Associated Engineering

GLOBAL PERSPECTIVE.
LOCAL FOCUS.

REPORT

Town of Bon Accord

Stormwater Master Plan

OCTOBER 2019

A Carbon Neutral Company

CANADA BEST MANAGED COMPANIES Platinum member

EXECUTIVE SUMMARY

The Town of Bon Accord (the Town) currently operates and maintains a stormwater drainage system. This system is comprised of ditches and culverts, which convey overland flow, and underground storm pipes to capture flows. Typically, the major system is comprised of infrastructure that conveys overland stormwater runoff (ditches, culverts) and the minor system includes underground infrastructure (storm pipes). It is evident that the existing stormwater infrastructure is not performing to its design intent, as the Town has been experiencing surface water drainage issues, ponding and localized flooding at various locations within the Town.

Surface water ponding in residential neighbourhood (March 2019)

Previous drainage studies, including a Drainage Study completed by UMA in 2005, identified existing drainage issues within the Town and provided general mitigation solutions. The Town retained Associated Engineering to complete a Stormwater Master Plan in April 2019 to identify existing drainage issues, provide mitigation options and develop a stormwater management plan for future development.

Associated Engineering undertook the following tasks to complete the Stormwater Master Plan:

- Background review of existing reports and as-built drawings;
- Reviewed various design standards and provided a recommendation;
- Assessed the existing minor and major systems within the Town, based on the current land use;
- Identified existing drainage issues and proposed upgrades;
- Assessed the minor and major systems, based on the future development;
- Assessed proposed upgrades based on future development;
- Developed a stormwater management plan for future development; and,
- Provided preliminary cost estimates (Class D) for proposed system upgrades.

There are three existing natural areas located in the Town boundary. These natural areas act as stormwater management facilities, as they collect and store stormwater runoff from the existing development and the undeveloped lands, to the north and west of the Town, before facilitating drainage towards the Sturgeon River. Only one of the natural areas (Natural Area 3) has an outlet, which discharges north towards the CNR line. The basins convey stormwater runoff through the storm pipes and the ditches and culverts.

The catchment areas for the minor and major systems were delineated using LiDAR data and the Rational Method was used to estimate the flows discharging into the systems. The results from the assessment of the existing minor and major systems concluded that the majority of the Town's stormwater infrastructure does not have capacity to convey flows generated from design storm events. Therefore, recommendations were made to upgrade sections of storm pipes within the minor system and culverts within the major system.

Future development is proposed within the undeveloped lands located north and west of the Town. Based on the proposed future land use, no flows from future developments will discharge into the existing minor system. Culverts within the upgraded major system were assessed based on flows generated from future developments contributing into the existing systems. Assessment results showed that most upgraded culverts within the existing system have capacity. If the Town carries out the proposed existing system upgrades, it is advantageous to upgrade all culverts for the ultimate development. A preliminary Class D cost estimate for upgrades to the existing minor and major systems was generated. A total of $3,120,000 was estimated to undertake the improvements.

All future development will require an on-site minor stormwater system and a major stormwater system. To mitigate any impacts on the drainage systems within the area, due to the proposed development, the Town requires stormwater management facilities. The stormwater management facilities will allow system discharge rates to be controlled to the recommended release rate of 6 L/s/ha. The future stormwater management concept for the Town consists of 9 stormwater management facilities.

To mitigate existing issues within the natural areas and to ensure the areas do not have negative impacts on future development and the downstream, improvements are required. All three natural areas are proposed to have control structures to ensure a release rate of 6 L/s/ha and have a normal water level established, based on property line and minimum freeboard.

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1 INTRODUCTION

1.1 Background Review

The Town of Bon Accord (the Town) is located approximately 40 km north of Downtown Edmonton on Highway 28. The current Town limits encompass approximately six quarter sections, as shown in **Figure 1-1**. The existing development is primarily within SW-18-56-23-4 and SE-18-56-23-4.

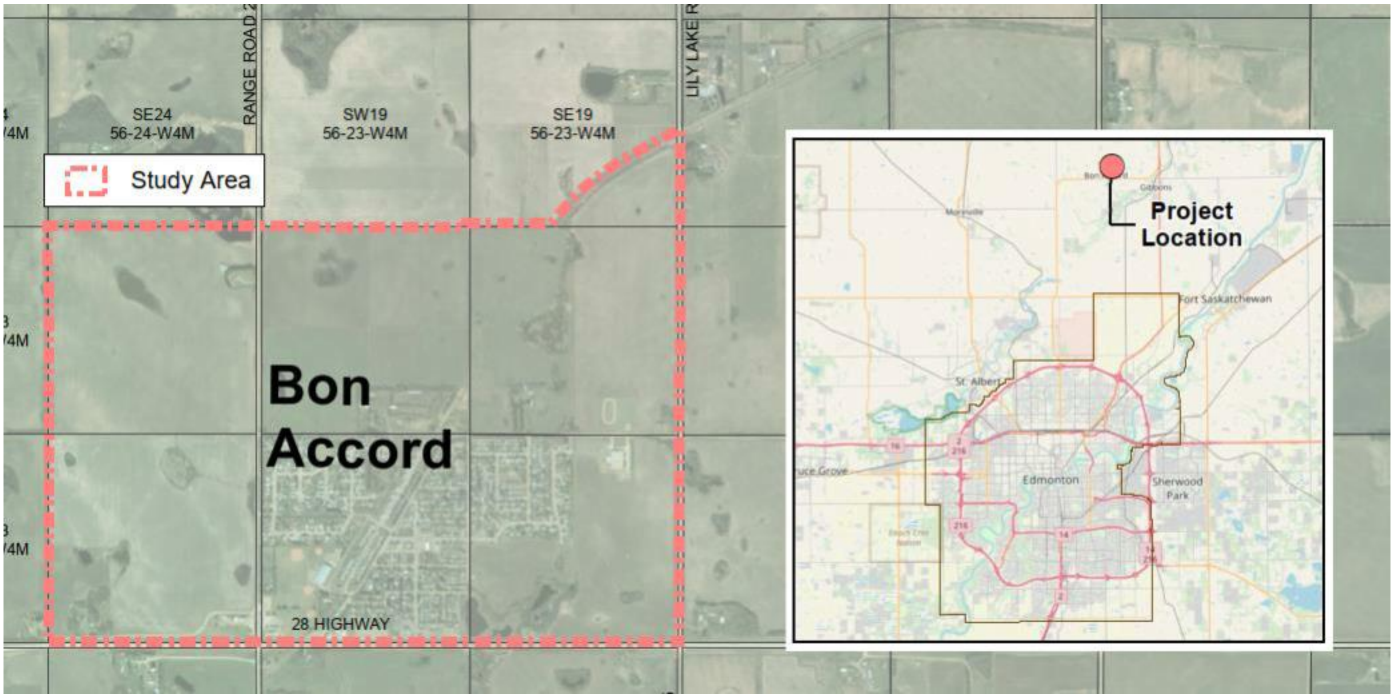


Figure 1-1
Town of Bon Accord

The Town currently operates and maintains a stormwater drainage system. This system is comprised of ditches and culverts, which convey overland flow, and storm pipes to capture flows. Typically, the major system is comprised of infrastructure that conveys overland stormwater runoff (ditches, culverts) and the minor system includes underground infrastructure (storm pipes). It is evident that the existing stormwater infrastructure is not performing to its design intent, as the Town has been experiencing surface water drainage issues, ponding and localized flooding at various locations within the Town.

Previous drainage studies, including a Drainage Study completed by UMA in 2005, identified existing drainage issues within the Town and provided general mitigation solutions. In addition, no stormwater management plan has been developed for the future development. The Town retained Associated Engineering to complete a Stormwater Master Plan to identify existing drainage issues, provide mitigation options and develop a stormwater management plan for the Town and future development.

Associated Engineering reviewed available design reports and completed a site visit with Town personnel in March 2019 to better understand the existing issues. Examples of findings during the review and site visit include the following:

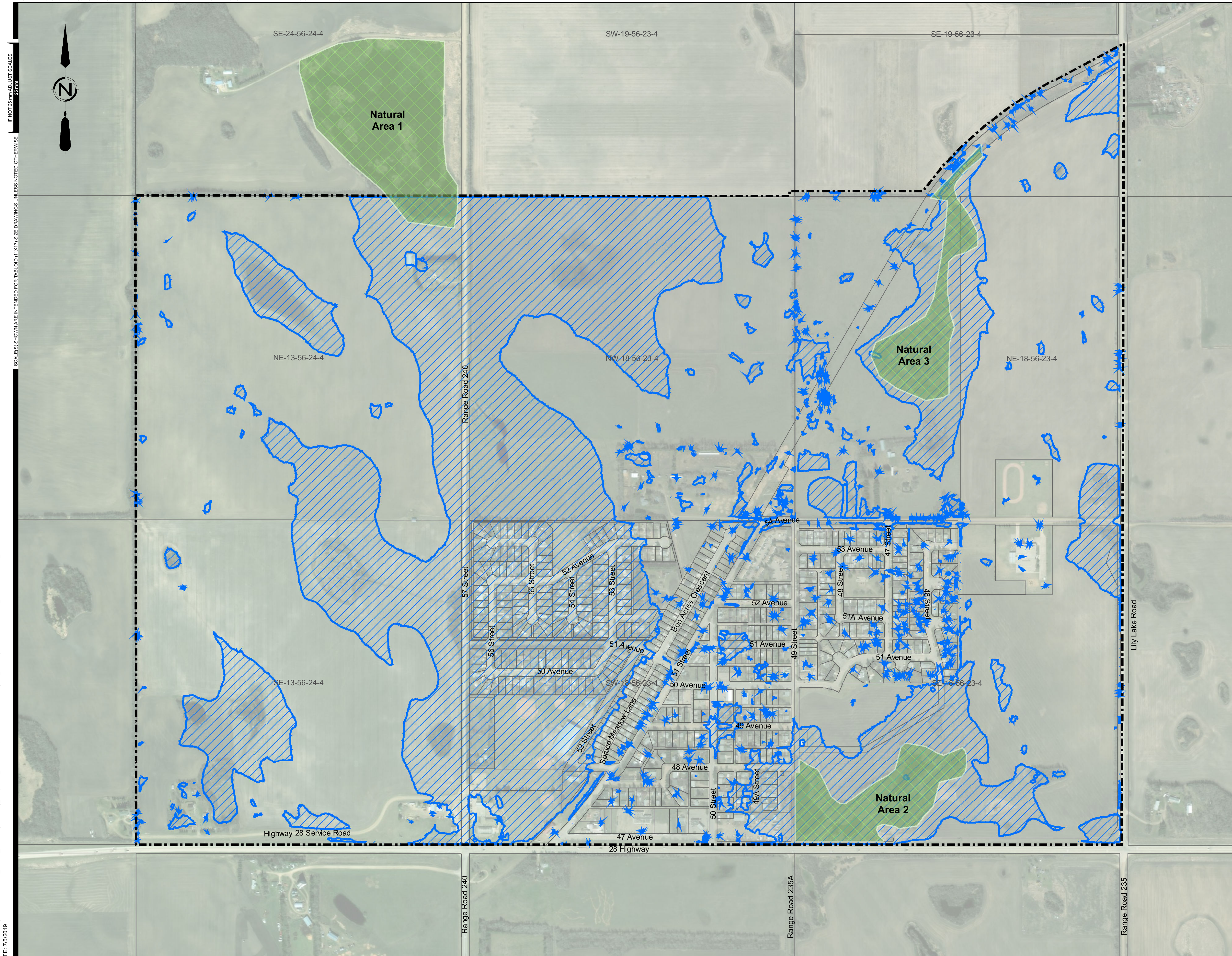
Ponding in ditch network (March 2019)

- The topography within the Town is generally flat and has limited grade within the ditches;
- During storm events and spring melt, flooding has been observed at the following locations:
    - Roadway along 51st Avenue and segments along the west ditch of 52nd Street; and,
    - North ditch along 51st Avenue from 56th Street to 53rd Street.
- There are several ditches, and culverts, that are undersized and are unable to convey flows during design storm events; and,
- Due to limited grade and capacity, stormwater runoff accumulates within the ditch network and causes overtopping of sidewalks and roadways.

Some areas of concern for surface water ponding are highlighted in **Figure 1-2**, which are located within the low sections within the Town. Although surface water ponding has occurred within residential neighbourhoods, the Town has not received any complaints about basement flooding. Only flooding up to property lines has been reported.

1.2 Existing and Future Developments

The existing land use within the current development was based on the 2016 Town of Bon Accord Land Use Bylaw. The future development land use was based on the "Meadows of Bon Accord Servicing Study" (Stantec, 2007), and "Annexation Servicing Study" (MPE Engineering, 2016) illustrated in **Figure 1-3**. Note that the Town recently annexed three quarter sections of land, located west of the existing development, in NE-13-56-24-W4, NW-18-56-23-W4 and SE-13-56-24-W4.



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Legend:

- Potential Ponding Areas (Low Spots)
- Natural Areas
- Town Boundary

Town of Bon Accord
building for tomorrow

FIGURE No. 1-2

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

EXISTING STORMWATER SYSTEM
AREAS OF CONCERN

AE PROJECT No.	2019-3459
SCALE	1:9,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

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

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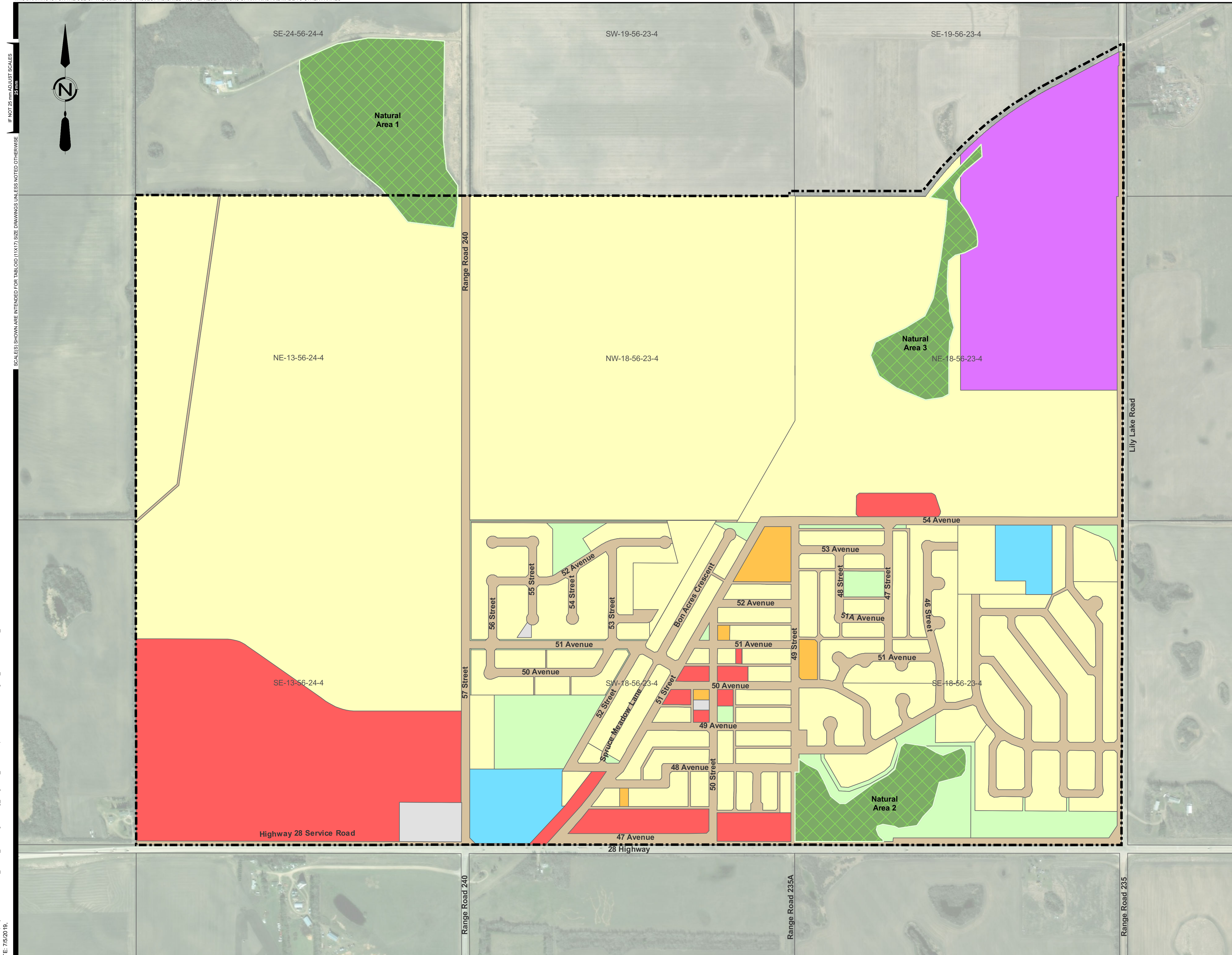
DATE: 7/5/2019.



Associated Engineering

Legend:

- Low Density Residential
- Medium Density Residential
- Commercial
- Industrial
- Institutional
- Public Utility
- Park/Open Space/ER
- Roadways
- Natural Areas
- Town Boundary

Town of Bon Accord
building for tomorrow

FIGURE No. 1-3

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

FUTURE LAND USE

AE PROJECT No.	2019-3459
SCALE	1:9,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

DATE: 7/5/2019.

2 DESIGN CRITERIA

As part of this project, Associated Engineering completed a review of the Town's stormwater design standards. In addition, the following design standards were also reviewed:

- Alberta Environment and Parks - Stormwater Management Guidelines for the Province of Alberta;
- City of Edmonton – Design and Construction Standards;
- Municipal Engineering Standards - City of St. Albert; and,
- Sturgeon County – General Municipal Servicing Standards.

Based on the review and discussion with the Town, Associated Engineering recommended that the Town adopt the City of Edmonton Design and Construction Standards (March 2015). This recommendation was based on the following:

- The proximity of the Town to the City of Edmonton;
- Nearby communities, such as St. Albert and Sturgeon County, have design criteria similar to City of Edmonton standards;
- The City of Edmonton Standards were recently updated in 2015; and,
- The City of Edmonton is using Intensity Duration Frequency (IDF) curves developed in 2018.

A design standards memorandum was submitted to the Town and is provided in **Appendix A**. A summary of the City of Edmonton's design standards used for this study is provided below.

2.1 Minor System

Storm drainage system elements should be designed to accommodate runoff flow rates and volumes as shown in **Table 2-1**.

Table 2-1
Minor System Design Basis

System Elements	Design Basis (Rainfall Return Period)
Minor drainage system components servicing areas of 30 ha and less	5 years
Minor drainage system trunk sewers servicing areas greater than 30 ha	5 year runoff rate plus 25%

The Rational Method was used to estimate runoff flow rates. The rational formula is expressed as:

Q_5 = CIA/360

Where:

Q_5 = Runoff generated by a storm with a return period of 5 years (m^3/s)
C = Runoff coefficient as per City of Edmonton Zoning Bylaw 12800 (refer to **Table 2-2**)

I = Rainfall intensity as per the 2018 EPCOR IDF curves (mm/hr)
A = Drainage area (ha)

Table A6, in Section 13 of the City of Edmonton Design and Construction Standards, was used to determine the time of concentration for each catchment area.

Table 2-2
Minor System Runoff Coefficients

Land Use	Minor System Runoff Coefficients
Industrial	0.60
Commercial	0.60
Public Utility	0.75
Park/Open Space/ER	0.10
Low Density Residential	0.50
Medium Density Residential	0.75
Institutional	0.30
Natural Area	0.01
Roadways	0.95

Table 2-3 presents the design criteria for other parameters used to assess the existing minor system.

Table 2-3
City of Edmonton Design and Construction Standards – Minor System

Parameter	Value
Manning's roughness coefficient, n	0.013
Velocity	
• Minimum	0.6 m/s
• Maximum	3.0 m/s
Minimum Slopes	
• 200 mm diameter	0.40%
• 250 mm diameter	0.28%
• 300 mm diameter	0.22%
• 375 mm diameter	0.15%
• 450 mm diameter	0.12%
• 525 mm diameter and larger	0.10%
Minimum Cover	2.0 m

2.2 Major System

Similar to the minor system, the Rational Method was used to estimate runoff flows. The rational formula for storm runoff is expressed as:

Q_{100} = CIA/360

Where:

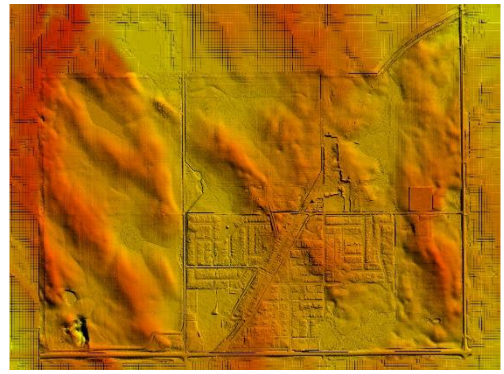
Q_{100} = Runoff generated by a storm with a return period of 100 years (m^3/s)
C = Runoff coefficient as per City of Edmonton Zoning Bylaw 12800 (refer to **Table 2-4**)
I = Rainfall intensity as per the 2018 IDF curves published by EPCOR (mm/hr)
A = Drainage area (ha)

The time of concentration for each catchment area was estimated using the Kirpich equation. For small areas (i.e.: less than 1 ha), Table A6 within the City of Edmonton Design and Construction Standards was used to determine the time of concentration.

Table 2-4
Major System Runoff Coefficients

Land Use	Minor System Runoff Coefficients
Industrial	0.75
Commercial	0.75
Public Utility	0.94
Park/Open Space/ER	0.13
Low Density Residential	0.63
Medium Density Residential	0.94
Institutional	0.38
Natural Area	0.01
Roadways	0.95

3 EXISTING DRAINAGE ASSESSMENT



LiDAR data (1 m and 15 m resolution)

There are three existing natural areas located within the Town boundary. Natural Area 1 is within NE-13-56-24-4, Natural Area 2 is within SE-18-56-23-4 and Natural Area 3 is within NE-18-56-23-4. These natural areas are shown in **Figure 3-1**. Currently, these natural areas act as stormwater management facilities, as they collect and store stormwater runoff from the existing development and undeveloped lands, to the north and west of the Town, before facilitating drainage towards the Sturgeon River. To better understand the existing drainage patterns into each natural area, drainage basins (basins) were delineated using a Geographical Information System (GIS) software, a 1 m Light Detection and Ranging (LiDAR) data and 15 m LiDAR data. The detailed LiDAR (1 m) was applied within the Town lands and the course LiDAR (15 m) was applied outside of the Town boundary to capture any offsite flows. The delineation provided the general flow patterns within each basin (**Figure 3-1**).

Note that only Natural Area 3 has an outlet, which discharges north into the CNR line. This is based on discussions with the Town and the Drainage Study completed in 2005. Limited or no information on this outlet is available.

Catchment delineation results show that all three basins are greater than 65 ha. Based on the City of Edmonton Design and Construction Standards, it is recommended that for drainage areas larger than 65 ha a computer model be developed to verify estimated runoff flows. Therefore, a PCSWMM model was developed to estimate the peak runoff generated within the three basins during a 1 in 100 year 24 hour design storm event.

Table 3-1 summarizes the basins characteristics.

Table 3-1
Drainage Basin Summary

Drainage Basin	Natural Area Within Basin	Legal Location of Natural Area	Drainage Basin Area (ha)	Estimated Peak Runoff (L/s) [1]	Release Rate (L/s/ha)
1	Natural Area 1	NE-13-56-24-4	253	1,490	6
2	Natural Area 2	SE-18-56-23-4	80	1,710	21
3	Natural Area 3	NE-18-56-23-4	71	680	10

1 – Estimated using PCSWMM

Table 3-1 shows that there is variation in flows within the basins. This is due to the different types of land uses within each basin. Based on the existing development within Basin 2, it has the largest estimated peak runoff due to less infiltration into the ground. In addition, flows are not currently controlled within this basin and are discharging into Natural Area 2. Basin assessment showed that Basin 1 is the most representative of pre-development flows because it consists of mainly undeveloped land. Therefore, it is recommended that all future development be controlled to a release rate of 6 L/s/ha into the Natural Areas.

As previously stated, the basins convey stormwater runoff through the storm pipes, ditches and culverts. The catchment areas for the minor and major systems were delineated using the LiDAR data. The Rational Method was used to estimate the flows discharging into the systems. In addition, the existing capacities were also determined.

Figure 3-2 presents the existing stormwater system (minor and major). **Figure B-1** in **Appendix B** presents the LiDAR boundaries and delineated catchment areas contributing into the various systems.

3.1 Minor System Assessment

The Town's minor system is located along 50 Street between 47th Avenue and 52nd Avenue (**Figure 3-2**). The minor system was evaluated using the design criteria outlined in **Section 2.1**, the existing land use plan and the following:

- Contributing catchment areas were delineated to storm manholes;
- Design flows were applied to the upstream manholes;
- Weighted runoff coefficients were applied to each contributing catchment area;
- The following data was obtained from the Town's GIS database:
  - Pipe material, size and length
  - Manhole ID's
  - Manhole invert and rim elevations
- The slope of the storm pipes was calculated using the available invert elevations and pipe lengths; and,
- Manholes labelled with "AE" in their ID were used to represent potential missing data.

Note, some information pertinent to the existing stormwater system was not available within the Town's GIS database. In addition, the available as-built information was not sufficient to supplement the missing information. Therefore, assumptions were made based on standard engineering practices and information from the Drainage Study completed in 2005.

Table 3-2 summarizes the existing minor system assessment.

Table 3-2
Existing Minor System Assessment

Upstream Manhole	Downstream Manhole	Design Flow (m^3/s)	Pipe Diameter (mm)	Pipe Slope (%)	Sufficient Capacity?	Sufficient Cover?
S703A	ST703	0.555	525	0.03	No	Yes
ST715	ST714	0.127	200	1.04	No	Yes
ST714	ST713	0.128	200	0.29	No	Yes
ST713	ST712	0.130	200	0.50	No	No
ST712A	ST712	0.019	200	1.13	Yes	No
ST712	ST710	0.161	750	0.63	Yes	No
ST711	ST710	0.317	200	0.04	No	No
ST710	ST709	0.494	750	0.08	No	Yes
ST709A	ST709	0.058	300	0.36	Yes	Yes
ST709	ST705	0.569	750	0.33	Yes	No

Upstream Manhole	Downstream Manhole	Design Flow (m^3/s)	Pipe Diameter (mm)	Pipe Slope (%)	Sufficient Capacity?	Sufficient Cover?
ST708	ST707	0.125	375	0.18	No	No
ST707	ST706	0.126	375	0.35	No	No
ST706	ST705	0.223	375	0.30	No	No
ST705	ST705A	0.793	750	0.37	No	No
AE_1	ST705C	0.087	300	0.50	No	No
ST705C	ST705B	0.087	300	0.50	No	No
ST705B	ST705A	0.093	300	0.67	No	No
ST705A	ST704_AE	0.888	750	0.23	No	No
AE_2	ST704	0.033	300	0.31	Yes	No
ST704	ST704A	0.033	300	0.31	Yes	No
ST704A	ST704_AE	0.134	375	0.31	No	No
ST704_AE	ST703	1.791	750	0.26	No	No
ST703	ST702	2.348	900	0.03	No	No
ST702	ST701	2.452	900	0.23	No	No
ST701	Natural Area 2	2.459	900	0.23	No	No

Results show that there are several storm pipes that do not have the capacity to convey flows generated during a 1 in 5 year design storm event. In addition, results indicate that there are several storm pipes that do not have adequate cover.

Figure 3-3 illustrates the storm pipes that have sufficient capacity, as well as pipes that do not. In addition, this figure shows storm pipes that do not have adequate cover. Detailed calculations are provided in Appendix C.

3.1.1 Proposed Upgrades to Minor System

Based on the above results, upgrades were proposed to the existing minor system to ensure that the storm pipe network conveys flows generated during the 1 in 5 year design storm event. Table 3-3 summarizes the estimated design flows, existing pipe slopes and proposed upgrades. The proposed upgrades are shown in Figure 3-4. Detailed calculations for the proposed upgrades are provided in Appendix D.

Table 3-3
Proposed Upgrades to Existing Minor System

Upstream Manhole	Downstream Manhole	Design Flow (m^3/s)	Slope (%)	Proposed Storm Pipe Diameter (mm) [1]
S703A	ST703	0.555	0.03	1200
ST715	ST714	0.127	1.04	375
ST714	ST713	0.128	0.29	450
ST713	ST712	0.130	0.50	450
ST711	ST710	0.317	0.04	900
ST710	ST709	0.494	0.08	900

Upstream Manhole	Downstream Manhole	Design Flow (m^3/s)	Slope (%)	Proposed Storm Pipe Diameter (mm) [1]
ST708	ST707	0.125	0.18	525
ST707	ST706	0.126	0.35	450
ST706	ST705	0.223	0.30	525
ST705	ST705A	0.793	0.37	900
AE_1	ST705C	0.087	0.50	375
ST705C	ST705B	0.087	0.50	375
ST705B	ST705A	0.093	0.67	375
ST705A	ST704_AE	0.888	0.23	1050
ST704A	ST704_AE	0.134	0.31	450
ST704_AE	ST703	1.791	0.26	1200
ST703	ST702	2.348	0.03	1950
ST702	ST701	2.452	0.23	1350
ST701	Natural Area 2	2.46	0.23	1350

[1] Nominal diameter.

In addition to the proposed upgrades provided above, the following are recommended:

- Pipe insulation should meet minimum cover requirements. To ensure frost heave does not occur, insulation is recommended to be placed below the frost line;
- Ensure that all storm pipes meet the minimum grade requirements. Re-grading may be required to meet velocity requirements. Existing storm pipes that do not meet the slope design standard requirements are identified in red text in **Appendix C**; and,
- Develop a maintenance plan for the storm pipe network, including but not limited to:
  - Regular cleaning of manholes; and,
  - Inspection of manhole and pipe conditions.

It is recommended that the Town complete a detailed assessment of the storm pipe network through topographical survey and CCTV to verify the analysis and proposed upgrades.

3.2 Major System Assessment

As previously stated, the Town has a major system, comprised of culverts and ditches (**Figure 3-2**). The ditches illustrated in **Figure 3-2** convey most of the stormwater runoff, as they are located along the main roadways. Residential ditches, located in front of resident's homes, are not shown. The major system was evaluated based the design criteria outlined in **Section 2.2**, the existing land use map and the following:

- Catchment areas were delineated to the upstream and downstream of each culvert;
- The following data was extracted from the Town's geographical information system (GIS);
  - Culvert length and diameter
  - Length of ditch

- The LiDAR surface was used to estimate the slope of the ditches, which was applied to the culverts along each segment;
- Weighted runoff coefficients were applied to each contributing catchment area;
- Culverts were assessed based on their full-flow capacity; and,
- Culvert crossings at local roadways were not assessed.

Limited or no information pertinent to the existing stormwater system was available within the Town's GIS database. Therefore, various assumptions were made based on standard engineering practices and information from the Drainage Study completed in 2005. In addition, the ditch networks were not assessed due to no information available.

Table 3-4 summarizes the existing major system assessment.

Table 3-4
Existing Major System Assessment

Culvert ID	Design Flow (m^3/s)	Existing Culvert Diameter (mm)	Full Flow Capacity (m^3/s)	Sufficient Capacity?
Culvert 24	0.01	600	0.05	Yes
Culvert 14	1.25	600	0.23	No
Culvert 13	3.36	700	0.35	No
Culvert 12	4.22	600	0.23	No
Culvert 10	2.27	700	0.20	No
Culvert 11	2.27	700	0.20	No
Culvert 15	0.27	500	0.23	No
Culvert 4	0.86	500	0.23	No
Culvert 2	1.03	400	0.13	No
Culvert 1	4.29	500	0.23	No
Culvert 35	4.49	500	0.23	No
Culvert 6	0.30	600	0.17	No
Culvert 5	0.45	400	0.06	No
Culvert 3	0.52	400	0.06	No
Culvert 36	0.93	400	0.06	No
Culvert 33	1.28	600	0.20	No
Culvert 8	0.01	500	0.20	Yes
Culvert 30	0.24	300	0.05	No
Culvert 7	2.38	300	0.05	No
Culvert 20	0.88	400	0.16	No
Culvert 19	0.88	400	0.16	No
Culvert 26	0.29	600	0.53	Yes
Culvert 21	0.29	600	0.53	Yes
Culvert 16	2.92	600	0.40	No
Culvert 18	0.03	400	0.13	Yes
Culvert 31	0.04	400	0.13	Yes

Culvert ID	Design Flow (m^3/s)	Existing Culvert Diameter (mm)	Full Flow Capacity (m^3/s)	Sufficient Capacity?
Culvert 32	0.16	400	0.13	No

Figure 3-5 presents the culverts the have sufficient capacity, as well as culverts that do not. The results show that the majority of the culverts do not have the capacity to convey the estimated design flow generated during a 1 in 100 year design storm event. Detailed calculations are provided in Appendix E.

Identified ponding areas (Figure 1-2) validates the major system assessment results.

3.2.1 Proposed Upgrades to Major System

The estimated design flows, proposed culvert diameters and full-flow capacities are summarized in Table 3-5. Note that diameters flagged with an asterix (*) are existing diameters that have capacity and do not need to be upgraded.

Table 3-5
Proposed Upgrades to Existing Major System

Culvert ID	Design Flow (m^3/s)	Proposed Size (mm)	Full Flow Capacity (m^3/s)
Culvert 24	0.01	600*	0.05
Culvert 14	1.25	1200	1.48
Culvert 13	3.36	1650	3.46
Culvert 12	4.22	1800	4.36
Culvert 10	2.27	1800	2.27
Culvert 11	2.27	1800	2.27
Culvert 15	0.27	600	0.37
Culvert 4	0.86	900	1.09
Culvert 2	1.03	900	1.09
Culvert 1	4.29	1650	5.50
Culvert 35	4.49	1650	5.50
Culvert 6	0.30	750	0.31
Culvert 5	0.45	900	0.50
Culvert 3	0.52	1050	0.76
Culvert 36	0.93	1200	1.09
Culvert 33	1.28	1350	1.73
Culvert 8	0.01	500*	0.20
Culvert 30	0.24	600	0.31
Culvert 7	2.38	1350	2.65
Culvert 20	0.88	900	1.36
Culvert 19	0.88	900	1.36
Culvert 26	0.29	600*	0.53

Culvert ID	Design Flow (m^3/s)	Proposed Size (mm)	Full Flow Capacity (m^3/s)
Culvert 21	0.29	600*	0.53
Culvert 16	2.92	1350	3.49
Culvert 18	0.03	400*	0.13
Culvert 31	0.04	400*	0.13
Culvert 32	0.16	450	0.17

The locations of the proposed culvert upgrades are presented in **Figure 3-6**. In addition to the proposed upgrades provided above, the following are recommended:

- Ditches are to have a width equal to the diameter of the upstream culvert;
- Adequate grading is to be provided within the ditches. A minimum value of 0.5% is recommended; and,
- Develop a maintenance plan for the ditch network, including but not limited to:
    - Cutting grass and vegetation within the ditches;
    - Maintenance of the ditch profile to ensure adequate grade; and,
    - Inspection for accumulation of sediment and other debris.

It is recommended that the Town complete a detailed topographic survey of ditches and culverts to verify the analysis and proposed upgrades.

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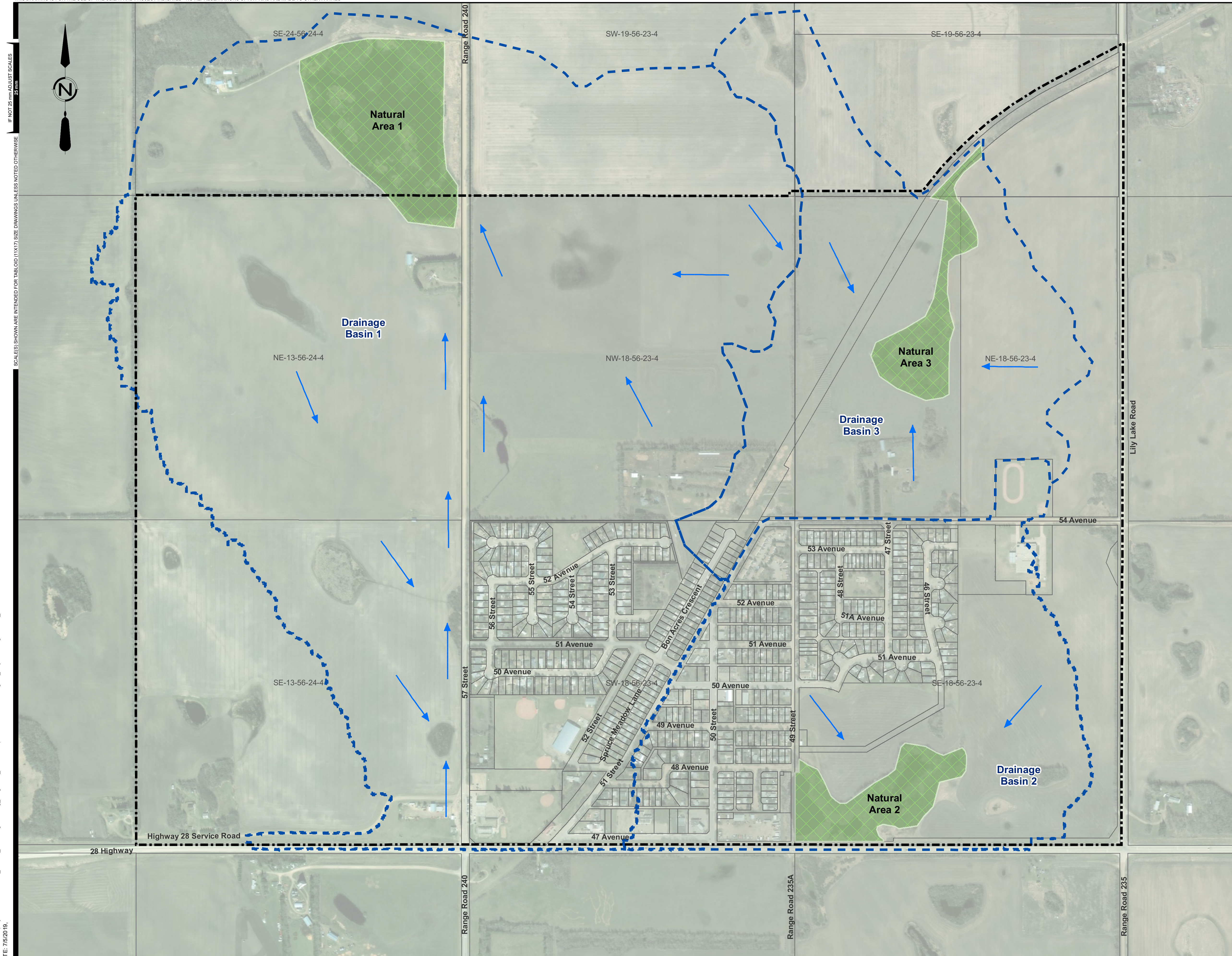

Legend:
- Drainage Direction
- Drainage Basins
- Natural Areas
- Town Boundary

FIGURE No. 3-1

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

MAJOR DRAINAGE BASINS

AE PROJECT No.	2019-3459
SCALE	1:9,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

IF NOT 25 mm ADJUST SCALES 25 mm

\\s-edm-fs-01\projects\2019\3459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig3-1_MajorDrainageBasins_11x17.mxd
DATE: 7/5/2019

Associated Engineering

Legend:

- Storm Manhole
- Drainage Ditch
- Natural Areas
- Town Boundary

Culvert

- Existing 300 mmø
- Existing 400 mmø
- Existing 500 mmø
- Existing 600 mmø
- Existing 700 mmø
- Existing 800 mmø

Storm Pipe

- Existing 150 mmø
- Existing 200 mmø
- Existing 300 mmø
- Existing 375 mmø
- Existing 525 mmø
- Existing 750 mmø
- Existing 900 mmø

*Existing stormwater infrastructure that was not assessed is not shown

Town of Bon Accord building for tomorrow

FIGURE No. 3-2

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

EXISTING STORMWATER SYSTEM

AE PROJECT No.	2019-3459
SCALE	1:5,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

DATE: 7/8/2019.

Associated Engineering

Legend:

- Storm Manhole
- Storm Pipe - Sufficient Capacity
- Storm Pipe - Insufficient Capacity
- Storm Pipe - Insufficient Cover
- Natural Area

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FIGURE No. 3-3

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

EXISTING MINOR SYSTEM ASSESSMENT

AE PROJECT No.	2019-3459
SCALE	1:3,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

Associated Engineering

Legend:

- Storm Manhole
- Natural Area
- Storm Pipe

Proposed Storm Pipe Upgrades

- Proposed 375 mmø
- Proposed 450 mmø
- Proposed 525 mmø
- Proposed 900 mmø
- Proposed 1050 mmø
- Proposed 1200 mmø
- Proposed 1350 mmø
- Proposed 1950 mmø

Town of Bon Accord
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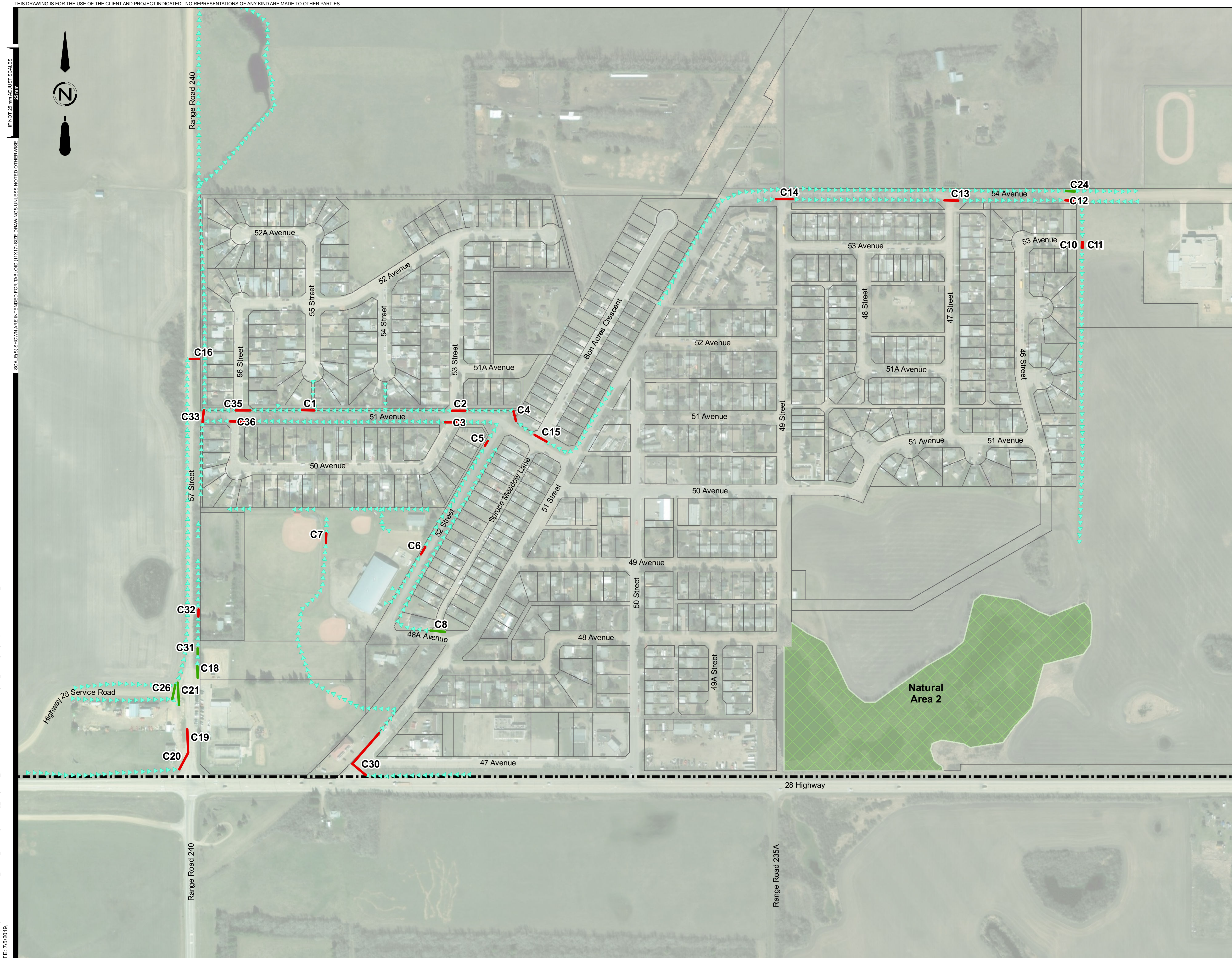
FIGURE No. 3-4

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

PROPOSED EXISTING MINOR SYSTEM UPGRADES

AE PROJECT No.	2019-3459
SCALE	1:3,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL



Associated Engineering

Legend:

- Culvert - Sufficient Capacity
- Culvert - Insufficient Capacity
- Drainage Ditch
- Natural Areas
- Town Boundary

Town of Bon Accord
building for tomorrow

FIGURE No. 3-5

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

EXISTING MAJOR SYSTEM ASSESSMENT

AE PROJECT No.	2019-3459
SCALE	1:5,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

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

\\s-edm-fs-01\projects\20193459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig3-7_ExistingMajorSystemAssessment_11x17.mxd
DATE: 7/5/2019.

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

Associated Engineering

Legend:

- Existing Culvert
- Drainage Ditch
- Natural Areas
- Town Boundary

Proposed Culvert Upgrades

- Proposed 450 mmø
- Proposed 600 mmø
- Proposed 750 mmø
- Proposed 900 mmø
- Proposed 1050 mmø
- Proposed 1200 mmø
- Proposed 1350 mmø
- Proposed 1650 mmø
- Proposed 1800 mmø

Town of Bon Accord
building for tomorrow

FIGURE No. 3-6

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

PROPOSED EXISTING MAJOR SYSTEM UPGRADES

AE PROJECT No.	2019-3459
SCALE	1:5,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

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DATE: 7/5/2019.

4 FUTURE STORMWATER MANAGEMENT PLAN

Future development is proposed within the west and north parts of the Town, in addition to the following locations:

- North of 54th Avenue (NE-18-56-23-W4); and,
- Within the undeveloped portion in SE-18-56-23-W4.

Based on the future land use concept (Figure 1-3), the development within these areas consists of low density residential, commercial and industrial land uses.

4.1 Minor System

Based on the future land use concept, no flows from future developments will discharge into the existing minor system. All future development minor systems should be designed separately from the existing system. Based on the details required to develop a stormwater management plan within the future development, the minor systems were not investigated.

4.2 Major System

The major system was evaluated based the design criteria outlined in **Section 2.2** and the future land use map. As previously stated, the ditches were not assessed due to no available information.

Based on the details required to develop a stormwater management plan within the future development, the required ditches were not investigated.

4.2.1 Culvert Assessment

Culverts within the upgraded major system were assessed based on flows generated from future developments contributing into the existing systems. Table 4-1 summarizes the major system assessment.

Table 4-1
Future Major System Assessment

Culvert ID	Design Flow (m^3/s)	Culvert Diameter (mm)[1]	Full Flow Capacity (m^3/s)	Sufficient Capacity?
Culvert 24	0.01	600	0.05	Yes
Culvert 14	1.25	1200	1.48	Yes
Culvert 13	3.36	1650	3.46	Yes
Culvert 12	4.22	1800	4.36	Yes
Culvert 10	2.35	1800	2.47	Yes
Culvert 11	2.35	1800	2.47	Yes
Culvert 15	0.27	600	0.37	Yes
Culvert 4	0.86	900	1.09	Yes
Culvert 2	1.03	900	1.09	Yes

Culvert ID	Design Flow (m³/s)	Culvert Diameter (mm)[1]	Full Flow Capacity (m³/s)	Sufficient Capacity?
Culvert 1	4.29	1650	5.5	Yes
Culvert 35	4.49	1650	5.5	Yes
Culvert 6	0.30	750	0.31	Yes
Culvert 5	0.45	900	0.5	Yes
Culvert 3	0.52	1050	0.76	Yes
Culvert 36	0.93	1200	1.09	Yes
Culvert 33	1.28	1350	1.73	Yes
Culvert 8	0.01	500	0.20	Yes
Culvert 30	0.24	600	0.31	Yes
Culvert 7	2.38	1350	2.65	Yes
Culvert 20	1.21	900	1.36	Yes
Culvert 19	1.21	900	1.36	Yes
Culvert 26	0.29	600	0.53	Yes
Culvert 21	0.29	600	0.53	Yes
Culvert 16	11.07	1350	0.40	No
Culvert 18	0.03	400	0.13	Yes
Culvert 31	0.04	400	0.13	Yes
Culvert 32	0.16	450	0.17	Yes

[1] Culvert diameter based on proposed upgrades from the existing minor system assessment.

Figure 4-1 presents the culverts that have sufficient capacity, as well as culverts that do not. Results show that all upgraded culverts within the existing system have capacity, except for Culvert 16 due to additional flows generated from future developments. Table 4-2 summarizes the proposed upgrade for Culvert 16.

Table 4-2
Proposed Upgrades to Future Major System

Culvert ID	Location	Design Flow (m³/s)	Proposed Culvert Diameter (mm)	Full Flow Capacity (m³/s)
Culvert 16	57th Street north of 51st Avenue	11.1	1500 (x 3)	4.62

The location of Culvert 16 is shown in Figure 4-2. If the Town undertakes the existing major system upgrades (outlined in **Section 3.2.1**), it is advantageous to upgrade Culvert 16 for the ultimate development. Note that Culvert 16 currently collects flows generated from the undeveloped lands to the west and north of the Town. It is anticipated that as development occurs within these areas, stormwater management practices will be implemented. Therefore, post-development surface water runoff into Culvert 16 is anticipated to be lower. It is recommended that the Town complete a detailed topographic survey of the ditches and culverts to verify the analysis, if required.

Detailed calculations are provided in **Appendix F**.

4.2.2 Stormwater Management Facilities

The entire future development will require an on-site minor and major stormwater system. The City of Edmonton's stated goal for stormwater management is "to provide drainage for urban areas that preserves and promotes the general health, welfare, security and economic wellbeing of the public and to protect and enhance the water quality of receiving watercourses". Therefore, to mitigate any impacts on the drainage systems within the area, due to the proposed development, the Town requires stormwater management facilities. The stormwater management facilities will allow system discharge rates to be controlled to the recommended release rate of 6 L/s/ha.

The City of Edmonton Design and Construction Standards state that a minimum drainage area of 5 ha is required to generate constant or periodic flow to a stormwater management facility, however, the smallest practical drainage area is 20 ha. Defining a minimum drainage area achieves the following:

- Maintaining the sustainability of the infrastructure;
- Providing constant or periodic flows into the facility; and,
- Preventing stagnant and long periods of dry conditions.

The stormwater management concept for the Town, for future development, consists of 9 stormwater management facilities. The proposed stormwater management facilities were placed in the existing low-lying areas, in consideration with the proposed future transportation plan (see Transportation Master Plan report) and on a minimum drainage area of 20 ha. Re-grading of the existing topography in some locations may be required, to ensure overland flows are conveyed into the facilities. These facilities are proposed to provide storage for storm events with design storm events of up to 100 years. It is recommended that all stormwater management facilities be constructed as per the City of Edmonton Design and Construction Standards.

Figure 4-3 presents the proposed stormwater management facility locations, their catchment areas and proposed drainage paths. The type of flow conveyance will be determined during the next phases of development.

The characteristics of the stormwater management facilities were determined using the Rational Method and the City of Edmonton 2018 IDF curve. **Table 4-3** summarizes the estimated catchment area, the volume and the proposed receiving waterbody for each facility.

Table 4-3
Proposed Stormwater Management Facility Characteristics

Stormwater Management Facility ID	Contributing Area (ha)	Estimated Storage Volume (m^3)	Proposed Receiving Waterbody[1]
SWMF 1	36	26,670	Unnamed Tributary in SW-13-56-24-4
SWMF 2	61	38,610	Natural Area 1
SWMF 3	33	19,880	Natural Area 1

Stormwater Management Facility ID	Contributing Area (ha)	Estimated Storage Volume (m^3)	Proposed Receiving Waterbody[1]
SWMF 4	25	15,060	Natural Area 1
SWMF 5	39	23,580	Natural Area 1
SWMF 6	16	9,270	Natural Area 3
SWMF 7	19	11,210	Natural Area 3
SWMF 8	40	26,580	Natural Area 3
SWMF 9	34	22,970	Unnamed Tributary in SW-17-56-23-4

[1] Tributary data - *Base Stream and Flow Representation. Acquired from Altalis Ltd. (1996)*

All proposed receiving waterbodies ultimately discharge into the Sturgeon River. Therefore, an environmental regulatory overview is required.

The final facility locations and sizes should be confirmed during the next stages of development. In addition, "leap-frogging" of development should be discouraged and sequential development should be encouraged.

4.2.3 Natural Areas

There are three natural areas located within the Town boundary. These natural areas act as stormwater management facilities before facilitating drainage towards the Sturgeon River. Majority of runoff flows generated within the existing development currently discharge into Natural Area 2. These flows are causing localized flooding within the adjacent residential areas. Therefore, no additional flows generated from the future development are proposed to be discharged into Natural Area 2.

As noted, only Natural Area 3 has an outlet to regulate flows. Therefore, improvements are required to mitigate existing issues in Natural Area 2 and to ensure Natural Area 1 does not have negative impacts on future development and the downstream system. It is proposed that control structures at each natural area are constructed to discharge flows at 6 L/s/ha. All natural areas should be assessed to ensure they can accommodate runoff flows. This will be achieved by establishing a design normal water level, based on the property line and the minimum freeboard.

All proposed improvements will require an environmental regulatory overview. The following sections outline the proposed improvements for each natural area.

4.2.3.1 Natural Area 1

Runoff from Basin 1 is conveyed into Natural Area 1 by overland flow and a ditch along 57th Street. Currently, there is no development surrounding Natural Area 1, however, residential development is proposed for the future. Flows from the future development will be controlled via stormwater management facilities at a discharge rate of 6 L/s/ha. It is recommended to construct an outlet for Natural Area 1 to ensure negative impacts on the development and the downstream system are mitigated.

Two drainage course options can be considered from the outlet of Natural Area 1:

1. Convey flows from Natural Area 1 to Natural Area 3 using a ditch system, where Natural Area 3 outlets north to the CNR line. This option is contingent on Natural Area 3 having adequate capacity to accommodate additional flows discharging from Natural Area 1. A detailed assessment is recommended to be undertaken to confirm this.
2. Flows from Natural Area 1 are discharged into an unnamed tributary, within NW-20-56-23-4, that ultimately conveys flows into the Sturgeon River.

4.2.3.2 Natural Area 2

Natural Area 2 receives runoff from the current development through the existing minor and major systems. Surrounding areas adjacent to Natural Area 2 have experienced flooding. To mitigate the existing flooding and drainage issues, the following are options are available:

Localized Flooding from Natural Area 2 (March 2019)

1. Lower the existing 800 mm diameter culvert at the south end of Natural Area 2 to establish a normal water level (NWL) based on the existing property line. This culvert conveys flows to the south across Highway 28 where it discharges into a ditch system. This ditch system runs east-west along Highway 28 and north-south along Lily Lake Road. Flows within the system ultimately discharges into the Surgeon River. Note that discussions with Alberta Transportation will need to be undertaken to alter the existing culvert crossing Highway 28.

2. Purchase and dispose of the adjacent homes within the existing impacted area, or flood zone. A detailed analysis, using a computer model, is recommended to define the flood zone.

3. Expand the existing Natural Area 2 to accommodate existing and future development flows without any negative impacts.

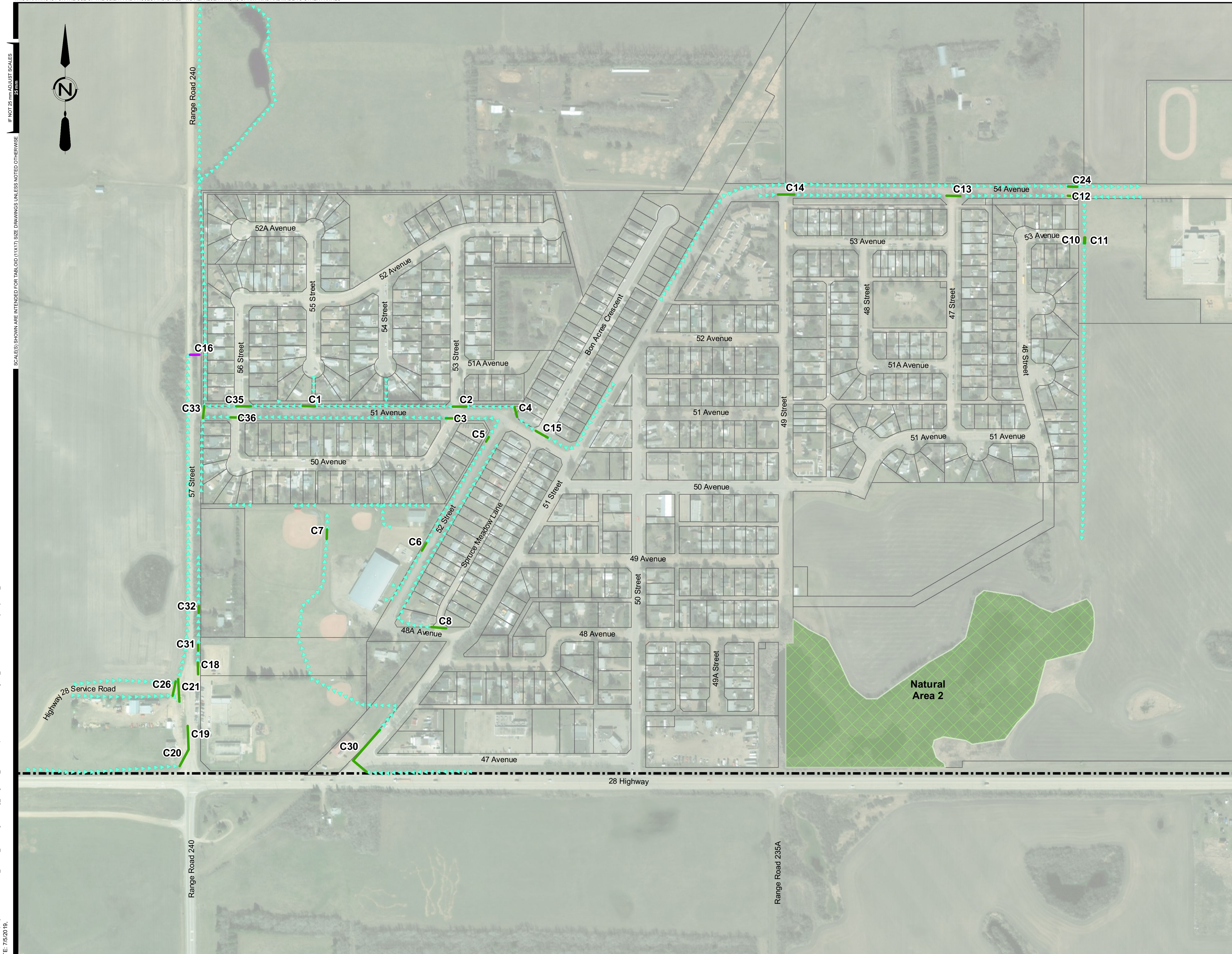
4.2.3.3 Natural Area 3

Based on the future land use plan, industrial and low density residential developments are proposed to be adjacent to Natural Area 3. It is recommended that the existing outlet be assessed to ensure flows are released at the controlled rate of 6 L/s/ha. In addition, it should be confirmed that Natural Area 3 can accommodate runoff flows from surrounding developments.

4.3 Snow Management

The Town has observed excessive surface water ponding, in some areas, during spring snowmelt. This is due to limited snow management. In addition, the snowmelt runoff could be contaminated with deleterious substances collected during maintenance of the roadways throughout the winter (sand or salt). These contaminates ultimately make their way into the Sturgeon River (downstream water body). To mitigate any impacts caused by snowmelt during spring within the existing and future development, the Town should consider developing a snow management program in addition to the construction of a snow management facility. The snow management program would involve the creation of a maintenance and operation program for hauling and disposing of their snow.

THIS DRAWING IS FOR THE USE OF THE CLIENT AND PROJECT INDICATED - NO REPRESENTATIONS OF ANY KIND ARE MADE TO OTHER PARTIES



Legend:
- Culvert - Sufficient Capacity
- Culvert - Insufficient Capacity
- Drainage Ditch
- Natural Areas
- Town Boundary

IF NOT 25 mm ADJUST SCALES 25 mm

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

Associated Engineering

Town of Bon Accord building for tomorrow

FIGURE No. 4-1

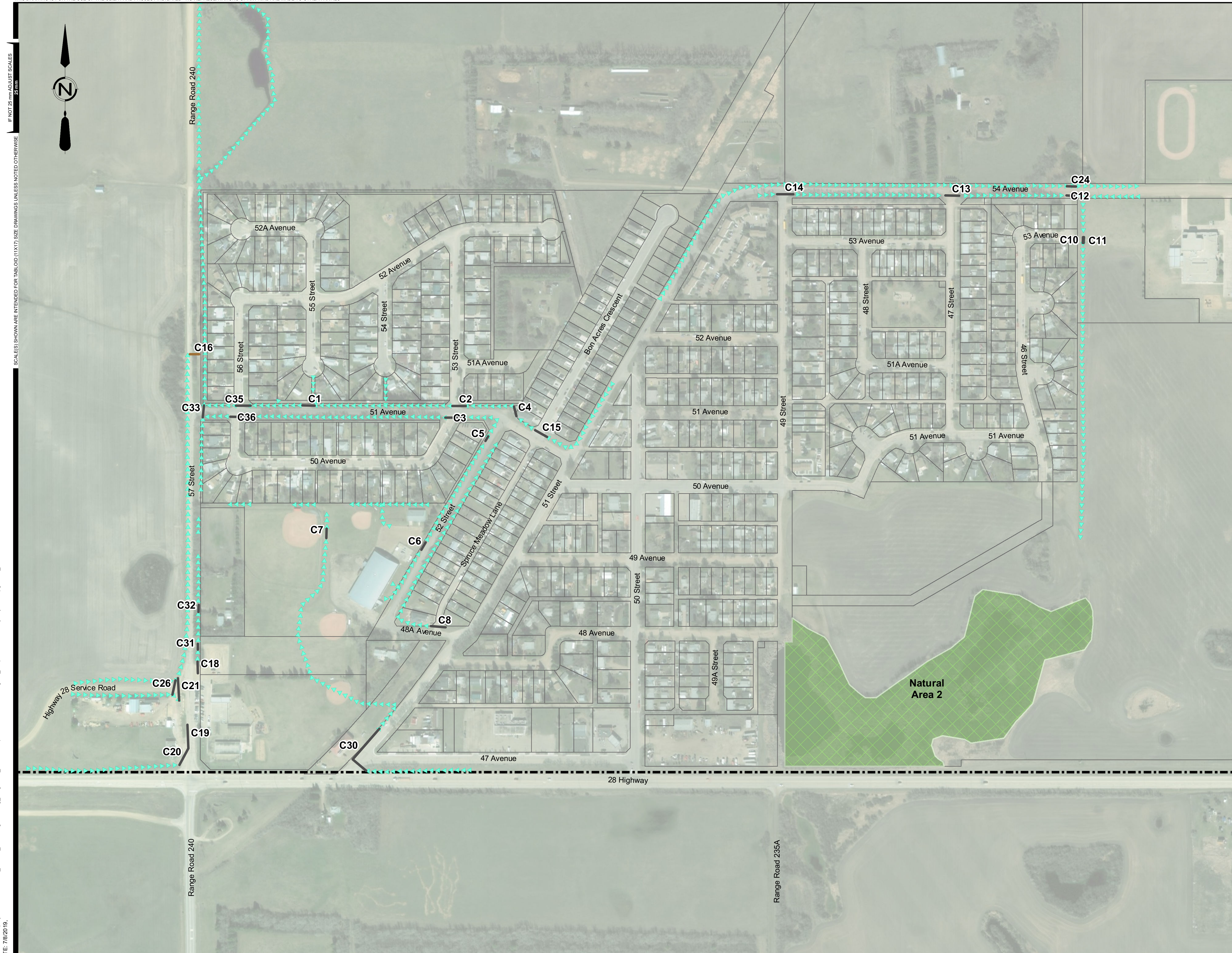
TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

FUTURE MAJOR SYSTEM ASSESSMENT

AE PROJECT No.	2019-3459
SCALE	1:5,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

\\s-edm-fs-01\projects\20193459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig4-1_EvaluationofFutureMajorSystem_11x17.mxd
DATE: 7/5/2019.

THIS DRAWING IS FOR THE USE OF THE CLIENT AND PROJECT INDICATED - NO REPRESENTATIONS OF ANY KIND ARE MADE TO OTHER PARTIES



IF NOT 25 mm ADJUST SCALES 25 mm

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE

\\s-edm-fs-01\projects\20193459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig4-2_ProposedFutureMajorSystemUpgrades_11x17.mxd
DATE: 7/8/2019.

Associated Engineering

Legend:

- Existing Culvert
- Drainage Ditch
- Natural Areas
- Town Boundary

Proposed Future Culvert Upgrades

- Proposed Three 1500 mmø Culverts

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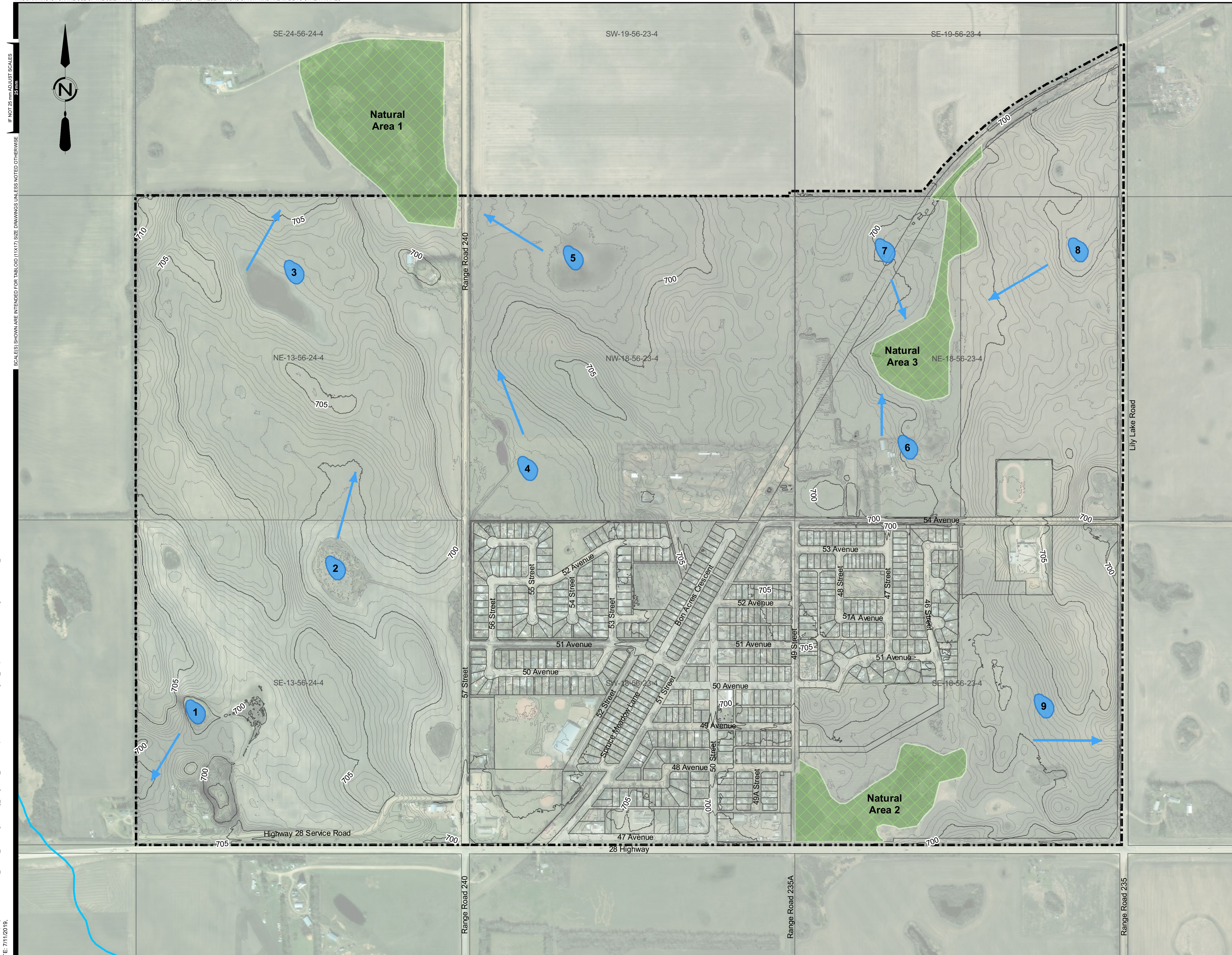
FIGURE No. 4-2

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

PROPOSED FUTURE MAJOR SYSTEM UPGRADES

AE PROJECT No.	2019-3459
SCALE	1:5,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

THIS DRAWING IS FOR THE USE OF THE CLIENT AND PROJECT INDICATED - NO REPRESENTATIONS OF ANY KIND ARE MADE TO OTHER PARTIES



Legend:

- Proposed SWMF Locations
- Drainage Directions
- Tributary
- Contours (0.5m Interval)
- Natural
- Town Boundary

Associated Engineering

Town of Bon Accord
building for tomorrow

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

FIGURE No. 4-3

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

PROPOSED STORMWATER MANAGEMENT FACILITIES

AE PROJECT No.	2019-3459
SCALE	1:9,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

\\s-edm-fs-01\projects\20193459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig4-3_ProposedStormwaterManagementFacilities_11x17.mxd
DATE: 7/11/2019.

5 COST ESTIMATE

5.1 Proposed Upgrades – Existing System

A preliminary cost estimate for upgrades to the existing minor and major systems is provided in **Table 5-1**. The following assumptions were used to generate the cost estimate:

- A unit price of $1,500 per linear meter of storm pipe replacement was assumed. This value includes surface restoration but not GST;
- 50% for Engineering and contingency has been included; and,
- Costs are in 2019 dollars.

Table 5-1
Existing System Upgrades – Cost Estimate

Item No.	Description	Estimated Cost
1.0	Remove and Replace Existing Storm Pipes	$ 1,450,000
2.0	Remove and Replace Existing Culverts	$ 630,000
	Total – Proposed Existing System Upgrades	$ 2,080,000
	Engineering and Contingency (50%)	$ 1,040,000
	Preliminary Cost Estimate Total	**$ 3,120,000**

Appendix G provides the detailed cost estimate.

6 CONCLUSIONS AND RECOMMENDATIONS

From the analysis described above, the following can be concluded:

1. There are three natural areas located within the Town boundary. These natural areas act as stormwater management facilities before facilitating drainage towards the Sturgeon River;

2. Assessment of the existing minor system showed that there are several storm pipes that do not have the capacity to convey flows generated during a 1 in 5 year design storm event. In addition, results indicate that there are several storm pipes that do not have adequate cover;

3. Assessment of the existing major system showed that the majority of the culverts do not have the capacity to convey the estimated design flow generated during a 1 in 100 year design storm event;

4. Based on the future land use concept, no flows from future developments will be discharged the existing minor system. Therefore, recommended upgrades for the existing minor system will be sufficient to accommodate flows from future development;

5. Majority of the upgraded culverts within the existing system have the capacity, except for five culverts; and,

6. A preliminary Class D cost estimate of $3,120,000 is required to undertake the existing system upgrades.

Associated Engineering recommends the following:

1. Upgrade the proposed existing minor system described in Section 3.1.1;

2. The following additional upgrades for the existing minor system:
   - Install adequate pipe insulation to meet minimum cover requirements.
   - Ensure that all storm pipes meet the minimum grade requirements.

3. Develop a maintenance plan for the storm pipe network;

4. All future minor systems should be designed separately from the existing system;

5. Upgrade the proposed existing major system described in Section 3.2.1 and 4.2.1;

6. The following additional upgrades for the existing major system:
   - Ensure all ditches have a width equal to the diameter of the upstream culvert.
   - Provide adequate grading within the ditches. A minimum value of 0.5% is recommended.

7. Develop a maintenance plan for the ditch network;

8. The Town complete a detailed assessment of the storm pipe network, culverts and ditches through topographical survey to verify the analysis and proposed upgrades;

9. All proposed stormwater management facilities within future development will be controlled to the release rate of 6 L/s/ha. The final facility locations and sizes are to be confirmed during the next stages of development. In addition, "leap-frogging" of development is to be discouraged and sequential development should be encouraged;

10. Improvements to Natural Areas 1, 2 and 3;

11. There are two viable drainage courses for Natural Area 1. A detailed assessment is to be completed during the next stages of development to select the best option;

12. There are three mitigation options identified to alleviate the existing flooding and drainage issues experienced within the surrounding areas of Natural Area 2. A detailed assessment is to be completed during the next stages of development to select the best option;

13. Confirm that Natural Area 3 can accommodate runoff flows from surrounding developments and upgrade as required;

14. The control structures for each natural area be constructed to discharge flows at 6 L/s/ha;

15. All natural areas should be assessed to ensure they can accommodate runoff flows. This will be achieved by establishing a design normal water level, based on the property line and the minimum freeboard;

16. All proposed improvements will require an environmental regulatory overview; and,

17. Consider construction of a snow storage facility to allow for snow management within existing developments and for future developments.

CLOSURE

This report was prepared for the Town of Bon Accord to provide a Stormwater Master Plan for the existing and future development areas.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Engineering Alberta Ltd.

2019-10-09
Diego Mejia, P.Eng.
Project Manager

2019-10-09
Akinbola George, M.A.Sc., P.Eng., PMP
Senior Water Resources Engineer

Lisa Butler, E.I.T.
Water Resources Engineer-In-Training

ASSOCIATED ENGINEERING
QUALITY MANAGEMENT SIGN-OFF
Signature:
Date: 2019-10-09

APEGA Permit to Practice P 3979

PERMIT STAMP

APPENDIX A - STORMWATER MASTER PLAN - PROPOSED DESIGN STANDARDS MEMORANDUM

Date:	April 17, 2019	**File:**	20193459.00.03.00
To:	Town of Bon Accord		
From:	Lisa Butler, E.I.T.		
Project:	2019-3459		
Subject:	Stormwater Master Plan - Proposed Design Standards		

MEMO

Associated Engineering completed a desktop review of the current stormwater design standards for the Town of Bon Accord (the Town). The current design standards for the Town, pertinent to stormwater, are provided in **Appendix A**. Due to limited stormwater information available, the following design standards were reviewed:

- Alberta Environment and Parks (AEP);
- City of Edmonton;
- City of St. Albert; and,
- Sturgeon County.

Table B-1 to **Table B-4** in **Appendix B** summarize the stormwater standards review. Based on our review and discussion with the Town on April 17, 2019, the Town will adopt the City of Edmonton Stormwater Design Standards (March 2015). This recommendation is made for the following reasons:

- The Town is close to the City of Edmonton;
- Other nearby communities, such as St. Albert and Sturgeon County, have similar design criteria to City of Edmonton Standards;
- The City of Edmonton Standards were most recently updated in 2015; and,
- The City of Edmonton is using the most current Intensity Duration Frequency (IDF) curves, developed in 2018.

Appendix A – Town of Bon Accord Stormwater Design Standards

4.0 STORM SEWER SYSTEM

The pipe storm sewer system shall be of sufficient capacity to carry storm water run-off quantities based on:

- the Rational Method of storm sewer design;
- a five year storm for the Edmonton area;
- a minimum run-off co-efficient for residential areas and a minimum inlet time of 20 minutes.

4.1 Storm Sewer Mains

Minimum size of 300 mm diameter.

All changes in direction of flow shall be no greater than 45^{o} in pipes exceeding 600 mm diameter or flows exceeding 1.5 m/s in any pipe.

Mains shall be installed to provide a minimum depth of cover of 1.75m unless otherwise approved.

Mains shall be of sulfate resistant concrete with either mortar or rubber ring jointing systems or polyethylene on approval of the Town and its Engineer after assessment of storm water conditions in commercial or Industrial areas. In residential areas leads and mains may be PVC or polyethylene on approval of the Town and its Engineer after assessment of storm water conditions.

Sand bedding shall be provided for all mains.
Sand bedding shall be 150 mm below the pipe and up to at least 300 mm above the pipe on all mains.
Sand bedding shall be compacted to 95% Standard Procter Density in 150 mm layers.
Sand bedding shall be well graded sand consisting of hard durable particles free from clay lumps, cementation, organic material, frozen material, or other deleterious materials. Gradations are to be within limits specified when tested to ASTM C136-84a and ASTM C117-84 and are to have a smooth curve without sharp breaks when plotted on a semi - log grading chart.

Sieve Size	%Passing
10.00 mm	100
5.00 mm	50 - 100
2.00 mm	30 - 90
.40 mm	10 - 50
.08 mm	0 - 10

Liquid limit maximum 25. Plasticity index maximum 6. Improved or special bedding shall be provided where soil conditions or trench load conditions dictate.

4.2 Storm Water Retention Ponds

Retention and detention ponds shall be incorporated into storm drainage systems to meet all standards and requirements of Alberta Environment.

4.3 Manholes

Refer to standards listed under Sanitary Sewage Collection System.

All precast manholes shall be perched when the main size is 600 mm to 1050 mm. Tee riser manholes shall be used above 1050 mm diameter.

4.4 Catch Basins

Surface water shall be intercepted with a sufficient number of catch basins such that the inlet capacity of the catch basins is sufficient to receive the calculated storm water flow. Surface water shall not be permitted to run a distance greater than 350m along roadways without provision for interception by catch basins. This distance shall be reduced on steep road grades according to good Engineering practises.

All catch basin bodies shall be of precast concrete sections (sulfate resistant) and constructed so as to provide a sump to trap rocks and gravel.

Catch basin leads shall be installed to provide a minimum depth of cover of 1.25 m unless otherwise approved. The minimum slope of catch basin leads shall be 2%.

All catch basin leads shall discharge directly into storm sewer manholes.

4.5 Trenching and Backfilling

The developer shall undertake all necessary excavating and backfilling in accordance with Occupational Health and Safety Act and Regulations and shall be entirely responsible for all damages to either private or public property.

All backfill shall be compacted under existing and proposed streets, concrete work, and under all other areas requested by the Town. The backfill material shall be either native or imported granular material, as requested by the Town, and shall be compacted to 95% of Standard Proctor Density unless otherwise approved.

Appendix B – Design Standards Review

Table B-1
Stormwater Management Guidelines for the Province of Alberta (January 1999) - Review Summary

Parameter	Design Criteria
MINOR SYSTEM	
Design Storm Event	1:5 Year
Calculation Method	Rational Method (Area < 50 ha)
Allowable Surcharge	In a 1:100 year event, should not exceed basement levels and the flow depth on streets should not exceed 300 mm
MAJOR SYSTEM	
Design Storm Event	1:100 Year
Maximum Allowable Ponding	0.30 m at the gutters
	Standing water should not exceed 0.50 m or extend to adjacent buildings
	0.05 m for arterial roads
Calculation Method	Rational Method (Area < 50 ha) or computer modelling (Area > 50 ha)
Stormwater Management Facilities - Wet Ponds	
Minimum Water Surface Area	2 ha
Maximum Side Slopes above Active Storage Zone	4(H):1(V) to 5(H):1(V)
Maximum Interior Side Slopes in Active Storage Zone	5(H):1(V) to 7(H):1(V)
Maximum Exterior Side Slopes	3(H):1(V)
Detention Time	24 hours
Length to Width Ratio	4:1 to 5:1
Minimum Permanent Pool Depth	2.0 m
Maximum Permanent Pool Depth	3.0 m
Stormwater Management Facilities - Dry Ponds	
Detention Time	24 hours
Maximum Active Retention Storage Depth	1.0 m to 1.5 m
Maximum Water Level	Below adjacent basement footings
Maximum Interior Side Slopes	4(H):1(V) to 5(H):1(V)
Maximum Exterior Side Slopes	3(H):1(V)
Minimum Freeboard	0.6 m
Minimum Ratio of Effective Length to Effective Width	4:1 to 5:1
Minimum Slope along Pond Bottom	1% (2% is preferred)
Drainage Swales	
Minimum Longitudinal Slope	1% to 2%
Check Dams	Used when the longitudinal slope exceeds 2% to 4%
Maximum Side Slopes	2.5 to 1 but are optimally less than 4 to 1
Minimum Bottom Width	0.75 m
Minimum Depth	0.5 m
Maximum Velocity	0.5 m/s

Table B-2

The City of Edmonton Design and Construction Standards Volume 3 Drainage (March 2015) - Review Summary

Parameter	Design Criteria
MINOR SYSTEM	
Design Storm Event	1:5 Year
Calculation Method	Rational Method (Area < 65 ha)
Runoff Coefficients	Based on Landuse Zoning (Bylaw 12800) or Land Use

Table A4 - Storm Runoff Coefficients and Imperviousness According to Zoning

Zoning or Classification Designation Per Bylaw # 12800 [1]	Runoff [2] Coefficient " C "	Imperviousness [3] " Imp " (%)
A, RR, AC	0.2	10 - 50
AP, Schools	0.3	10 - 50
RF1, RF2, RF3, RF4, RMH, AGU	0.5	40 - 65
MA, IH	0.5	40 - 70
RF5, RF6, RSL, RA7	0.65	40 - 90
RA8, US, PU	0.75	40 - 90
CNC, CSC, IB, IM, RA9, CB1, CHY, AGI, CO	0.9	40 - 100
CB2	0.95	70 - 100
RMX, CMS, DC1, DC2, DC3, DC4	*	40 - 100

[1] For zonings not shown in this table, the runoff coefficient "C" and the percentage of imperviousness "Imp%" shall be estimated by the designer.

[2] Minimum design values to be used without specific area analysis. To be used only for calculation of peak runoff rates by the rational method.

[3] Typical ranges based on land use bylaw site coverage limits and typical paving practice.

Table A5 - Storm Runoff Coefficients and Imperviousness According to Land Use

Land Use	Runoff Coefficient 1 " C "	Imperviousness " Imp " (%)
Asphalt, concrete, roof areas	0.95	90 - 100
Industrial, commercial	0.60	50 - 100
Single family residential	0.65	40 - 60
Predominant grassed areas, parkland	0.10	10 - 30

Parameter	Design Criteria
Runoff Coefficients for Design Storm Events with a Return Period Greater than 10 Years	C x 1.1 for return periods between 10 and 25 years
	C x 1.2 for return periods between 25 and 50 years
	C x 1.25 for return periods greater than 50 years
Rainfall Data	2018 IDF Curve
Time of Concentration	

Table A6 - Design Inlet Time (Minutes) with Respect to Catchment Imperviousness and Size

Imperviousness (%) Catchment Area (A)	30	50	> 70
A = 8 ha or less	8	8	5
8 ha < A < 40 ha	9.2	9.2	6
A = 40 ha or more	10.4	10.4	7.25

Parameter	Design Criteria
Drainage Areas (< 30 ha)	
Surcharge of Sewer Pipes	None
Maximum Ponding Depth	150 mm
Acceptable Depths of Flow and Ponding on Roadways	No over-topping of curbs occurs on local roadways, a width equivalent to one traffic lane remains free from inundation on collector roads and one traffic lane in each travel direction remains free from inundation on arterial roads
Stormwater Quality	BMPs prior to discharging into a pipes system
Drainage Areas (>30 ha)	
Design Capacity	Reserve capacity included to account for unanticipated changes in land use and runoff
	Pipes are to be designed to accommodate, without surcharge, 1.25 times the rate of flow which would occur in a 5-year return period rainfall event

Table B-2

The City of Edmonton Design and Construction Standards Volume 3 Drainage (March 2015) - Review Summary

Parameter	Design Criteria
Surcharge of Sewer Pipes	Where the storm trunk will receive both uncontrolled flow from areas ≥ 30 ha and controlled discharge from stormwater management facilities, the pipes shall be designed to accommodate, without surcharge, 1.25 times the 5 year design flow from the uncontrolled lands plus the maximum design stormwater management facility outflow rate
Hyetograph	4-hour Chicago when using computer simulation
Storm Pipe Sizing	
Methodology	Manning's Equation for pipe full conditions
Manning's n Values	All smooth-wall pipe (n = 0.013)
	Corrugated metal pipe - unpaved (n = 0.024)
	Corrugated metal pipe - invert paved (n = 0.020)
	Corrugated metal pipe - all paved (n = 0.013)
Minimum Storm Pipe Size	300 mm diameter
Minimum Catchbasin Lead Size	250 mm diameter
Minimum Foundation Drain Sewer Size	200 mm diameter
Mean Velocity (Flowing Full)	0.90 m/s to 1.0 m/s
Acceptable Range of Velocities	0.6 m/s < V < 3.0 m/s
Supercritical Flows	Sewers shall not be designed to operate in super-critical flow conditions during flows les than design capacity conditions. Hydraulic structure are required under super-critical flow regimes and must have a minimum design life of 75 years
Minimum Pipe Slopes	200 mm diameter = 0.40 % (foundation drain sewer)
	250 mm diameter = 0.28% (foundation drain sewer)
	300 mm diameter = 0.22%
	375 mm diameter = 0.15%
	450 mm diameter = 0.12%
	525 mm diameter = 0.10%
	600 mm diameter and larger = 0.10%
	Catchbasin lead = 1.0%
Minimum Pipe Slopes (Aligned in a Curve)	300 mm diameter = 0.25%
	375 mm diameter = 0.18%
	450 mm diameter = 0.15%
	525 mm diameter = 0.13%
	600 mm diameter and larger = 0.10%
Depth of Cover from Finished Grade to Pipe Obvert	
Pipes < 610 mm diameter	2.0 m
Pipes > 610 mm diameter	1.5 m
Spacing Requirements	
Maximum Flow Distance in Roadway Gutters	150 m
Maximum Flow Distance in Lanes and Walkways	180 m
MAJOR SYSTEM	
Design Storm Event	1:100 Year
Calculation Method	Rational Method (Area < 65 ha) or computer modelling (Area > 65 ha)
Maximum Ponding Depth	Below the lowest anticipated landscape grade or opening at any adjacent buildings, with a freeboard provision generally in the order of 350 mm with a minimum of 150 mm
	Less than 350 mm in roadways and other public right-of-way's

Table B-2
The City of Edmonton Design and Construction Standards Volume 3 Drainage (March 2015) - Review Summary

Parameter	Design Criteria
	Less than 150 mm for arterial roadways
Storage Elements	
Over-topping	None due to storm events equal to or less severe than the critical storage event for the catchment served
Retention Volume	Equivalent of 120 mm of water over the total catchment area draining the facility
Modelling	Used to verify the performance of each storage facility
	24-hour Huff distribution is used when modelling stormwater management
Emergency Overflow	To be provided wherever feasible
Freeboard	0.3 m if an emergency overflow is provided
	0.5 m if an emergency overflow is not provided
Drawdown Time	1 in 5 year runoff capacity to be available within 24 hours
	1 in 25 year runoff capacity to be available within 48 hours
	90% of the facility full volume to be available within 96 hours
Flow Capacity of Streets	Apply the modified Manning's formula with n = 0.013 for roadways and n = 0.05 for grassed boulevards
Stormwater Management Facilities (SWMFs) - Wet Pond and Constructed Wetlands	
Outflow Control Works	Outlet from a SWMF must incorporate appropriate means for control of outflow
Outflow Control Gate	Slide gate or similar means to stop the discharge of impounded water
Maintenance and Service Manual	Required for every SWMF
Signage	Required for safety
Minimum Sizing	2.0 ha at normal water level for constructed wetlands
Side Slopes	7(H):1(V) for areas normal or infrequently covered by water
	3(H):1(V) for 1.0 m below normal water level
	5(H):1(V) for confined spaces or areas with extreme topography
Minimum Depth	2.5 m between normal water level and the bottom of the pond
Inlet/Outlet Spacing	Located to maximum detention time and circulation. Distanced as far as possible from each other to avoid hydraulic short-circuiting
Inlet and Outlets	Fully submerged with the pipe crown being 1.0 m below the normal water level
Stormwater Management Facilities (SWMFs) - Dry Ponds	
Maximum Live Storage	3.0 m (measured from the invert elevation of the outlet pipe)
Minimum Slope of Pond Bottom	0.7% (1.0% or greater is preferred)
Side Slopes	7(H):1(V) within private property
	5(H):1(V) within public property
Inlets and Outlets	Require grates provided over openings
	Maximum clear bar spacing of 150 mm
	Maximum velocity through the grate = 1.0 m/s
	Physically separated around the perimeter and distanced as far as possible to avoid short-circuiting
Culverts	
Minimum Size	400 mm diameter
Swales Crossing Several Properties	
Minimum Depth	150 mm
Maximum Side Slope	4(H):1(V)
Minimum Longitudinal Slope	1.5%
Grassed Swales Serving Lots on Both Sides	
Minimum Depth	150 mm
Maximum Side Slope	4(H):1(V)

Table B-2
The City of Edmonton Design and Construction Standards Volume 3 Drainage (March 2015) - Review Summary

Parameter	Design Criteria
Minimum Longitudinal Slope	1.5%
Grassed Swales with Concrete Gutter	
Range of Depth	75 mm to 150 mm
Range of Width	500 mm to 610 mm
Maximum Side Slope	4(H):1(V)
Minimum Thickness	100 mm
OTHER	
Mike Urban (or Mouse) and Mike 21 models are recommended for use in the design of dual (major and minor) drainage systems	
The 4-hour Chicago distribution hyetographs should be used for analysis of major and minor conveyance systems by computer simulation	

Table B-3
City of St. Albert Municipal Engineering Standards (April 2013)- Review Summary

Parameter	Design Criteria
MINOR SYSTEM	
Design Storm Event	1:5 Year
Calculation Method	Rational Method (Area < 65 ha) or computer modelling (Area > 65 ha)
Runoff Coefficients - C	Parks, Reserves, Grassed areas = 0.15
	Single Family Residential = 0.50
	Multi-Family Residential = 0.70
	Commercial = 0.70
	Paved Areas and Roofs = 0.95
Runoff Coefficients for Design Storm Events with a Return Period Greater than 10 Years	C x 1.1 for return periods between 10 and 25 years
	C x 1.2 for return periods between 25 and 50 years
	C x 1.25 for return periods greater than 50 years
Time of Concentration	(see table below)

	Design Inlet Time (t_i)	Imperviousness		
		30%	50%	> 70%
Area	$t_i \leq 8.0$ ha	8.0 min	8.0 min	5.0 min
	$8.0 < t_i < 40$ ha	9.2 min	9.2 min	6.0 min
	$t_i \geq 40$ ha	10.4 min	10.4 min	7.3 min

Parameter	Design Criteria
Rainfall Data	Edmonton City Centre Airport IDF Curve
Gravity Sewer Mains	
Minimum Pipe Diameter	300 mm
Design Mean Flow Velocity	0.9 m/s to 1.0 m/s
Minimum Velocity	0.6 m/s
Maximum Velocity	3.0 m/s
Manning's n	0.013
Minimum Pipe Slope	150 mm diameter = 0.60%
	300 mm diameter = 0.22%
	375 mm diameter = 0.15%
	450 mm diameter = 0.12%
	≥ 525 mm diameter = 0.10%
Minimum Pipe Slope (Curved Alignment)	(see table below)

C/L Sewer Radius (m)	Increase Minimum Pipe Slope (%)	Minimum Manhole Spacing (m)
92-100	50	92
100-150	40	95
150-200	30	105
200-250	20	115
205-300	10	125
> 300	0	135

Parameter	Design Criteria
Storm Sewer Trunk Mains	

Table B-3
City of St. Albert Municipal Engineering Standards (April 2013)- Review Summary

Parameter	Design Criteria
Servicing Area	> 30 ha
Surcharge of Sewer Pipes	Accommodate, without surcharge, the design flow multiplied by 1.25
	Where the storm truck will receive both uncontrolled flow from areas ≥ 30 ha and controlled discharge from stormwater management facilities, the pipes shall be designed to accommodate the anticipated uncontrolled design flow multiplied by 1.25 plus the design maximum outflow rates from the stormwater management facilities
Horizontal Alignment	3.0 m horizontally from any water main and 1.8 m horizontally from any sanitary sewer main or gas line
Manhole Spacing	
Maximum Distance	135 m for sewers less than 1200 mm in diameter
	500 m for sewers 1200 mm in diameter or greater
Catchbasins	
Maximum Spacing	120 m
Minimum Pipe Diameter	250 mm
Minimum Velocity	0.6 m/s
Maximum Velocity	3.0 m/s
Manning's n	0.013
Minimum Slope	1.0%
Maximum Length	30 m
Minimum Depth of Cover	1.5 m
MAJOR SYSTEM	
Design Storm Event	1:100 Year
Maximum Depth of Peak Flows and Ponding	150 mm on arterial roadways
	350 mm below the lowest anticipated landscape grade or opening along adjacent lots and buildings
Manning's n	n = 0.013 for roadways
	n = 0.050 for grassed boulevards
Culverts	
Minimum Size	400 mm diameter
Maximum Clear Bar Spacing	150 mm
Stormwater Management Facilities - Wet Ponds	
Minimum Surface Area at Normal Water Level	2.0 ha
Minimum Depth of Pond at Normal Water Level	2.5 m
Minimum Width of the Water Surface at Normal Water Level	25 m
Inlets and Outlets	Fully submerged with pipe obverts a minimum of 1.0 m below the normal water level
	Inverts a minimum of 150 mm above the lake bottom
	Located as far from each other as possible to avoid hydraulic short-circuiting
	Normal operating level shall be at or below the pipe invert at the nearest manhole on the inlet storm sewer main
	Anticipated high water level during a 1:5 year rainfall event shall be at or below the pipe obvert at the nearest manhole on the inlet storm sewer main
Emergency Overflow	Required to redirect flows in excess of the design peak flow
Normal Water Level	Set at a minimum of 300 mm below the lowest basement weeping tile of any adjacent buildings
Side Slopes	Maximum of 3(H):1(V) on the pond exterior

Table B-3
City of St. Albert Municipal Engineering Standards (April 2013)- Review Summary

Parameter	Design Criteria
	Maximum of 5(H):1(V) on the pond interior
Best Management Practices	Refer to Alberta Environment
Stormwater Management Facilities - Dry Ponds	
Maximum Active Storage Depth	1.5 m
Inlets and Outlets	Located as far as possible away from each other to avoid short-circuiting
	Must include gratings with a maximum clear bar spacing of 150 mm
Emergency Overflow	Required to redirect flows in excess of the design peak flow
Minimum Slope of Pond Bottom	2%
Drainage Swales	
Minimum Width of Right-of-Ways or Easements	3 m
Minimum Slope	2%

Table B-4
Sturgeon County General Municipal Servicing Standards (May 2009) - Review Summary

Parameter	Design Criteria
MINOR SYSTEM	
Design Storm Event	1:5 Year
Calculation Method	Rational Method (Area < 65 ha) or computer modelling (Area > 65 ha)
Rainfall Data	Edmonton Municipal Airport - IDF Period 1914-1995
Runoff Coefficients	CR-1 = 0.2
	CR-2, CR-E = 0.3
	HR = 0.4
	Grassed Areas (Parks, Playgrounds) = 0.15
	Undeveloped Land (Farmland) = 0.1
	Pavement, Concrete, Buildings = 0.9
	Gravel Roadways = 0.3
Time of Concentration	Maximum 10 minutes
Pipe Sizing	
Minimum Pipe Size for Storm Sewer Main	300 mm diameter
Minimum Pipe Size for Foundation Drains Accommodating Flow from Weeping Tiles Only	150 mm diameter
Minimum Pipe Size for Catchbasins Leads	250 mm diameter
Manning's' n	0.013
Velocity	
Minimum Full-Flow Velocity	0.6 m/s
Maximum Full-Flow Velocity	3.0 m/s
Minimum Pipe Slope	300 mm diameter = 0.194%
	375 mm diameter = 0.145%
	450 mm diameter = 0.114%
	525 mm diameter = 0.092%
	600 mm diameter = 0.077%
	675 mm diameter = 0.065%
	750 mm diameter = 0.057%
	900 mm diameter = 0.045%
	1050 mm diameter = 0.036%
	1200 mm diameter = 0.031%
	1350 mm diameter = 0.027%
	1500 mm diameter = 0.023%
	1650 mm diameter = 0.020%
	1800 mm diameter = 0.018%
	1950 mm diameter = 0.016%
	2100 mm diameter = 0.015%
	2250 mm diameter = 0.013%
	2400 mm diameter = 0.012%
	2550 mm diameter = 0.011%
	2820 mm diameter = 0.010%

Table B-4
Sturgeon County General Municipal Servicing Standards (May 2009) - Review Summary

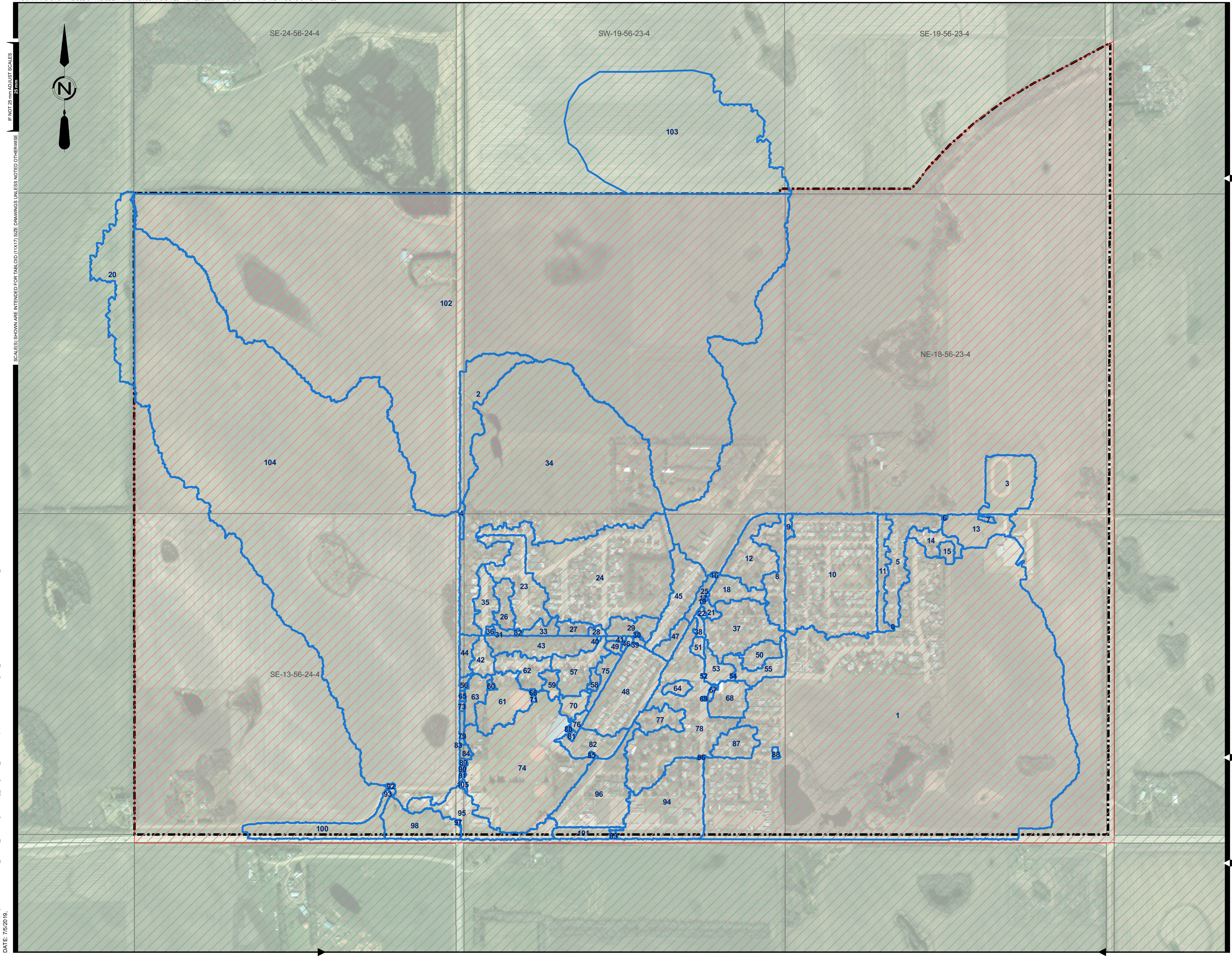
Parameter	Design Criteria
Minimum Pipe Slope for Curved Sewers	300 mm diameter = 0.25%
	375 mm diameter = 0.18%
	450 mm diameter = 0.15%
	525 mm diameter = 0.13%
	600 mm diameter and greater = 0.10%
Minimum Slope for Catchbasins Leads	1.0%
Minimum Depth of Cover	2.2 m for sewer main
	1.5 m for catchbasins lead
Manhole Spacing	
Sewers less than 1200 mm diameter	120 m
Sewers 1200 mm diameter to 1650 mm diameter	500 m
Sewers larger than 1650 mm diameter	800 m
Minimum Manhole Size	1200 mm inside diameter
MAJOR SYSTEM	
Design Storm Event	1:100 Year
Calculation Method	Rational Method (Area < 65 ha) or computer modelling (Area > 65 ha)
Rainfall Data	Edmonton Municipal Airport - IDF Period 1914-1995
Stormwater Management Facilities - Wet Ponds and Lakes	
High Water Level	300 mm below the lowest building opening on adjacent lots
Minimum Surface Area at Normal Water Level	2 ha
Maximum Side Slopes	3(H):1(V) from the lake bottom to 1 m below normal water level
	7(H):1(V) for 1 m below normal water level and above
Minimum Depth from Normal Water Level to Lake Bottom	2.5 m
Inlet and Outlets	Fully submerged and at least 200 mm above the lake bottom and 1.0 m below normal water level
Overflow Channel	Required at the high water level
Stormwater Management Facilities - Dry Ponds	
Maximum Storage Depth	1.5 m from the invert of the outlet pipe
Minimum Pond Bottom Slope	1.0%
Maximum Side Slopes	7(H):1(V) within private property
	5(H):1(V) within public property
Inlet and Outlets	Maximum bar spacing of 150 mm
Drainage Swales	
Minimum Clearance	200 mm between the edge of a swale and property line
Minimum Slope	0.75% (on private property)
	0.5% (on public property)
	1.5% (without a concrete gutter)
Other	
The design of both the major and minor systems must meet the requirements outlined by Alberta Environment	

APPENDIX B - LIDAR BOUNDARIES AND CATCHMENT AREAS (FIGURE B-1)

THIS DRAWING IS FOR THE USE OF THE CLIENT AND PROJECT INDICATED - NO REPRESENTATIONS OF ANY KIND ARE MADE TO OTHER PARTIES

IF NOT 25 mm ADJUST SCALES

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



Associated Engineering

Legend:

- 1m LiDAR Extent
- 15m LiDAR Extent
- Catchment Areas
- Town Boundary

Town of Bon Accord
building for tomorrow

FIGURE No. B-1

TOWN OF BON ACCORD
STORM MASTER PLAN UPDATE

LIDAR BOUNDARIES AND CATCHMENT AREAS

AE PROJECT No.	2019-3459
SCALE	1:9,000
COORD. SYSTEM	NAD 1983 3TM 114
DATE	2019 OCTOBER
REV	
DESCRIPTION	ISSUED FOR FINAL

\\a-edm-fs-01\projects\20193459\00_Master_Servicing\Working_Dwgs\010_GIS\ArcMap\StormMasterPlan\Fig3-4_LiDARBoundaries&CatchmentAreas_11x17.mxd
DATE: 7/5/2019.

APPENDIX C - EXISTING MINOR SYSTEM ASSESSMENT - DETAILED CALCULATIONS

ASSOCIATED ENGINEERING ALBERTA LTD.
MUNICIPAL ENGINEERING GROUP
STORM SEWER DESIGN CHART
RATIONAL METHOD FOR CIRCULAR PIPE

LOCATION	Edmonton 2018 (COE, 2018)	INITIAL CONCENTRATION TIME	COE Standards	IDF PARAMETERS:	DESIGNED BY Lisa Butler
CLIENT	Town of Bon Accord	RETURN PERIOD	5	a= 24.568	REVISED BY Laurel Richards
PROJECT	Stormwater Master Plan			b= -0.735	PAGE 1 OF 1
PROJECT NO.	2019-3459			c= 0.0900	DATE DESIGN/CHECK 5-Jul-19

CATCHMENT DATA									PIPE DESIGN DATA											PIPE PROFILE				
CATCHMENT NO.	FROM MH	TO MH	LOCAL AREA (A) ha	RUNOFF COEFF (C)	TC min	RAIN INT. I mm/hr	INCREMENTAL FLOW CIA*0.00278 m³/s	CUMULATIVE FLOW (m³/s)	PIPE TYPE	n	SLOPE (%)	SIZE mm	FLOW AREA m²	WETTED PERIMETER m	HYDRAULIC RADIUS	CAP. m³/s	VEL. m/s	LENGTH m	TIME IN PIPE min	UPSTREAM MH INVERT m	UPSTREAM MH RIM m	DROP IN PIPE m	DOWNSTREAM MH INVERT m	DOWNSTREAM MH RIM m
94	S703A	ST703	3.20	0.70	5.00	89.08	0.55	0.55	PVC	0.01	0.03	525.00	0.22	1.65	0.13	0.07	0.40	98.60	4.11	697.945	700.626	0.028	697.917	700.598
18	ST715	ST714	0.70	0.73	5.00	89.08	0.13	0.13	VCT	0.01	1.04	200.00	0.03	0.63	0.05	0.03	1.10	35.90	0.54	699.510	702.440	0.375	699.135	702.880
17	ST714	ST713	0.01	0.95	5.00	89.08	0.00	0.13	VCT	0.01	0.29	200.00	0.03	0.63	0.05	0.02	0.60	10.40	0.29	698.960	702.880	0.030	698.930	702.850
19	ST713	ST712	0.01	0.95	5.00	89.08	0.00	0.13	VCT	0.01	0.50	200.00	0.03	0.63	0.05	0.02	0.80	46.80	0.98	698.930	702.850	0.233	698.697	700.410
21	ST712A	ST712	0.10	0.76	5.00	89.08	0.02	0.02	CONC	0.01	1.13	200.00	0.03	0.63	0.05	0.03	1.20	30.40	0.42	699.400	701.160	0.345	699.055	700.410
22	ST712	ST710	0.05	0.94	5.00	89.08	0.01	0.16	AC	0.01	0.63	750.00	0.44	2.36	0.19	0.88	2.00	49.30	0.41	698.697	700.410	0.310	698.387	701.847
37	ST711	ST710	2.00	0.64	5.00	89.08	0.32	0.32	CONC	0.01	0.04	200.00	0.03	0.63	0.05	0.01	0.30	56.80	3.16	698.860	700.410	0.022	698.838	701.847
38	ST710	ST709	0.10	0.65	5.00	89.08	0.02	0.49	CONC	0.01	0.08	750.00	0.44	2.36	0.19	0.32	0.80	53.10	1.11	698.410	701.847	0.043	698.367	701.253
50	ST709A	ST709	0.50	0.56	8.00	73.94	0.06	0.06	CONC	0.01	0.36	300.00	0.07	0.94	0.08	0.06	0.90	122.20	2.26	698.267	700.810	0.434	697.833	701.253
51	ST709	ST705	0.10	0.70	5.00	89.08	0.02	0.57	CONC	0.01	0.33	750.00	0.44	2.36	0.19	0.64	1.50	46.50	0.52	698.385	701.253	0.155	698.230	700.500
55	ST708	ST707	0.70	0.72	5.00	89.08	0.12	0.12	CONC	0.01	0.18	375.00	0.11	1.18	0.09	0.07	0.70	72.10	1.72	698.990	700.370	0.131	698.859	700.680
54	ST707	ST706	0.01	0.95	5.00	89.08	0.00	0.13	CONC	0.01	0.35	375.00	0.11	1.18	0.09	0.10	1.00	50.60	0.84	698.839	700.680	0.175	698.664	700.180
53	ST706	ST705	0.50	0.78	5.00	89.08	0.10	0.22	CONC	0.01	0.30	375.00	0.11	1.18	0.09	0.10	0.90	21.60	0.40	698.644	700.180	0.064	698.580	700.500
52	ST705	ST705A	0.01	0.95	5.00	89.08	0.00	0.79	CONC	0.01	0.37	750.00	0.44	2.36	0.19	0.68	1.60	56.70	0.59	698.240	700.500	0.210	698.030	700.010
68	AE_1	ST705C	0.80	0.53	8.00	73.94	0.09	0.09	PVC	0.01	0.50	300.00	0.07	0.94	0.08	0.07	1.00	17.90	0.30	698.550	699.589	0.089	698.461	699.500
	ST705C	ST705B					0.00	0.09	PVC	0.01	0.50	300.00	0.07	0.94	0.08	0.07	1.00	23.80	0.40	698.461	699.500	0.118	698.343	699.800
67	ST705B	ST705A	0.05	0.54	8.00	73.94	0.01	0.09	PVC	0.01	0.67	300.00	0.07	0.94	0.08	0.08	1.20	14.30	0.20	698.343	699.800	0.096	698.247	700.010
69	ST705A	ST704_AE	0.01	0.95	5.00	89.08	0.00	0.89	CONC	0.01	0.23	750.00	0.44	2.36	0.19	0.54	1.30	45.00	0.58	698.030	700.010	0.105	697.925	700.224
64	AE_2	ST704	0.20	0.67	5.00	89.08	0.03	0.03	PVC	0.01	0.31	300.00	0.07	0.94	0.08	0.05	0.80	17.80	0.37	699.066	700.631	0.056	699.010	700.575
	ST704	ST704A					0.00	0.03	PVC	0.01	0.31	300.00	0.07	0.94	0.08	0.05	0.80	56.10	1.17	699.010	700.575	0.175	698.835	700.400
77	ST704A	ST704_AE	0.60	0.68	5.00	89.08	0.10	0.13	PVC	0.01	0.31	375.00	0.11	1.18	0.09	0.10	0.90	51.20	0.95	698.835	700.400	0.160	698.675	700.224
78	ST704_AE	ST703	4.50	0.69	5.00	89.08	0.77	1.79	CONC	0.01	0.26	750.00	0.44	2.36	0.19	0.57	1.30	101.90	1.31	697.905	700.224	0.263	697.642	700.598
86	ST703	ST702	0.01	0.95	5.00	89.08	0.00	2.35	CONC	0.01	0.03	900.00	0.64	2.83	0.23	0.30	0.50	107.00	3.57	697.542	700.598	0.030	697.512	698.852
87	ST702	ST701	0.70	0.60	5.00	89.08	0.10	2.45	CONC	0.01	0.23	900.00	0.64	2.83	0.23	0.86	1.40	69.20	0.82	697.511	698.852	0.156	697.355	698.869
88	ST701	Natural Area 2	0.04	0.69	5.00	89.08	0.01	2.46	CONC	0.01	0.23	900.00	0.64	2.83	0.23	0.86	1.40	27.60	0.33	697.354	698.869	0.062	697.292	698.807

APPENDIX D - PROPOSED UPGRADES TO EXISTING MINOR SYSTEM - DETAILED CALCULATIONS

ASSOCIATED ENGINEERING ALBERTA LTD.
MUNICIPAL ENGINEERING GROUP
STORM SEWER DESIGN CHART
RATIONAL METHOD FOR CIRCULAR PIPE

LOCATION	Edmonton 2018 (COE, 2018)	INITIAL CONCENTRATION TIME	COE Standards min	IDF PARAMETERS:	DESIGNED BY Lisa Butler
CLIENT	Town of Bon Accord	RETURN PERIOD	5 year	a= 24.568	REVISED BY Laurel Richards
PROJECT	Stormwater Master Plan			b= -0.735	PAGE 1 OF 1
PROJECT NO.	2019-3459			c= 0.0900	DATE DESIGN/CHECK 5-Jul-19

CATCHMENT DATA									PIPE DESIGN DATA													PIPE PROFILE				
CATCHMENT NO.	FROM MH	TO MH	LOCAL AREA (A) ha	RUNOFF COEFF (C)	TC min	RAIN INT. I mm/hr	INCREMENTAL FLOW CIA*0.00278 m³/s	CUMULATIVE FLOW (m³/s)	PIPE TYPE	n	SLOPE (%)	SIZE mm	SIZE mm	FLOW AREA m²	WETTED PERIMETER m	HYDRAULIC RADIUS	CAP. m³/s	VEL. m/s	LENGTH m	TIME IN PIPE min	UPSTREAM MH INVERT m	UPSTREAM MH RIM m	DROP IN PIPE m	DOWNSTREAM MH INVERT m	DOWNSTREAM MH RIM m
94	S703A	ST703	3.2	0.70	5	89.08	0.555	0.555	PVC	0.013	0.03	1129	1129	1.001	3.547	0.282	0.56	0.60	98.6	2.739	697.945	700.626	0.028	697.917	700.598
18	ST715	ST714	0.7	0.73	5	89.08	0.127	0.127	VCT	0.013	1.04	330	330	0.085	1.035	0.082	0.13	1.50	35.9	0.399	699.510	702.440	0.375	699.135	702.880
17	ST714	ST713	0.007	0.95	5	89.08	0.002	0.128	VCT	0.013	0.29	423	423	0.140	1.328	0.106	0.13	1.00	10.4	0.173	698.960	702.880	0.030	698.930	702.850
19	ST713	ST712	0.009	0.95	5	89.08	0.002	0.130	VCT	0.013	0.50	383	383	0.115	1.204	0.096	0.13	1.20	46.8	0.65	698.930	702.850	0.233	698.697	700.410
21	ST712A	ST712	0.1	0.76	5	89.08	0.019	0.019	CONC	0.013	1.13	200	200	0.031	0.628	0.050	0.03	1.20	30.4	0.422	699.400	701.160	0.345	699.055	700.410
22	ST712	ST710	0.05	0.94	5	89.08	0.012	0.161	AC	0.013	0.63	750	750	0.442	2.356	0.188	0.88	2.00	49.3	0.411	698.697	700.410	0.310	698.387	701.847
37	ST711	ST710	2.0	0.64	5	89.08	0.317	0.317	CONC	0.013	0.04	864	864	0.586	2.713	0.216	0.32	0.60	56.8	1.578	698.860	700.410	0.022	698.838	701.847
38	ST710	ST709	0.1	0.65	5	89.08	0.016	0.494	CONC	0.013	0.08	890	890	0.621	2.795	0.222	0.50	0.90	53.1	0.983	698.410	701.847	0.043	698.367	701.253
50	ST709A	ST709	0.5	0.56	8	73.94	0.058	0.058	CONC	0.013	0.36	300	300	0.071	0.942	0.075	0.06	0.90	122.2	2.263	698.267	700.810	0.434	697.833	701.253
51	ST709	ST705	0.1	0.70	5	89.08	0.017	0.569	CONC	0.013	0.33	750	750	0.442	2.356	0.188	0.64	1.50	46.5	0.517	698.385	701.253	0.155	698.230	700.500
55	ST708	ST707	0.7	0.72	5	89.08	0.125	0.125	CONC	0.013	0.18	461	461	0.167	1.448	0.115	0.13	0.80	72.1	1.502	698.990	700.370	0.131	698.859	700.680
54	ST707	ST706	0.007	0.95	5	89.08	0.002	0.126	CONC	0.013	0.35	409	409	0.131	1.285	0.102	0.13	1.00	50.6	0.843	698.839	700.680	0.175	698.664	700.180
53	ST706	ST705	0.5	0.78	5	89.08	0.097	0.223	CONC	0.013	0.30	516	516	0.209	1.622	0.129	0.22	1.10	21.6	0.327	698.644	700.180	0.064	698.580	700.500
52	ST705	ST705A	0.007	0.95	5	89.08	0.002	0.793	CONC	0.013	0.37	798	798	0.500	2.507	0.200	0.80	1.60	56.7	0.591	698.240	700.500	0.210	698.030	700.010
68	AE_1	ST705C	0.8	0.53	8	73.94	0.087	0.087	PVC	0.013	0.50	333	333	0.087	1.046	0.083	0.09	1.10	17.9	0.271	698.550	699.589	0.089	698.461	699.500
	ST705C	ST705B					0.000	0.087	PVC	0.013	0.50	333	333	0.087	1.046	0.083	0.09	1.10	23.8	0.361	698.461	699.500	0.118	698.343	699.800
67	ST705B	ST705A	0.05	0.54	8	73.94	0.006	0.093	PVC	0.013	0.67	319	319	0.080	1.002	0.080	0.09	1.20	14.3	0.199	698.343	699.800	0.096	698.247	700.010
69	ST705A	ST704_AE	0.007	0.95	5	89.08	0.002	0.888	CONC	0.013	0.23	906	906	0.645	2.846	0.226	0.89	1.40	45.0	0.536	698.030	700.010	0.105	697.925	700.224
64	AE_2	ST704	0.2	0.67	5	89.08	0.033	0.033	PVC	0.013	0.31	300	300	0.071	0.942	0.075	0.05	0.80	17.8	0.371	699.066	700.631	0.056	699.010	700.575
	ST704	ST704A					0.000	0.033	PVC	0.013	0.31	300	300	0.071	0.942	0.075	0.05	0.80	56.1	1.169	699.010	700.575	0.175	698.835	700.400
77	ST704A	ST704_AE	0.6	0.68	5	89.08	0.101	0.134	PVC	0.013	0.31	422	422	0.140	1.327	0.106	0.13	1.00	51.2	0.853	698.835	700.400	0.160	698.675	700.224
78	ST704_AE	ST703	4.5	0.69	5	89.08	0.769	1.791	CONC	0.013	0.26	1158	1158	1.053	3.637	0.289	1.80	1.80	101.9	0.944	697.905	700.224	0.263	697.642	700.598
86	ST703	ST702	0.01	0.95	5	89.08	0.002	2.348	CONC	0.013	0.03	1940	1940	2.956	6.095	0.485	2.35	0.80	107.0	2.229	697.542	700.598	0.030	697.512	698.852
87	ST702	ST701	0.7	0.60	5	89.08	0.104	2.452	CONC	0.013	0.23	1343	1343	1.417	4.219	0.336	2.50	1.80	69.2	0.641	697.511	698.852	0.156	697.355	698.869
88	ST701	Natural Area 2	0.04	0.69	5	89.08	0.007	2.459	CONC	0.013	0.23	1335	1335	1.400	4.194	0.334	2.46	1.80	27.6	0.256	697.354	698.869	0.062	697.292	698.807

APPENDIX E - EXISTING MAJOR SYSTEM ASSESSMENT - DETAILED CALCULATIONS

Rational Method Calculations - Existing Major System

Contributing Catchments	C1	C2	C3	C4	C5	A1	A2	A3	A4	A5	C	Length (m)	Slope (m/m)	Tc (min)	I (mm/hr)	Area (m^2)	Area (ha)	Incremental Design Flow 1:100 Year (m^3/s)	Cumulative Design Flow 1:100 Year (m^3/s)	Design Flow into Culvert 1:100 Year (m^3/s)	Existing Culvert Size (mm)	Full Flow Capacity of Culvert 1:100 Year (m^3/s)	Sufficient Capacity?	Proposed Size (mm)
16	0.84					230					0.84	24	0.04	5	188.51	230	0.02	0.01	0.01					
Culvert 24																				0.01	600	0.05	Yes	N/A
12, 8	0.91	0.85				14938	12114				0.88	299	0.05	5	188.39	27052	2.71	1.25	1.25					
Culvert 14																				1.25	600	0.23	No	1200
9, 10	0.84	0.68				1089	68172				0.68	23	0.01	8	161.01	69261	6.93	2.11	3.36					
Culvert 13																				3.36	700	0.35	No	1650
11, 5	0.78	0.69				7227	15555				0.72	300	0.05	5	187.78	22782	2.28	0.85	4.22					
Culvert 12																				4.22	600	0.23	No	1800
6, 7, 13, 14	0.84	0.58	0.33	0.62		122	482	10903	5178		0.43	23	0.01	8	161.01	16685	1.67	3.22E-01	4.54					
Culvert 10																				2.27	700	0.20	No	1800
Culvert 11																				2.27	700	0.20	No	1800
25, 47	0.77	0.77				2784	3976				0.77	248	0.04	5	188.51	6760	0.68	0.27	0.27					
Culvert 15																				0.27	500	0.23	No	600
45, 39	0.74	0.88				14484	524				0.74	276	0.04	5	188.29	15008	1.50	0.58	0.86					
Culvert 4																				0.86	500	0.23	No	900
30, 29	0.72	0.65				176	5605				0.65	130	0.05	8	161.01	5781	0.58	0.17	1.03					
Culvert 2																				1.03	400	0.13	No	900
28, 27, 33, 24, 23	0.76	0.66	0.66	0.69	0.75	954	2822	2743	79189	18453	0.70	496	0.04	8	161.29	104161	10.42	3.27	4.29					
Culvert 1																				4.29	500	0.23	No	1650
26, 32, 31, 36	0.63	0.72	0.61	0.85		5033	280	988	459		0.65	145	0.05	8	161.01	6760	0.68	0.20	4.49					
Culvert 35																				4.49	500	0.23	No	1650
82, 81, 80, 76	0.68	0.7	0.13	0.53		8501	400	182	1295		0.65	162	0.05	8	161.01	10378	1.04	0.30	0.30					
Culvert 6																				0.30	600	0.17	No	750
75, 49	0.69	0.6				3894	1149				0.67	193	0.05	8	161.01	5043	0.50	0.15	0.45					
Culvert 5																				0.45	400	0.06	No	900
46, 41	0.92	0.9				679	657				0.91	70	0.08	5	188.51	1336	0.13	0.06	0.52					
Culvert 3																				0.52	400	0.06	No	1050
40, 43	0.95	0.69				106	13125				0.69	294	0.06	8	161.01	13231	1.32	0.41	0.93					
Culvert 36																				0.93	400	0.06	No	1200
42, 56, 44	0.78	0.73	0.74			4569	818	3507			0.76	143	0.06	5	188.51	8894	0.89	0.35	1.28					
Culvert 33																				1.28	600	0.20	No	1350
85	0.9					238					0.90	25	0.07	5	188.51	238	0.02	0.01	0.01					
Culvert 8																				0.01	500	0.20	Yes	N/A
99, 101	0.95	0.95				342	4439				0.95	178	0.04	5	188.51	4781	0.48	0.24	0.24					
Culvert 30																				0.24	300	0.05	No	600
96, 74	0.81	0.36				26740	70156				0.48	444	0.04	8	164.55	96896	9.69	2.14	2.38					
Culvert 7																				2.38	300	0.05	No	1350
100, 98	0.48	0.81				15482	13785				0.64	550	0.07	7	170.67	29267	2.93	0.88	0.88					
Culvert 20																				0.88	400	0.16	No	900
Culvert 19																				0.88	400	0.16	No	900
93, 95	0.15	0.78				239	16201				0.77	439	0.03	8	162.99	16440	1.64	0.57	0.57					
Culvert 26																				0.29	600	0.53	Yes	N/A
Culvert 21																				0.29	600	0.53	Yes	N/A
92, 104, 20	0.13	0.14	0.125			261	557817	29870			0.14	1724	0.04	21	103.04	587948	58.79	2.34	2.92					
Culvert 16																				2.92	600	0.40	No	1350
91, 105	0.87	0.69				274	387				0.76	55	0.03	5	188.51	661	0.07	0.03	0.03					
Culvert 18																				0.03	400	0.13	Yes	N/A
90		0.83					231				0.83	17	7	5.0	188.51	231	0.02	0.01	0.04					
Culvert 31																				0.04	400	0.13	Yes	N/A
89, 84	0.72	0.75				324	968				0.74	56	0.05	5.0	188.51	1292	0.13	0.05	0.09					
Culvert 32																				0.16	400	0.13	No	450

APPENDIX F - FUTURE MAJOR SYSTEM ASSESSMENT - DETAILED CALCULATIONS

Rational Method Calculations - Future Major System

Contributing Catchments	C1	C2	C3	C4	C5	A1	A2	A3	A4	A5	C	Length (m)	Slope (m/m)	Tc (min)	I (mm/hr)	Area (m²)	Area (ha)	Incremental Design Flow 1:100 Year (m³/s)	Cumulative Design Flow 1:100 Year (m³/s)	Design Flow into Culvert 1:100 Year (m³/s)	Existing Culvert Size (mm)	Full Flow Capacity of Culvert 1:100 Year (m³/s)	Sufficient Capacity?	Proposed Size (mm)
16	0.84					230					0.84	24	0.04	5	188.51	230	0.02	0.01	0.01					
Culvert 24																				0.01	600	0.05	Yes	N/A
12, 8	0.91	0.85				14938	12114				0.88	299	0.05	5	188.39	27052	2.71	1.25	1.25					
Culvert 14																				1.25	1200	1.48	Yes	N/A
9, 10	0.84	0.68				1089	68172				0.68	23	0.01	8	161.01	69261	6.93	2.11	3.36					
Culvert 13																				3.36	1650	3.46	Yes	N/A
11, 5	0.78	0.69				7227	15555				0.72	300	0.05	5	187.78	22782	2.28	0.85	4.22					
Culvert 12																				4.22	1800	4.36	Yes	N/A
6, 7, 13, 14	0.85	0.63	0.6	0.73		122	482	10903	5178		0.64	23	0.01	8	161.01	16685	1.67	4.80E-01	4.70					
Culvert 10																				2.35	1800	2.47	Yes	N/A
Culvert 11																				2.35	1800	2.47	Yes	N/A
25, 47	0.77	0.77				2784	3976				0.77	248	0.04	5	188.51	6760	0.68	0.27	0.27					
Culvert 15																				0.27	600	0.37	Yes	N/A
45, 39	0.74	0.88				14484	524				0.74	276	0.04	5	188.29	15008	1.50	0.58	0.86					
Culvert 4																				0.86	900	1.09	Yes	N/A
30, 29	0.72	0.65				176	5605				0.65	130	0.05	8	161.01	5781	0.58	0.17	1.03					
Culvert 2																				1.03	900	1.09	Yes	N/A
28, 27, 33, 24, 23	0.76	0.66	0.66	0.69	0.75	954	2822	2743	79189	18453	0.70	496	0.04	8	161.29	104161	10.42	3.27	4.29					
Culvert 1																				4.29	1650	5.5	Yes	N/A
26, 32, 31, 36	0.63	0.72	0.61	0.85		5033	280	988	459		0.65	145	0.05	8	161.01	6760	0.68	0.20	4.49					
Culvert 35																				4.49	1650	5.5	Yes	N/A
82, 81, 80, 76	0.68	0.7	0.13	0.53		8501	400	182	1295		0.65	162	0.05	8	161.01	10378	1.04	0.30	0.30					
Culvert 6																				0.30	750	0.31	Yes	N/A
75, 49	0.69	0.6				3894	1149				0.67	193	0.05	8	161.01	5043	0.50	0.15	0.45					
Culvert 5																				0.45	900	0.5	Yes	N/A
46, 41	0.92	0.9				679	657				0.91	70	0.08	5	188.51	1336	0.13	0.06	0.52					
Culvert 3																				0.52	1050	0.76	Yes	N/A
40, 43	0.95	0.69				106	13125				0.69	294	0.06	8	161.01	13231	1.32	0.41	0.93					
Culvert 36																				0.93	1200	1.09	Yes	N/A
42, 56, 44	0.78	0.73	0.74			4569	818	3507			0.76	143	0.06	5	188.51	8894	0.89	0.35	1.28					
Culvert 33																				1.28	1350	1.73	Yes	N/A
85	0.9					238					0.90	25	0.07	5	188.51	238	0.02	0.01	0.01					
Culvert 8																				0.01	500	0.20	Yes	N/A
99, 101	0.95	0.95				342	4439				0.95	178	0.04	5	188.51	4781	0.48	0.24	0.24					
Culvert 30																				0.24	600	0.31	Yes	N/A
96, 74	0.81	0.36				26740	70156				0.48	444	0.04	8	164.55	96896	9.69	2.14	2.38					
Culvert 7																				2.38	1350	2.65	Yes	N/A
100, 98	0.84	0.91				15482	13785				0.87	550	0.07	7	170.67	29267	2.93	1.21	1.21					
Culvert 20																				1.21	900	1.36	Yes	N/A
Culvert 19																				1.21	900	1.36	Yes	N/A
93, 95	0.75	0.78				239	16201				0.78	439	0.03	8	162.99	16440	1.64	0.58	0.58					
Culvert 26																				0.29	600	0.53	Yes	N/A
Culvert 21																				0.29	600	0.53	Yes	N/A
92, 104, 20	0.75	0.65	0.125			261	557817	29869.508			0.62	1724	0.04	21	103.04	587948	58.79	10.49	11.07					
Culvert 16																				11.07	1350	0.40	No	3 1500 mm dia
91, 105	0.87	0.69				274	387				0.76	55	0.03	5	188.51	661	0.07	0.03	0.03					
Culvert 18																				0.03	400	0.13	Yes	N/A
90	0.83					231					0.83	17	7	5.0	188.51	231	0.02	0.01	0.04					
Culvert 31																				0.04	400	0.13	Yes	N/A
89, 84	0.72	0.75				324	968				0.74	56	0.05	5.0	188.51	1292	0.13	0.05	0.09					
Culvert 32																				0.16	450	0.17	Yes	N/A

APPENDIX G - PRELIMINARY COST ESTIMATE

Preliminary Cost Estimate

Item No.	Description	Quantity	Unit	Unit Price	Extension
Proposed Minor System Upgrades					
1.0	Remove and Replace Existing Storm Pipe				
1.1	S703A to ST703 (1200 mm diameter)	99	m	$ 1,500	$ 148,000
1.2	ST715 to ST714 (375 mm diameter)	36	m	$ 1,500	$ 54,000
1.3	ST714 to ST713 (450 mm diameter)	10	m	$ 1,500	$ 16,000
1.4	ST713 to ST712 (450 mm diameter)	47	m	$ 1,500	$ 71,000
1.5	ST711 to ST710 (900 mm diameter)	57	m	$ 1,500	$ 86,000
1.6	ST710 to ST709 (900 mm diameter)	53	m	$ 1,500	$ 80,000
1.7	ST708 to ST707 (525 mm diameter)	72	m	$ 1,500	$ 109,000
1.8	ST707 to ST706 (450 mm diameter)	51	m	$ 1,500	$ 76,000
1.9	ST706 to ST705 (525 mm diameter)	22	m	$ 1,500	$ 33,000
1.10	ST705 to ST705A (900 mm diameter)	57	m	$ 1,500	$ 86,000
1.11	AE_1 to ST705C (375 mm diameter)	18	m	$ 1,500	$ 27,000
1.12	ST705C to ST705B (375 m diameter)	24	m	$ 1,500	$ 36,000
1.13	ST705B to ST705A (375 mm diameter)	14	m	$ 1,500	$ 22,000
1.14	ST705A to ST704_AE (1050 mm diameter)	45	m	$ 1,500	$ 68,000
1.15	ST704A to ST704_AE (450 mm diameter)	51	m	$ 1,500	$ 77,000
1.16	ST704_AE to ST703 (1200 mm diameter)	102	m	$ 1,500	$ 153,000
1.17	ST703 to ST702 (1950 mm diameter)	107	m	$ 1,500	$ 161,000
1.18	ST702 to ST701 (1350 mm diameter)	69	m	$ 1,500	$ 104,000
1.19	ST701 to Natural Area 2 (1350 mm diameter)	28	m	$ 1,500	$ 42,000
	Sub-Total - Proposed Existing Minor Upgrades				$ 1,450,000
Proposed Major System Upgrades					
2.0	Remove and Replace Existing Culverts				
2.1	Culvert 14 (1200 mm diameter)	23	m	$ 1,500	$ 34,000
2.2	Culvert 13 (1650 mm diameter)	19	m	$ 1,500	$ 29,000
2.3	Culvert 12 (1800 mm diameter)	13	m	$ 1,500	$ 20,000
2.4	Culvert 10 (1800 mm diameter)	8	m	$ 1,500	$ 13,000
2.5	Culvert 11 (1800 mm diameter)	8	m	$ 1,500	$ 13,000
2.6	Culvert 15 (600 mm diameter)	19	m	$ 1,500	$ 29,000
2.7	Culvert 4 (900 mm diameter)	13	m	$ 1,500	$ 20,000
2.8	Culvert 2 (900 mm diameter)	18	m	$ 1,500	$ 28,000
2.9	Culvert 1 (1650 mm diameter)	17	m	$ 1,500	$ 26,000
3.0	Culvert 35 (1650 mm diameter)	20	m	$ 1,500	$ 31,000
3.1	Culvert 6 (750 mm diameter)	12	m	$ 1,500	$ 18,000
3.2	Culvert 5 900 mm diameter)	7	m	$ 1,500	$ 11,000
3.3	Culvert 3 (1050 mm diameter)	23	m	$ 1,500	$ 34,000
3.4	Culvert 36 (1200 mm diameter)	20	m	$ 1,500	$ 30,000
3.5	Culvert 33 (1350 mm diameter)	17	m	$ 1,500	$ 25,000
3.6	Culvert 30 (600 mm diameter)	81	m	$ 1,500	$ 121,000
3.7	Culvert 7 (1350 mm diameter)	13	m	$ 1,500	$ 21,000
3.8	Culvert 20 (900 mm diameter)	26	m	$ 1,500	$ 39,000
3.9	Culvert 19 (900 mm diameter)	33	m	$ 1,500	$ 49,000
4.0	Culvert 16 (1350 mm diameter)	13	m	$ 1,500	$ 20,000
4.1	Culvert 32 (450 mm diameter)	10	m	$ 1,500	$ 15,000
	Sub-Total - Proposed Existing Major Upgrades				$ 630,000
	Total - Proposed Existing Minor and Major Upgrades				$ 2,080,000
	Engineering and Contingency (50%)				$ 1,040,000
	Preliminary Cost Estimate Total				**$ 3,120,000**