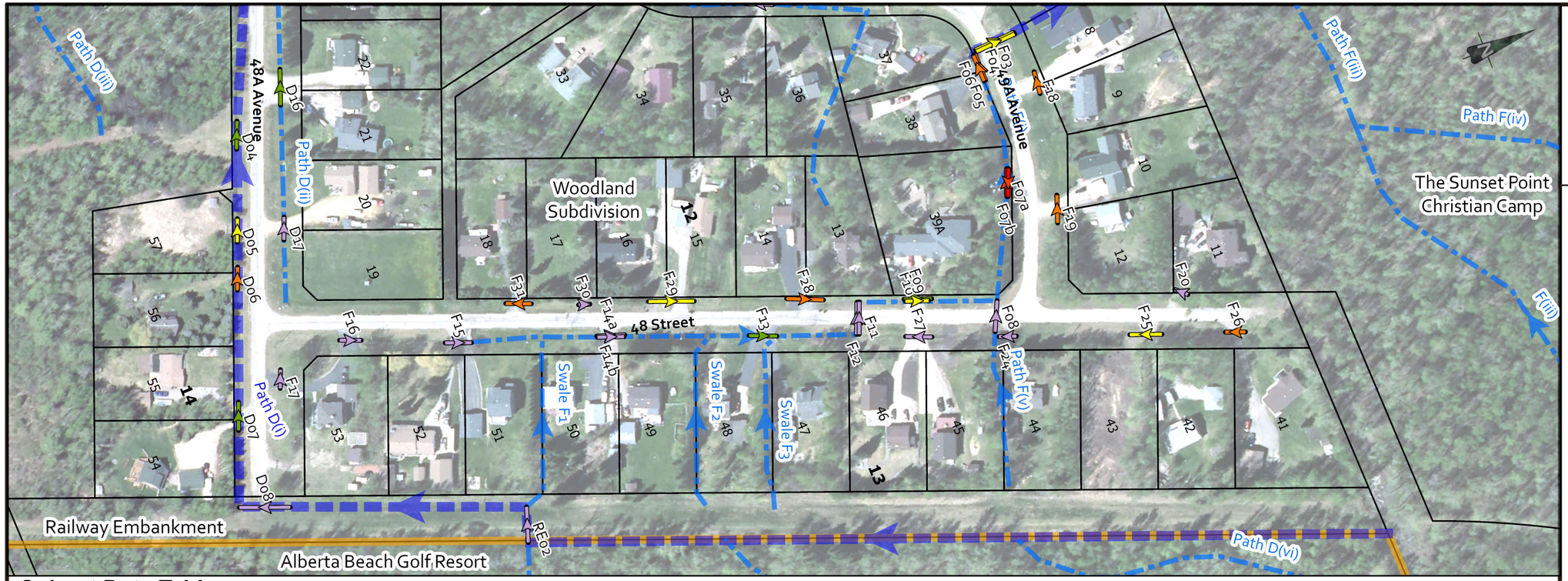

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
D04	600	12.29	1.7	1977	69.43	0.490	0.47	1.04	0.00
D05	600	10.26	1.2	1977	69.20	0.489	0.39	1.25	0.00
D06	600	10.09	0.5	1977	69.09	0.433	0.26	1.67	0.15
D07	600	12.35	1.6	1977	68.79	0.486	0.46	1.06	0.00
D08	600	22.22	0.9	1977	2.56	0.051	0.34	0.15	0.00
D16	300	15.69	1.6	1977	0.82	0.088	0.07	1.26	0.00
D17	300	10.01	2.2	1977	0.34	0.092	0.08	1.15	0.00
E06	400	10.47	1.5	1977	0.12	0.037	0.15	0.25	0.00
E07	400	11.48	1.6	1977	0.52	0.021	0.15	0.14	0.00
F03	600	18.23	0.5	1977	9.22	0.335	0.24	1.40	0.00
F04	600	18.23	0.4	1977	9.22	0.335	0.24	1.40	0.00
F05	400	12.21	0.8	1977	8.58	0.456	0.33	1.38	0.02
F06	600	11.94	1.6	1977	8.58	0.456	0.33	1.38	0.02
F07a	400	12.24	0.2	1977	8.36	0.588	0.18	3.27	0.20
F07b	600	12.23	0.3	1977	8.36	0.588	0.18	3.27	0.00
F08	600	13.56	0.8	1977	3.22	0.266	0.33	0.81	0.00
F09	600	12.09	0.3	1977	8.12	0.257	0.21	1.22	0.00
F10	600	10.19	1.9	1977	8.12	0.257	0.21	1.22	0.00
F11	600	14.16	1	1977	6.42	0.204	0.36	0.57	0.00
F12	600	13.99	1.2	1977	2.47	0.167	0.40	0.42	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
F13	600	12.25	0.6	1977	2.47	0.320	0.27	1.19	0.00
F14a	500	12.31	0.9	1977	1.42	0.191	0.21	0.91	0.00
F14b	500	11.58	0	1977	1.42	0.191	0.21	0.91	0.00
F15	600	11.52	2.7	1977	0.81	0.208	0.60	0.35	0.00
F16	300	9.38	0.7	1977	0.17	0.040	0.05	0.80	0.00
F17	300	8.16	2.8	1977	0.17	0.056	0.10	0.56	0.00
F18	300	9.89	0.3	1977	0.54	0.064	0.03	2.13	0.00
F19	300	12.14	0.9	1977	0.54	0.091	0.05	1.82	0.00
F20	300	6.08	1.6	1977	0.21	0.065	0.07	0.93	0.00
F21	300	11.08	3	1977	0.30	0.020	0.10	0.20	0.00
F24	500	7.6	3.3	1977	3.22	0.255	0.40	0.64	0.00
F25	300	14.01	3.9	1977	2.92	0.131	0.11	1.19	0.11
F26	400	8.72	1.8	1977	2.69	0.217	0.16	1.36	0.00
F27	400	11.55	2	1977	3.79	0.084	0.17	0.49	0.00
F28	300	16.05	0.6	1977	1.35	0.076	0.04	1.90	0.02
F29	300	19.87	0.8	1977	0.78	0.061	0.05	1.22	0.00
F30	300	4.88	0.4	1977	0.24	0.032	0.04	0.80	0.00
F31	300	11.16	0.4	1977	0.07	0.064	0.04	1.60	0.00
RE02	500	15.52	1.8	1977	38.76	0.269	0.30	0.90	0.00

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-7

Outlet D and F Flow Paths on 48 Street and Railway Embankment

SE DESIGN AND CONSULTING INC.

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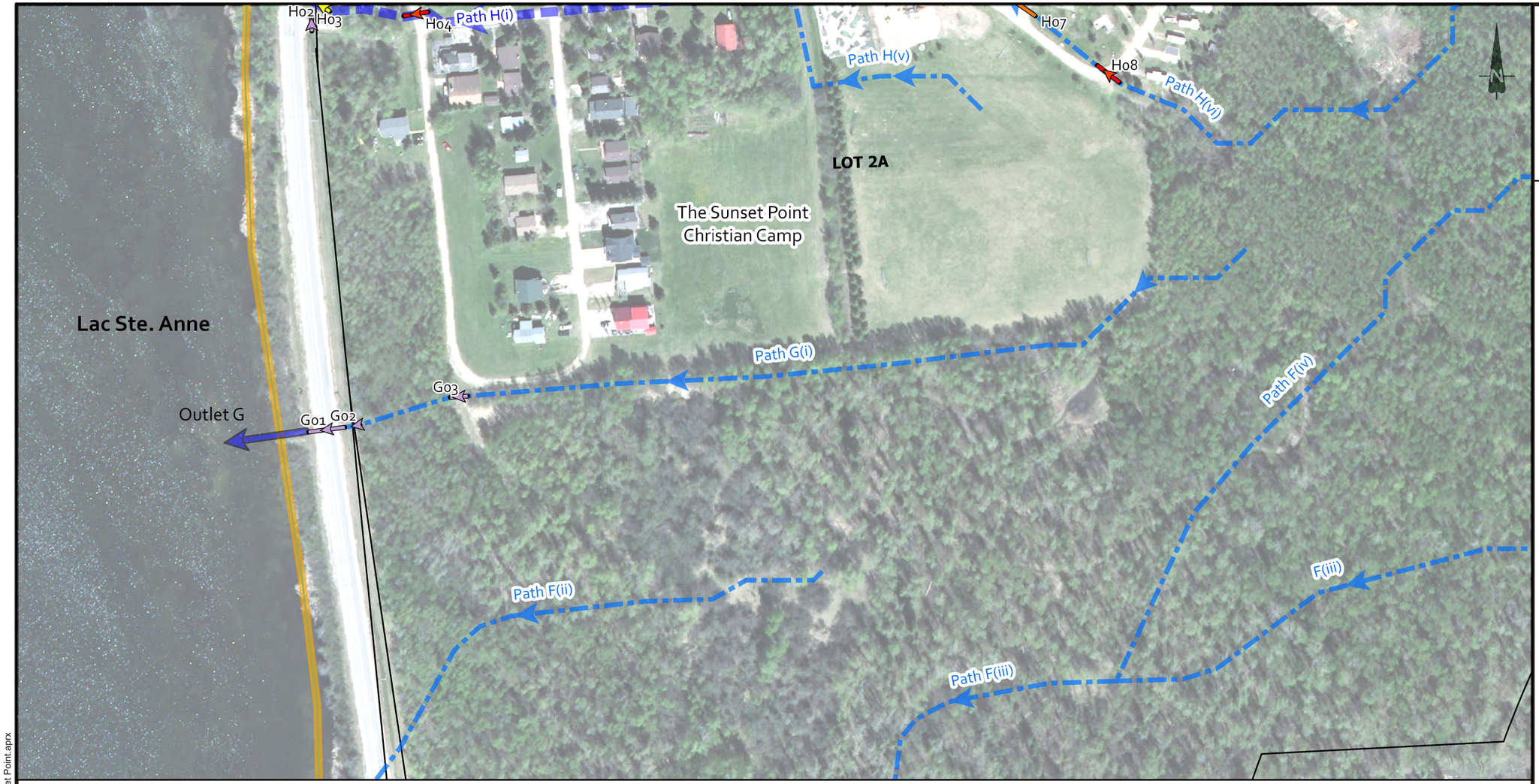

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Minor Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
G01	600	16.32	1.6	1999	4.17	0.354	0.46	0.77	0.00
G02	600	2.48	3.2	1999	3.29	0.276	0.65	0.42	0.00
G03	600	7.89	1	1999	3.29	0.286	0.37	0.77	0.00
H02	600	7.9	2	1999	16.79	0.634	0.52	1.22	0.66
H03	400	6.34	5.5	1999	0.16	0.055	0.29	0.19	0.00
H04	600	11.19	3.2	1999	16.22	0.478	0.65	0.74	0.84
H06	600	54.68	2.5	1999	11.44	0.518	0.58	0.89	0.00
H07	400	39.59	0.9	1999	2.74	0.186	0.12	1.55	0.18
H08	400	12.52	0.2	1999	2.17	0.223	0.06	3.72	0.07

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-8

Outlet G Flow Paths

SE DESIGN AND CONSULTING INC.

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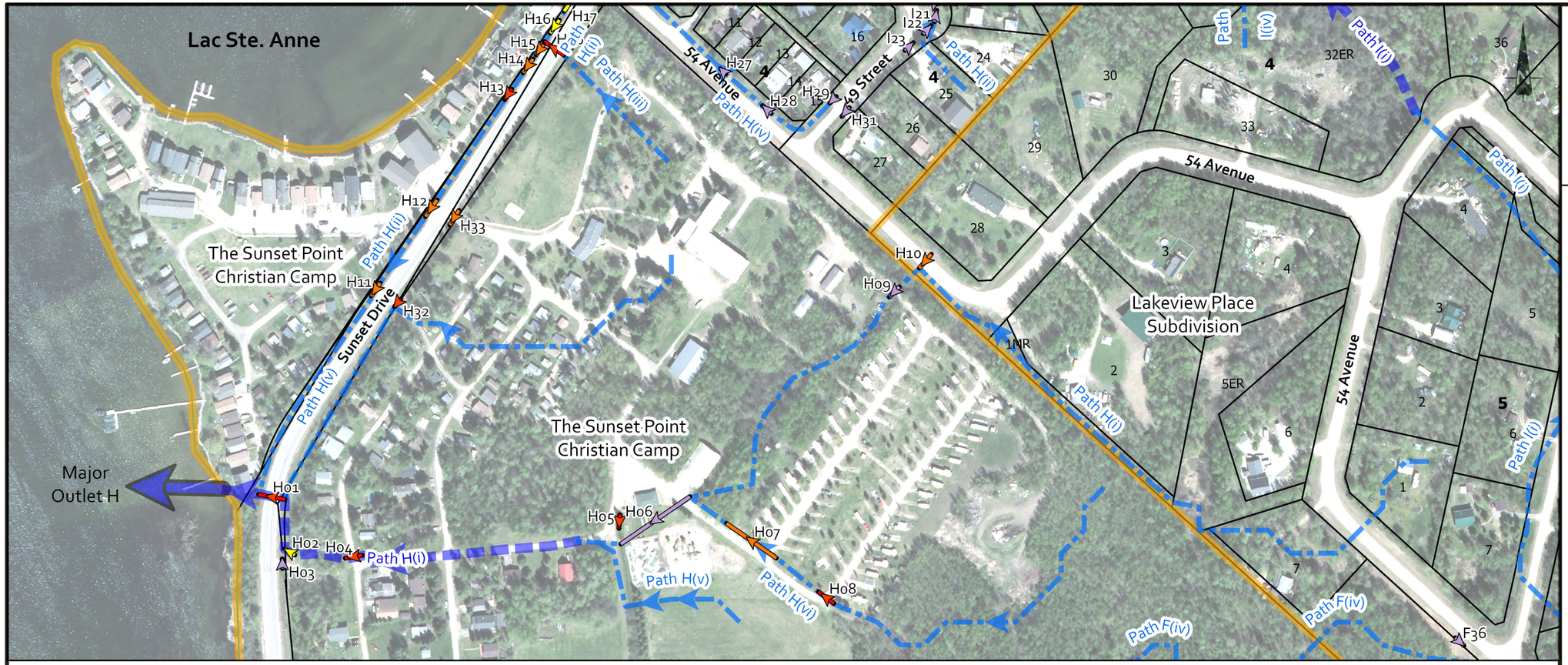

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
F36	400	7.53	0.8	2001	0.24	0.076	0.11	0.69	0.00
H01	600	17.55	0.1	1999	21.69	0.519	0.12	4.33	1.19
H02	600	7.9	2	1999	16.79	0.634	0.52	1.22	0.66
H03	400	6.34	5.5	1999	0.16	0.055	0.29	0.19	0.00
H04	600	11.19	3.2	1999	16.22	0.478	0.65	0.74	0.84
H05	400	9.01	-0.1	1999	0.38	0.097	0.04	2.42	0.00
H06	600	54.68	2.5	1999	11.44	0.518	0.58	0.89	0.00
H07	400	39.59	0.9	1999	2.74	0.186	0.12	1.55	0.18
H08	400	12.52	0.2	1999	2.17	0.223	0.06	3.72	0.07
H09	400	9.11	4.1	1999	4.50	0.201	0.25	0.80	0.00
H10	600	11.94	0.2	2001	1.18	0.251	0.15	1.67	0.00
H11	500	10.42	-0.8	1999	3.85	0.316	0.20	1.58	0.06
H12	400	13.16	1.7	1999	3.85	0.256	0.16	1.60	0.21
H13	400	8.35	1.2	1999	3.85	0.271	0.13	2.08	0.34
H14	400	11.07	1.6	1999	3.85	0.226	0.16	1.41	0.47
H15	400	8.16	1.3	1999	3.85	0.190	0.14	1.36	0.52

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
H16	400	10.48	1	1999	1.88	0.088	0.11	0.80	0.20
H17	400	28.51	1.9	1999	1.88	0.097	0.12	0.81	0.20
H26	600	15.54	1.8	1999	1.97	0.175	0.49	0.36	1.43
H27	400	5.15	1.4	1974	0.67	0.119	0.14	0.85	0.00
H28	400	7.47	3.9	1974	0.41	0.056	0.24	0.23	0.00
H29	400	6.05	2.3	1974	0.24	0.003	0.19	0.02	0.00
H30	400	7.55	0.4	1974	0.02	0.007	0.08	0.09	0.00
H31	400	7.49	0.3	1974	0.01	0.000	0.06	0.00	0.00
H32	400	6.46	0.6	1999	2.25	0.263	0.10	2.63	0.18
H33	400	11.25	0.7	1999	0.90	0.170	0.10	1.70	0.00
I20	400	2.88	4.9	1974	0.33	0.106	0.27	0.39	0.00
I21	400	7.54	4.8	1974	0.33	0.102	0.27	0.38	0.00
I22	400	7.4	2.3	1974	0.18	0.053	0.19	0.28	0.00
I23	400	7.39	1.4	1974	0.18	0.053	0.14	0.38	0.00
I24	400	7.4	2	1974	0.26	0.009	0.18	0.05	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:3,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-9

Outlet H Flow Paths in Christian Camp

SE DESIGN AND CONSULTING INC.

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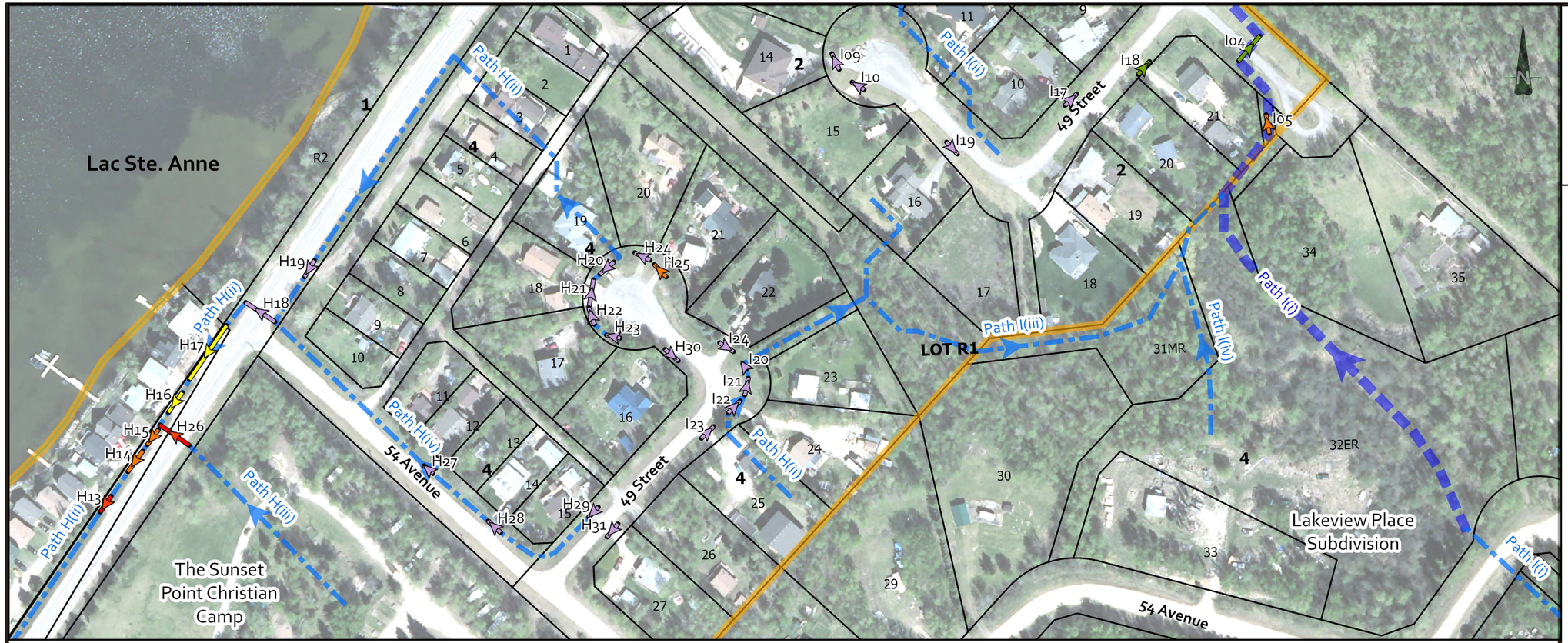

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-10

Outlet H - 49 Street and 54 Avenue Flow Paths

SE DESIGN AND CONSULTING INC.

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
H13	400	8.35	1.2	1999	3.85	0.271	0.13	2.08	0.34
H14	400	11.07	1.6	1999	3.85	0.226	0.16	1.41	0.47
H15	400	8.16	1.3	1999	3.85	0.190	0.14	1.36	0.52
H16	400	10.48	1	1999	1.88	0.088	0.11	0.80	0.20
H17	400	28.51	1.9	1999	1.88	0.097	0.12	0.81	0.20
H18	600	15.18	0.2	1974	1.88	0.269	0.47	0.57	0.00
H19	400	8.32	5.1	1974	0.46	0.098	0.28	0.35	0.00
H20	400	7.93	1.8	1974	0.15	0.084	0.16	0.53	0.00
H21	400	12.29	2.7	1974	0.15	0.056	0.20	0.28	0.00
H22	400	7.57	3.2	1974	0.15	0.056	0.20	0.28	0.00
H23	300	6.14	3.6	1974	0.07	0.027	0.11	0.25	0.00
H24	400	7.42	-0.5	1974	0.07	0.065	0.09	0.72	0.00
H25	400	7.49	0.1	1974	0.07	0.065	0.04	1.63	0.00
H26	600	15.54	1.8	1999	1.97	0.175	0.49	0.36	1.43
H27	400	5.15	1.4	1974	0.67	0.119	0.14	0.85	0.00
H28	400	7.47	3.9	1974	0.41	0.056	0.24	0.23	0.00
H29	400	6.05	2.3	1974	0.24	0.003	0.19	0.02	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
H30	400	7.55	0.4	1974	0.02	0.007	0.08	0.09	0.00
H31	400	7.49	0.3	1974	0.01	0.000	0.06	0.00	0.00
I02	400	109.81	1	1974	15.35	0.137	0.12	1.14	0.00
I03	400	105.08	0.8	1974	15.35	0.144	0.11	1.31	0.00
I04	600	14.18	2.6	1974	15.24	0.518	0.59	0.88	0.06
I05	500	8.3	1.2	1974	13.92	0.274	0.24	1.14	0.53
I09	400	7.58	7.1	1974	0.26	0.088	0.33	0.27	0.00
I10	200	6.14	5.5	1974	0.11	0.038	0.29	0.13	0.00
I17	400	7.25	1.9	1974	0.08	0.028	0.17	0.16	0.00
I18	300	7.49	1.9	1974	0.65	0.095	0.08	1.19	0.00
I19	400	7	2.9	1974	0.27	0.089	0.21	0.42	0.00
I20	400	2.88	4.9	1974	0.33	0.106	0.27	0.39	0.00
I21	400	7.54	4.8	1974	0.33	0.102	0.27	0.38	0.00
I22	400	7.4	2.3	1974	0.18	0.053	0.19	0.28	0.00
I23	400	7.39	1.4	1974	0.18	0.053	0.14	0.38	0.00
I24	400	7.4	2	1974	0.26	0.009	0.18	0.05	0.00

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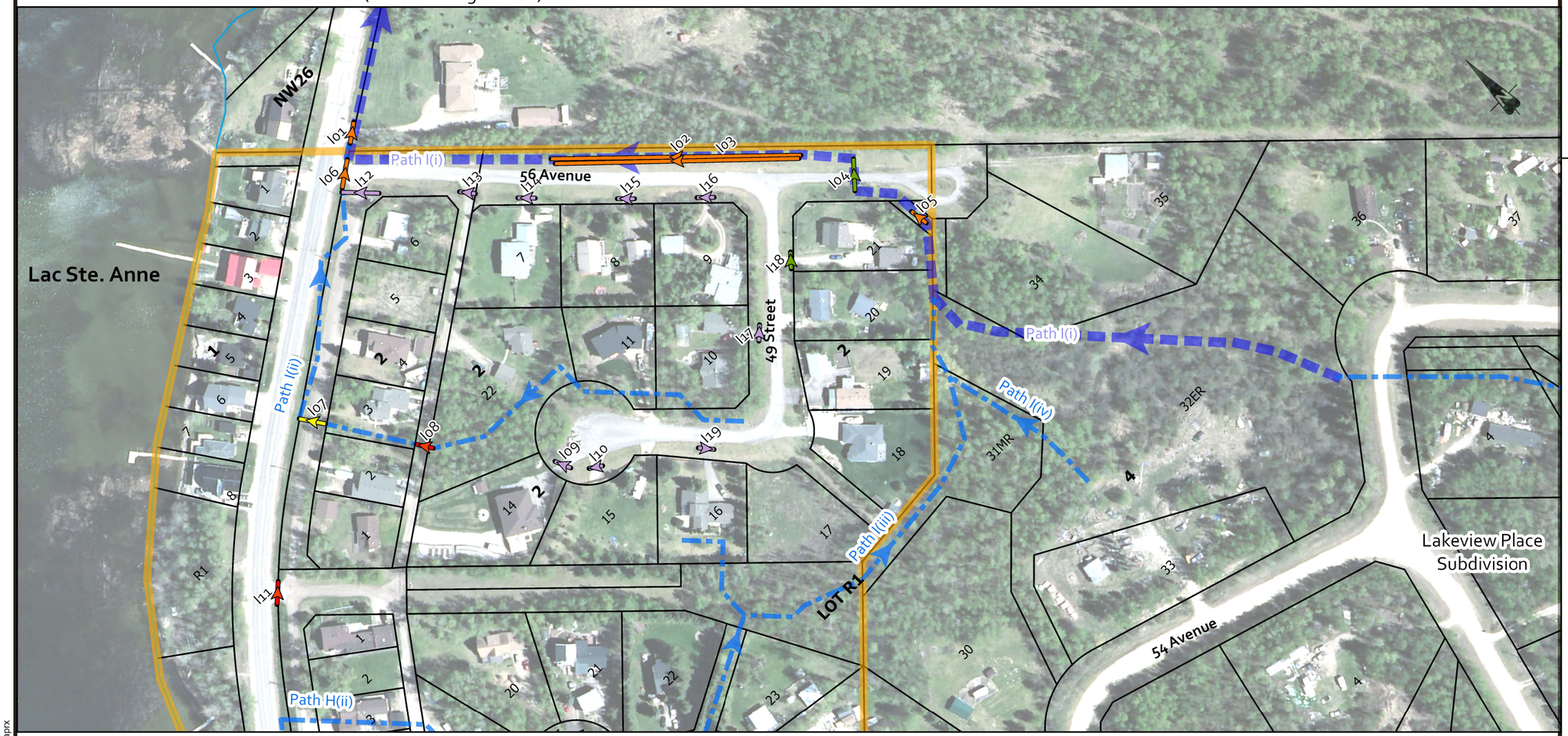
Continues to Outlet I (Shown on Figure A12)



Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
H24	400	7.42	-0.5	1974	0.07	0.065	0.09	0.72	0.00
H25	400	7.49	0.1	1974	0.07	0.065	0.04	1.63	0.00
I01	600	9.47	0.8	1960	21.82	0.592	0.33	1.79	1.40
I02	400	109.81	1	1974	15.35	0.137	0.12	1.14	0.00
I03	400	105.08	0.8	1974	15.35	0.144	0.11	1.31	0.00
I04	600	14.18	2.6	1974	15.24	0.518	0.59	0.88	0.06
I05	500	8.3	1.2	1974	13.92	0.274	0.24	1.14	0.53
I06	600	12.79	0.9	1974	6.21	0.384	0.34	1.13	1.34
I07	400	11.76	3.6	1974	2.32	0.285	0.23	1.24	0.32
I08	400	7.73	0.5	1974	1.30	0.205	0.09	2.28	0.13
I09	400	7.58	7.1	1974	0.26	0.088	0.33	0.27	0.00

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
I10	200	6.14	5.5	1974	0.11	0.038	0.29	0.13	0.00
I11	300	10.25	1	1974	3.00	0.143	0.06	2.38	0.71
I12	600	16.39	2.2	1974	0.85	0.191	0.54	0.35	0.00
I13	400	7.01	3.3	1974	0.74	0.167	0.22	0.76	0.00
I14	600	7.67	1.2	1974	0.74	0.193	0.39	0.49	0.00
I15	400	7.57	1.6	1974	0.52	0.134	0.15	0.89	0.00
I16	400	7.59	0.5	1974	0.27	0.077	0.09	0.86	0.00
I17	400	7.25	1.9	1974	0.08	0.028	0.17	0.16	0.00
I18	300	7.49	1.9	1974	0.65	0.095	0.08	1.19	0.00
I19	400	7	2.9	1974	0.27	0.089	0.21	0.42	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-11
Outlet I Flow Paths

SE DESIGN AND CONSULTING INC.

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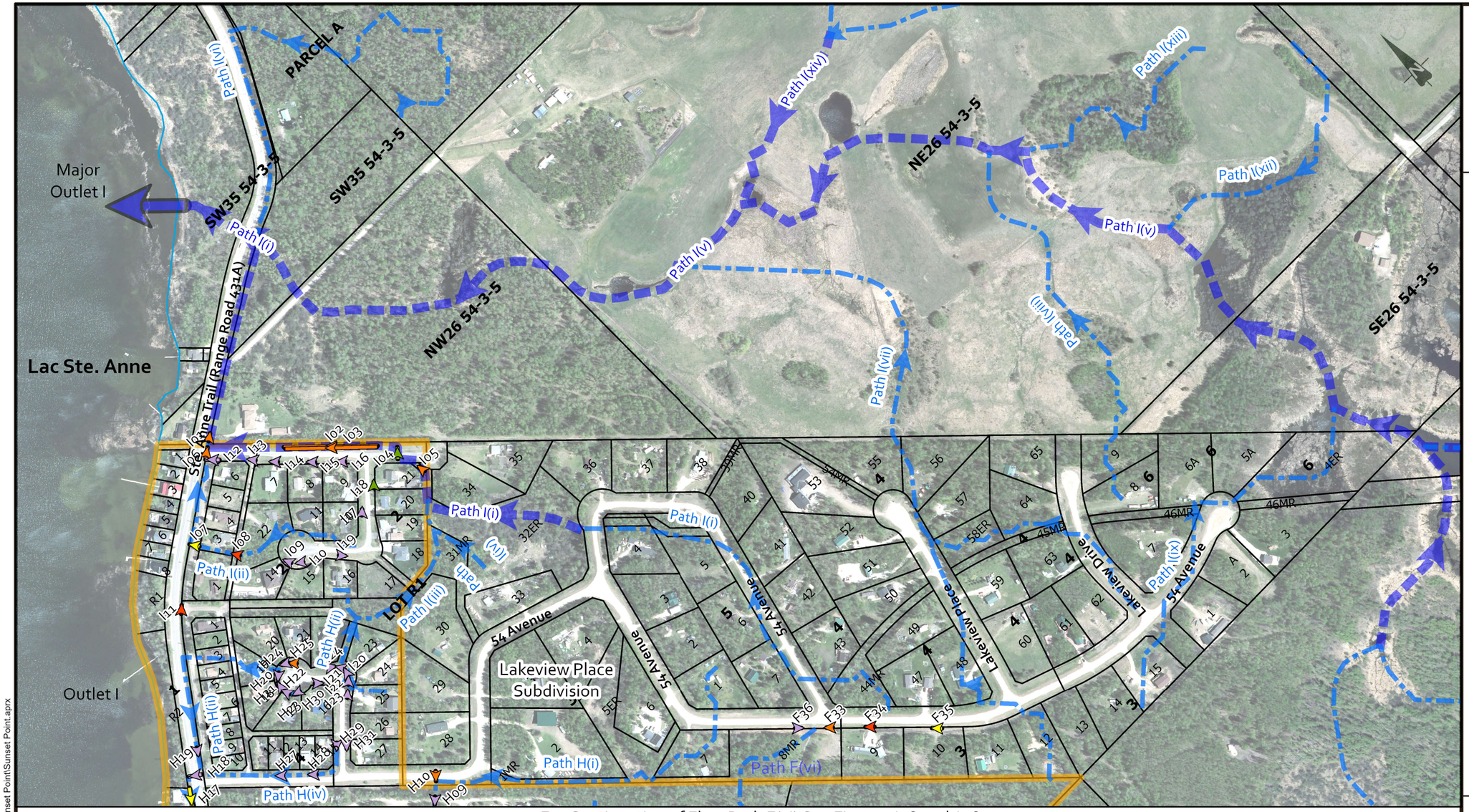
Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)



Legend:

- Minor Flow Paths
- Major Flow Paths
- Major Outlets

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:5,000

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
F33	400	7.4	2	2001	3.81	0.287	0.18	1.59	0.53
F34	400	10.42	0.3	2001	3.37	0.249	0.07	3.56	0.45
F35	600	11.61	0.9	2001	2.28	0.437	0.35	1.25	0.17
F36	400	7.53	0.8	2001	0.24	0.076	0.11	0.69	0.00

For complete culvert data table please see Figure A-11

Figure A-12

Outlet I and Flow Paths Through Lakeview Place

SE DESIGN AND CONSULTING INC.

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Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
RE01	400	11.09	-1.1	1960	21.30	0.269	0.13	2.09	0.00

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,500

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Figure A-13

Dugout (Storm Pond) Flow Paths

SE DESIGN AND CONSULTING INC.

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Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Minor Flow Paths
- Major Flow Paths

Municipal Boundary

- Sunset Point

Culvert Capacity

- Inadequate
- 5-Year
- 10-Year
- 25-Year
- 100-Year

Scale: 1:2,500

Notes:
1. Aerial photograph provided by Lac Ste. Anne County
2. All flow rates are for 1:25-year rainfall event.
3. Installation year approximated from subdivision records
4. Peak flow ratio is: Max Flow/Full Flow
5. Overflow is flow passing over a roadway or approach, assuming 1m ditch depth.

Culvert Data Table

Name	Diameter (mm)	Length (m)	Slope (%)	Year	Cont. Area (ha)	Max. Flow (cms)	Full Flow (cms)	Flow Ratio	Overflow (cms)
RE02	500	15.52	1.8	1977	38.76	0.269	0.30	0.90	0.00

For complete culvert table please see Figure A-7

Figure A-14

Culvert RE02 Flow Paths

SE DESIGN AND CONSULTING INC.

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APPENDIX B:
Preliminary Cost Estimates

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

PROJECT 1: EMBANKMENT DRAINAGE SYSTEM - EAST DITCH
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	5,000.00	5,000.00
1.2		Dewatering of Construction Area	5	day	1,800.00	9,000.00
		TOTAL FOR SCHEDULE 1.0				14,000.00
		SCHEDULE 2.0 - EMBANKMENT EAST DITCH				
2.1		Clearing and Grubbing	1.38	ha	12,000.00	16,560.00
2.2		Topsoil stripping and stockpile to depth of 0.20m	14,000	m^2	2.25	31,500.00
2.3		Remove and dispose of existing CSP culvert	2	ea.	1,500.00	3,000.00
2.4		Supply and Install 20.0m 800mm CSP c/w Trenching, Clay cap, non Woven Geotextile, rip rap, and aniamal Grate	1	ea.	11,500.00	11,500.00
2.5		Common excavation, grading and compaction at 95% standard proctor density	850	m^3	6.00	5,100.00
2.6		Removal of excess material	3,425	m^3	10.00	34,250.00
2.7		Supply and install North American Green SC150 Erosion Control Mat	4,325	m^2	4.00	17,300.00
2.8		Spread topsoil from stock pile complete with hydroseed	14,000	m^2	6.00	84,000.00
						203,210.00

ESTIMATE SUMMARY

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**14,000.00**
SCHEDULE 2.0 - EMBANKMENT EAST DITCH	**$**	**203,210.00**
SUBTOTAL	**$**	**217,210.00**
CONTINGENCY (10%)	**$**	**21,721.00**
UTILITY COORDINATION AND HYDROVAC	**$**	**4,000.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**5,600.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**10,600.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**12,000.00**
LEGAL SURVEY AND RW REGISTRATION	**$**	**5,800.00**
TOTAL PROJECT COST	**$**	**271,131.00**

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

PROJECT 1: EMBANKMENT DRAINAGE SYSTEM - 48A AVENUE CULVERT AND DITCH IMPROVEMENTS
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	10,000.00	10,000.00
		TOTAL FOR SCHEDULE 1.0				10,000.00
		SCHEDULE 2.0 - STORMWATER COLLECTION SYSTEM (PHASE 2)				
2.1		Clearing and Grubbing	0.10	ha	8,500.00	850.00
2.2		Topsoil stripping and stockpile to depth of 0.20m	2,350	m^2	2.25	5,287.50
2.3		Remove and dispose of existing CSP culvert	7	ea.	1,500.00	10,500.00
2.4		Supply and Install 800mm CSP approach c/w Clay cap, non Woven Geotextile, rip rap, and remove and replace existing road structure				
		.1 11.0m Length	3	ea.	6,600.00	19,800.00
		.2 12.5m length	2	ea.	7,500.00	15,000.00
2.5		Supply and Install 24.0m 800mm CSP road crossing c/w Clay cap, non Woven Geotextile, rip rap, and remove and replace existing road structure	1	ea.	14,400.00	14,400.00
2.6		Common excavation, grading and compaction at 95% standard proctor density and removal of excess material	675	m^3	6.00	4,050.00
2.8		Supply and install North American Green SC150 Erosion Control Mat	2,225	m^2	4.00	8,900.00
2.9		supply and install rock check dams	5	ea	250.00	1,250.00
2.10		Supply and install rip rap Armoring at trail intersection (D50= 50mm) c/w non woven geotextile Filter layer	40	m^2	12.00	480.00
2.10		Spread topsoil from stock pile complete with hydroseed	2400	m^2	6.00	14,400.00
		TOTAL FOR SCHEDULE 2.0				94,917.50

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**10,000.00**
SCHEDULE 2.0 - STORMWATER COLLECTION SYSTEM (PHASE 2)	**$**	**94,917.50**
SUBTOTAL	**$**	**104,917.50**
CONTINGENCY (10%)	**$**	**10,000.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**1,800.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**6,650.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**4,350.00**
TOTAL PROJECT COST	**$**	**127,717.50**

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

PROJECT 2: CENTRAL DRAINAGE WAY
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	10,000.00	10,000.00
		TOTAL FOR SCHEDULE 1.0	5	day	1,800	10,000.00
		SCHEDULE 2.0 - DRAINAGE DITCH PHASE I				
2.1		Mulching of treed area	0.41	ha	12,000.00	4,920.00
2.2		Clearing and Grubbing	0.15	ha	8,000.00	1,200.00
2.3		Topsoil stripping and stockpile to depth of 0.20m	5,600	m^2	2.25	12,600.00
2.4		Remove and dispose of existing CSP culvert	1	ea.	1,500.00	1,500.00
2.5		Spread topsoil from stock pile and seed	5600	m^2	4.00	22,400.00
2.6		Common excavation, grading and compaction at 95% standard proctor density and removal of excess material	450	m^3	6.00	2,700.00
2.7		Excess material to be removed from Site	1,625	m^3	14.00	22,750.00
2.8		Supply and install 16.0 m length 800mm CSP for road crossings c/w rip rap, Trenching and Road restoration(100mm ACP, 300mm base course, 150mm subgrade preparation)	1	ea	8,000.00	8,000.00
2.9		Supply and install rock check dams	5	ea	200.00	1,000.00
2.10		Supply and install rip rap Armoring at trail intersection (D50= 50mm) c/w non woven geotextile Filter layer	40	m^2	12.00	480.00
2.10		Supply and install North American Green SC150 Erosion Control Mat	1,750	m^2	4.00	7,000.00
		TOTAL FOR SCHEDULE 2.0				84,550.00

ESTIMATE SUMMARY

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**10,000.00**
SCHEDULE 2.0 - DRAINAGE DITCH PHASE I	**$**	**84,550.00**
SUBTOTAL	**$**	**94,550.00**
CONTINGENCY (10%)	**$**	**9,300.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**2,500.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**5,200.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**7,200.00**
GEOTECHNICAL TESTING	**$**	**2,000.00**
LEGAL SURVEY AND RW REGISTRATION	**$**	**6,600.00**
TOTAL PROJECT COST	**$**	**127,350.00**

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

PROJECT 3: 56 AVENUE CULVERT REPLACEMENTS AND DITCH REHABILITATION
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	10,000.00	10,000.00
		TOTAL FOR SCHEDULE 1.0	5	day	1,800	10,000.00
		SCHEDULE 2.0 - STORMWATER/ROADWAY DITCH				
2.1		Mulching of treed area	0.25	ha	8,000.00	2,000.00
2.2		Clearing and Grubbing	0.18	ha	12,000.00	2,208.00
2.3		Topsoil stripping and stockpile to depth of 0.20m	4,350	m^2	2.25	9,787.50
2.4		Remove and dispose of existing CSP culvert	4	ea.	1,500.00	6,000.00
2.5		Spread topsoil from stock pile and seed	4350	m^2	4.00	17,400.00
2.6		Excess material to be removed from Site	725	m^3	14.00	10,150.00
2.7		Supply and install 12m length 600mm CSP for road crossings c/w rip rap, Trenching and Road restoration(100mm ACP, 300mm base course, 150mm subgrade preparation)	1	ea	4,500.00	4,500.00
2.8		Supply and install 112m length 800mm CSP c/w Trenching, Rip Rap, and Geotextile Fabric	1	ea	42,000.00	42,000.00
2.9		Supply and install North American Green SC150 Erosion Control Mat	925	m^2	4.00	3,700.00
		TOTAL FOR SCHEDULE 2.0				97,745.50

ESTIMATE SUMMARY

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**10,000.00**
SCHEDULE 2.0 - STORMWATER/ROADWAY DITCH	**$**	**97,745.50**
SUBTOTAL	**$**	**107,745.50**
		5,600.00
CONTINGENCY (10%)	**$**	**10,600.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**12,000.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**5,870.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**8,200.00**
GEOTECHNICAL TESTING	**$**	**1,760.00**
TOTAL PROJECT COST	**$**	**151,775.50**

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

DRAINAGE RECOMMENDATIONS FOR FUTURE RESIDENTIAL DEVELOPMENT PARCEL 1
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	10,000.00	10,000.00
		TOTAL FOR SCHEDULE 1.0				10,000.00
		SCHEDULE 2.0 - BACK OF LOT DRAINAGE SWALE				
2.1		Mulching of treed area	0.98	ha	8,000.00	7,840.00
2.2		Clearing and Grubbing	0.15	ha	6,500.00	975.00
2.3		Topsoil stripping and stockpile to depth of 0.20m	11,500	m^2	2.25	25,875.00
2.4		Spread topsoil from stock pile and seed	11500	m^2	4.00	46,000.00
2.5		Common excavation, grading and compaction at 95% standard proctor density and removal of excess material	275	m^3	6.00	1,650.00
2.6		Excess material to be removed from Site	1,600	m^3	14.00	22,400.00
2.7		Supply and install 8m length 600mm CSP c/w rip rap, Trenching, Geotextile, and Clay Cap	1	ea	3,500.00	3,500.00
2.8		Supply and Install rip rap appron	75	m^2	85.00	6,375.00
		TOTAL FOR SCHEDULE 2.0				114,615.00

ESTIMATE SUMMARY

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**10,000.00**
SCHEDULE 2.0 - BACK OF LOT DRAINAGE SWALE	**$**	**114,615.00**
SUBTOTAL	**$**	**124,615.00**
CONTINGENCY (10%)	**$**	**12,460.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**3,430.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**6,850.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**9,600.00**
GEOTECHNICAL TESTING	**$**	**2,055.00**
TOTAL PROJECT COST	**$**	**159,010.00**

SUMMER VILLAGE OF SUNSET POINT
STORMWATER MANAGEMENT PLAN
LAC STE. ANNE COUNTY, ALBERTA

DRAINAGE RECOMMENDATIONS FOR FUTURE RESIDENTIAL DEVELOPMENT PARCEL 2
(PROJECT 2: CENTRAL DRAINAGE WAY PHASE II - DITCH EXTENSION)
PROJECT ESTIMATE

Item	Spec. No.	Description	Quantity and/or Unit		Unit Price $	Contract Value $
		SCHEDULE 1.0 - GENERAL REQUIREMENTS				
1.1		General Requirements	1	ea.	10,000.00	10,000.00
		TOTAL FOR SCHEDULE 1.0				10,000.00
		SCHEDULE 2.0 - DRAINAGE DITCH PHASE 2				
2.1		Mulching of treed area	0.86	ha	8,000.00	6,880.00
2.2		Clearing and Grubbing	0.13	ha	6,500.00	845.00
2.3		Topsoil stripping and stockpile to depth of 0.20m	9,900	m^2	2.25	22,275.00
2.5		Spread topsoil from stock pile and seed	9,900	m^2	4.00	39,600.00
2.6		Common excavation, grading and compaction at 95% standard proctor density and removal of excess material	1,225	m^3	10.00	12,250.00
2.7		Supply and install North American Green SC150 Erosion Control Mat	1,500	m^2	4.00	6,000.00
2.8		Supply and install rock check dams .1 15m spacing on slopes above 1% grade. .2 25m spacing on slopes below 1% grade.	7	ea	200.00	1,400.00
		TOTAL FOR SCHEDULE 2.0				89,250.00

ESTIMATE SUMMARY

SCHEDULE 1.0 - GENERAL REQUIREMENTS	**$**	**10,000.00**
SCHEDULE 2.0 - DRAINAGE DITCH PHASE 2	**$**	**89,250.00**
SUBTOTAL	**$**	**99,250.00**
CONTINGENCY (10%)	**$**	**10,000.00**
PRELIMINARY ENGINEERING AND SURVEY	**$**	**3,000.00**
DESIGN ENGINEERING AND APPROVALS	**$**	**5,500.00**
CONSTRUCTION SURVEY, INSPECTION AND MANAGEMENT	**$**	**8,000.00**
GEOTECHNICAL TESTING	**$**	**2,000.00**
TOTAL PROJECT COST	**$**	**127,750.00**

APPENDIX C:
Site Photos

Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Sunset Point
- Site Photo 18-Jul-2019
- Existing Culvert

Scale: 1:2,500

Figure C-1

Site Photo Map

SE DESIGN AND CONSULTING INC.

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Summer Village of Sunset Point

W26 54-3-5, NW23 54-3-5 and NE22 54-3-5

Stormwater Management Plan (SWMP)

Legend:

- Sunset Point
- Site Photo 18-Jul-2019
- Existing Culvert

Scale: 1:1,500

Figure C-2

Site Photo Map 2/2

SE DESIGN AND CONSULTING INC.

S:\7- Miscelaneous\Misc-0185 - Sunset Point - SWM Plan\ArcGIS\Site Photo Map\Site Photo Map.aprx

Photo 1 – Railway embankment west ditch, culvert D08 inlet, facing north.

Photo 2 – Railway embankment east ditch, facing east.

Photo 3 – Culvert RE02 outlet, facing east.

Photo 4 – Culvert RE02 inlet, facing east.

Photo 5 – Rear yard Lot 49 (48 Street), as seen from the railway embankment, facing west.

Photo 6 – Railway embankment north of Lot 49 (48 Street), facing north.

Photo 7 – Railway embankment from behind Lot 53 (48 Street), culvert D08 inlet (center), facing south.

Photo 8 – Existing railway embankment recreational trail, facing north.

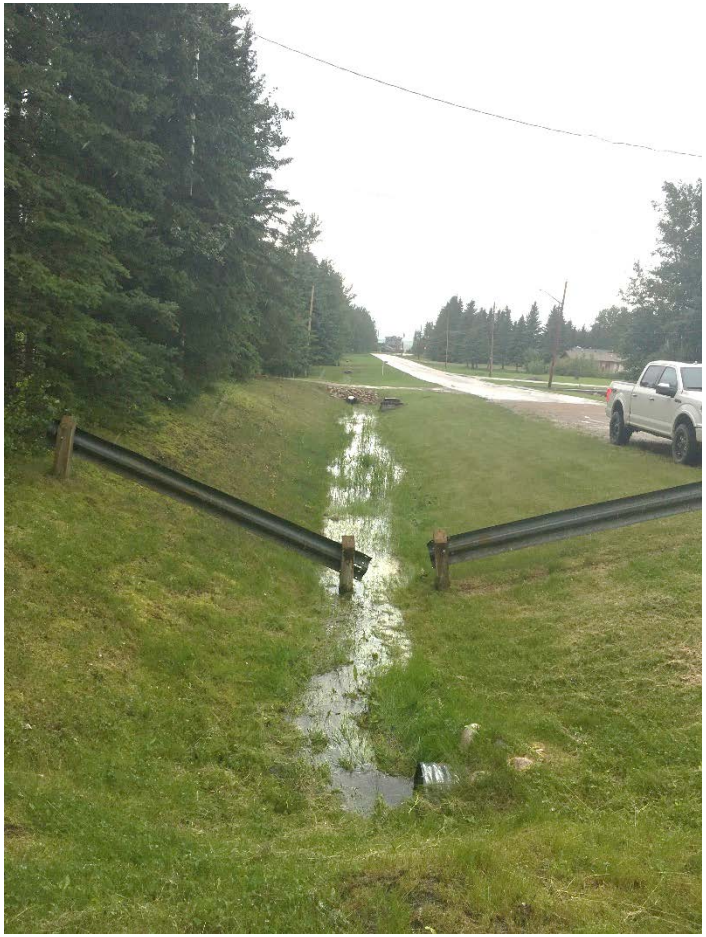


Photo 9 – Flow Path D(i), 48A Avenue south ditch, facing west.

Photo 10 – Existing Dugout, facing northwest.

Photo 11 – 48 Street property line swale, facing east.

Photo 12 – 48 Street property line swale, facing east.

Photo 13 – 48 Street property line swale, facing east.

Photo 14 – Culvert F11 and F12 48 Street crossing inlet, facing east.

Photo 15 – F03 and F04 culvert inlet (left) and F05/F06 culvert outlet (right), facing east.

Photo 16 – F03 and F04 culvert inlet (facing north).

Photo 17 – Lot 7/8 swale and culvert F03 and F04 outlet, facing south.

Photo 18 – Lot 7/8 swale facing north.

Photo 19 – Lot 7 rear lot ditch (to be filled), facing west.

Photo 20 – Lot 8 rear lot ditch (to be filled), facing east.

Photo 21 – Lot 7 rear lot ditch (to be filled), facing west toward Lot 6 and MR.

Photo 22 – Existing stormwater ditch through the MR, Major Flow Path F(i), facing east.

Photo 23 – Culvert F02 outlet (Sunset Drive Recreational Trail Crossing), facing east.

Photo 24 – Culvert F02 inlet, facing northwest.

Photo 25 – Culvert F01 inlet, facing west.

Photo 26 – Culvert F01 outlet, facing west.

Photo 27 – Culvert F01 outlet, facing east.

Photo 28 – Ditch along rear yard of Lots 20 and 21, Block 2 (49 Street), Path I(i), facing south.

Photo 29 – Culvert I04 inlet, facing north

Photo 30 – Culvert I04 outlet, blocked by shrubs, facing east.

Photo 31 – Culvert I03/I02 inlet, facing west.

Photo 32 – Wetland at possible Flow Path I(i) crossing, no visible evidence of culvert crossing to Outlet I, facing east.

Photo 33 – East ditch of Sunset Drive/Ste. Anne Trail and Flow Path I(i), no visible evidence of culvert crossing to Outlet I, facing north.

APPENDIX D:
Calculations

CULVERT CALCULATIONS

Manning Equation (Type I Culvert Flow - Unsubmerged inlet and outlet):

$$Q = VA \quad V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Where:

Q = Discharge (flow rate) (m^3/s)
V = Average velocity (m/s)
A = Flow area of pipe, culvert, or channel (m^2)
k = Unit conversion factor [k=1.49 for English units (ft, s) k=1.0 for SI units (m,s)]
n = Manning's Roughness Coefficient
P = Wetted Perimeter (m) - portion of the circumference that is in contact with water
S = Longitudinal slope of pipe, culvert or channel (m/m)

Project 1 - Embankment Drainage System - Culvert Flow Calculations for 1:25-Year Rainfall Runoff Event

	Contributing Area (ha)	Peak Flow (m^3/s)	Recommended Pipe Size (mm)	Minimum Slope (%)	Manning #	Total Capacity (m^3/s)	Peak Velocity (m/s)
P CSP - 001	66.04	0.93	800	2.50%	0.022	1.24	2.24
P CSP - D07	68.80	0.98	800	2.00%	0.022	1.11	2.85
P CSP - D06	69.09	0.98	800	0.50%	0.022	0.55	2.07
P CSP - D05	69.20	1.01	800	0.50%	0.022	0.55	2.17
P CSP - D04	69.43	1.03	800	0.50%	0.022	0.55	2.56
P CSP - D03	74.16	1.08	TO BE REMOVED				
P CSP - D02	76.82	1.19	1050	0.55%	0.022	1.20	1.60
P CSP - D01	79.66	1.19	1050	0.55%	0.022	1.20	2.21

Project 2 - 49a Avenue Major Flow Path and Central Draiange Way - Culvert Flow Calculations for 1:25-Year Rainfall Runoff Event

Component	Contributing Area (ha)	Peak Flow (m^3/s)	Recommended Pipe Size (mm)	Minimum Slope (%)	Manning #	Capacity (m^3/s)	Peak Velocity (m/s)	Combined Capacity (m^3/s)
P CSP-F02a	15.85	0.97	800	0.60%	0.022	0.61	1.36	1.21
P CSP-F02b			800	0.60%	0.022	0.61	1.36	
E CSP-F01(a)	19.63	1.10	600	3.40%	0.022	0.67	2.70	1.63
P CSP-F01b			800	1.50%	0.022	0.96	2.10	

Project 3 - 56 Avenue Replacement of Culverts and Ditch Rehabilitation - Culvert Flow Calculations for 1:25-Year Rainfall Runoff Event

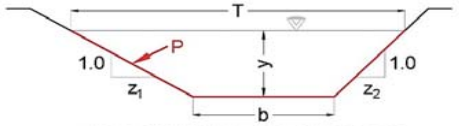
Component	Contributing Area (ha)	Peak Flow (m^3/s)	Recommended Pipe Size (mm)	Minimum Slope (%)	Manning #	Capacity (m^3/s)	Peak Velocity (m/s)
P CSP-I02	15.4	0.59	800	1.00%	0.022	0.78	2.24
P CSP-I01	21.8	2.06	1200	1.25%	0.022	2.58	1.91

Manning Equation For Open Channel Flow:

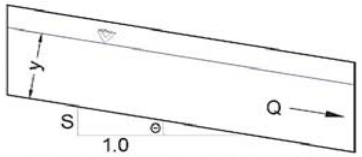
$$Q=VA$$

Where:

Q = Flow Rate, (m^3/s)
V = Average Velocity, (m/s)
A = Flow Area, (m^2)



OPEN CHANNEL - SECTION VIEW



OPEN CHANNEL - SIDE VIEW

Velocity (V)

$$V=\frac{k}{n}R^{2/3}S^{1/2}$$

Where:

k = Unit conversion factor [k=1.49 for English units (ft, s) k=1.0 for SI units (m,s)]
n = Manning's Roughness Coefficient
R = Hydraulic Radius (m)
S = Longitudinal Channel Slope (m/m)

Trapezoidal Flow Area (A)

$$A=\frac{y}{2}(b+T)$$

Where:

y = flow depth (m) - iterate to find this value, unless measured
b = bottom width of channel (m)
T = top width of flow (m)
T = top width of flow (m)

Top Width of Flow (T)

$$T=b+y(z_1+z_2)$$

Where:

y = flow depth (m) - iterate to find this value, unless measured
b = bottom width of channel (m)
z_1 = slope of left bank (H:V)
z_2 = slope of right bank (H:V)

Wetted Perimeter (P)

$$P=b+y\left(\sqrt{1+z_1^2}+\sqrt{1+z_2^2}\right)$$

Hydraulic Radius (R)

$$R=\frac{A}{P}$$

Angle Formed by Slope (Θ)

$$\theta=\tan^{-1}S$$

Froude Number (F)

$$F=V\sqrt{\frac{T}{gA\cos\theta}}$$

Where:

g = acceleration due to gravity (32.174ft/s^2 of 9.8066m/s^2)
Θ = angle formed by slope
** F <1 = subcritical,F=1 = critical, F>1 - supercritical

Project 1 - Embankment Drainage System - Proposed East Ditch Open-Channel Flow Calculations

Channel Name	Contributing Area (ha)	Q_{25} (m^3/s)	Q_{des} (m^3/s)	V_{25} (m/s)	A (m^2)	n	R	S (%)	S (m/m)	P(m)	b (m)	T (m)	z_1	z_2	Θ (°)	F	y (m)
P East Ditch - N	38.59	0.25	0.25	0.50	0.494	0.030	0.20	0.2	0.0020	2.51	0.50	2.38	3.00	2.50	0.115	0.35	0.343
P East Ditch - S	21.25	0.16	0.16	0.49	0.327	0.030	0.16	0.3	0.0025	2.06	0.50	1.96	3.00	2.50	0.143	0.38	0.266

Project 2 - Central Draiange Way Open-Channel Flow Calculations

Channel Name	Contributing Area (ha)	Q_{25} (m^3/s)	Q_{des} (m^3/s)	V_{25} (m/s)	A (m^2)	n	R	S (%)	S (m/m)	P(m)	b (m)	T (m)	z_1	z_2	Θ (°)	F	y (m)
P Ditch-01	9.28	0.64	0.64	0.87	0.732	0.030	0.23	0.5	0.0050	3.24	1.00	3.13	3.00	3.00	0.286	0.58	0.355
P Ditch-02	16.99	1.23	1.23	0.95	1.295	0.030	0.26	0.5	0.0050	5.06	2.00	4.97	4.00	4.00	0.286	0.59	0.372
P Ditch-03	27.98	1.18	1.18	0.88	1.335	0.030	0.29	0.4	0.0037	4.61	2.00	4.48	3.00	3.00	0.210	0.52	0.413

Project 3 - 56 Avenue Replacement of Culverts and Ditch Rehabilitation Open-Channel Flow Calculations

Channel Name	Contributing Area (ha)	Q_{25} (m^3/s)	Q_{des} (m^3/s)	V_{25} (m/s)	A (m^2)	n	R	S (%)	S (m/m)	P(m)	b (m)	T (m)	z_1	z_2	Θ (°)	F	y (m)
P Ditch-04	15.62	0.72	0.72	0.79	0.915	0.030	0.19	0.5	0.0050	4.74	3.00	4.67	4.00	3.00	0.286	0.57	0.239
P Ditch-05	15.73	0.71	0.71	0.78	0.906	0.030	0.19	0.5	0.0050	4.72	3.00	4.66	4.00	3.00	0.286	0.57	0.237
P Ditch-06	22.52	1.88	1.88	2.10	0.894	0.030	0.19	3.6	0.0364	4.71	3.00	4.64	4.00	3.00	2.085	1.53	0.234

APPENDIX E:
Existing Infrastructure Review

(Please see separate document)