



Ninth Line Class Environmental Assessment

Eglinton Avenue West to Derry Road West

Drainage and Stormwater Management Report

City of Mississauga
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Contents

1	Introduction	1
1.1	Background information	2
2	Existing Drainage Conditions	4
2.1	Watershed and Subwatershed	4
2.2	Land Use	4
2.3	Hydrogeological Conditions	4
2.4	Existing Drainage Pattern	5
2.5	Aquatic Resources	5
2.6	Transverse Crossings	6
2.6.1	Existing Condition Summary	6
2.6.2	Assessment Criteria	6
2.6.3	Hydraulic Assessment of Transverse Crossings	7
3	Proposed Drainage Condition	9
3.1	Roadway Drainage System	9
3.1.1	Minor Drainage System	9
3.1.2	Major Drainage System	9
3.2	Hydraulic Assessment of East Lisgar Branch	9
3.3	Transverse Crossings	11
3.3.1	Hydraulic Assessment of Proposed Transverse Crossings	11
4	Stormwater Management Strategy	14
4.1	Stormwater Management Criteria	14
4.1.1	Water Quality Control	14
4.1.2	Water Quantity Control	14
4.1.3	Water Balance and Erosion Control	15
4.2	Hydrologic Modeling	15
4.3	Pavement Area Analysis	15
4.4	Stormwater Best Management Practice Options	16
4.4.1	Bioretention Cells	16
4.4.2	Oil-Grit Separator Units	18
4.4.3	Online Storage Pipes	19
4.4.4	Supplemental BMP Measures	20
4.5	Erosion and Sediment Control during Construction	20
4.6	Stormwater Management Plan Summary	21
5	Conclusions	22

Tables

Table 2-1: Summary of Existing Drainage Areas.....	5
Table 2-2: Summary of Transverse Crossings	6
Table 2-3: Summary of Transverse Crossings Condition Assessment	6
Table 2-4: Design Peak Flows - Transverse Crossings.....	7
Table 2-5: Hydraulic Analysis Results for the Transverse Culverts (Existing Condition)	8
Table 3-1: Transverse Crossing Recommendations	11
Table 3-2: Hydraulic Analysis Results for the Transverse Crossings (Proposed Condition).....	12
Table 3-3: Hydraulic Analysis Results for Alternative Scenarios at C-3 Crossing.....	13
Table 4-1: Pavement Area Analysis.....	16
Table 4-2: Summary of Proposed Water Quality Treatment Strategy	18
Table 4-3: Summary of Proposed Water Quantity Treatment Strategy	19
Table 4-4: Summary of Stormwater Management Plan.....	21

Figures

Figure 1: Study Area and Study Corridor	1
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Appendices

Appendix A: Drainage Area Plans
Appendix B: Hydraulic Assessment Output Files
Appendix C: LID Screening Tool
Appendix D: Bioretention Cell Schematic
Appendix E: Stormwater Management Calculations

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1 Introduction

The City of Mississauga has initiated a Schedule 'C' Municipal Class Environmental Assessment (EA) Study to assess potential transportation improvements to Ninth Line, from Eglinton Avenue West to Derry Road West. HDR has been retained by the City of Mississauga to conduct the Ninth Line Class EA Study.

This Drainage and Stormwater Management Report has been prepared in support of the Class EA Study and complies with the Ministry of the Environment, Conservation and Parks (MECP), Conservation Halton (CH), and the City of Mississauga's Policies and Standards. The Ninth Line Class EA study limits are illustrated in **Figure 1**.



Figure 1: Study Area and Study Corridor

The Ninth Line Class EA study limits span approximately 6.2 km in the City of Mississauga. Ninth Line is a major two-lane north-south arterial road and intersects with a number of existing and future local roads and entrances within the project limits. The existing right-of-way and land use vary throughout the corridor.

There is one regulated watercourse that crosses Ninth Line within the project limits, which is NLT-1 and is located downstream of Osprey Marsh. This watercourse is regulated by Conservation Halton. In addition, two unregulated drainage features, Drainage Features B and C, cross Ninth Line and discharge to existing Stormwater Management Ponds A and B. The watercourse and the two drainage features are tributaries to the East Lisgar Branch of Sixteen Mile Creek. There is a storm outfall that discharges to an open channel 330 m south of Britannia Road, referred to as Drainage Feature D, which is not classified as a crossing. Refer to the Drainage Area Plans in **Appendix A** for the location of the crossings.

The objective of the Drainage and Stormwater Management Report is to develop a strategic approach to the level of development of the proposed project that will:

- Identify and evaluate existing drainage patterns, and transverse culvert locations;
- Identify potential stormwater runoff quality and quantity impacts to the receiving watercourses/ storm sewer systems resulting from changes to the roadway cross-section (i.e. increased pavement area); and
- Propose an appropriate drainage system, transverse culvert upgrades, and a stormwater management system in conjunction with the proposed road widening to mitigate any potential impact.

1.1 Background information

In preparation of the Ninth Line Class Environmental Assessment Drainage and Stormwater Management Report, the following essential documents were obtained and reviewed:

1. City of Mississauga Storm Drainage Design Requirements, January 2020;
2. Ministry of the Environment, Conservation and Parks (MECP) Stormwater Management Practices Planning and Design Manual, March 2003;
3. Conservation Halton (CH) Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document, April 2006 (last amended, November 2020);
4. Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC) Low Impact Development Stormwater Management Planning and Design Guide, 2010;
5. Sustainable Technologies Evaluation Program (STEP) Low Impact Development Stormwater Management (LID SWM) Planning and Design Guide, 2020;
6. Region of Peel and CVC's LID Implementation Process for Regional Road Right-of-Ways (2014);
7. Stormwater Management Design Report for the Churchill Meadows Stormwater Management Facilities, prepared by Rand Engineering Corporation, December 1997;
8. Draft Ninth Line Lands Scoped Subwatershed Study Phase 1, Phase 2, and Phase 3, prepared by Amec Foster Wheeler/Wood, April 2020;

9. Draft Natural Environment Assessment Report for the Ninth Line Environmental Assessment and Preliminary Design, prepared by NRSI Inc., March 2021;
10. Draft Preliminary Geotechnical Investigation Report for the Ninth Line Class Environmental Assessment Study, prepared by Thurber Engineering Inc., December 2020;
11. Draft Structural Assessment Report for Ninth Line Environmental Assessment and Preliminary Design, prepared by HDR, October 2020;
12. Conservation Halton's Complete Application Checklist – Environmental Assessment, dated July 2020; and
13. MECP Response to Notice of Commencement Letter dated April 30, 2020.

2 Existing Drainage Conditions

2.1 Watershed and Subwatershed

Conservation Halton (CH) have jurisdiction with respect to drainage and stormwater management of the Sixteen Mile Creek Watershed within the Ninth Line Class EA project limits. A small portion of the study corridor is located within the Credit Valley Conservation's (CVC) Sawmill Creek Subwatershed; however, since there are no watercourses/tributaries to Sawmill Creek within this portion, the CH criteria for stormwater management is applied to the entire study corridor. The study area also falls under the jurisdiction of the Ministry of Natural Resources and Forestry (MNR) Aurora District. There is one (1) regulated watercourse crossing and two (2) unregulated crossings within the study limits, all located within the Conservation Halton Sixteen Mile Creek Watershed. The Sixteen Mile Creek Watershed encompasses approximately 357 km² of land area. Refer to the Drainage Plans in **Appendix A** for the crossing locations.

2.2 Land Use

Based on the site investigation and the available background information, the existing land use along Ninth Line varies along the study corridor and includes commercial, industrial, institutional, and residential land uses. Along the west side of Ninth Line, the existing land use also includes open spaces, stormwater management ponds, and agricultural land uses.

2.3 Hydrogeological Conditions

A preliminary Geotechnical Investigation was completed for the Ninth Line EA by Thurber Engineering Ltd. in August 2020. As part of this investigation, thirty (30) boreholes were drilled within the study corridor and standpipe piezometers were installed in seven (7) of the boreholes to measure groundwater levels.

Based on the results of the Geotechnical Investigation, the soil material at the locations where low impact development (LID) measures are proposed was classified as silty clay and silty clay till. The estimated hydraulic conductivity of this type of material is 0.51 mm/hr, or 1.42×10^{-5} cm/s (Rawls, W.J. et al., 1983)¹. This approximately corresponds to an infiltration rate of 31 mm/hr, as per Table C1 in Appendix C of the CVC/TRCA LID SWM Planning and Design Guide (2010). A safety correction factor of 3.0 was applied to estimate the soil infiltration rate at the base of the proposed BMPs. Accordingly, the percolation rate of the native soil is estimated to be 10.3 mm/hr.

As part of the Geotechnical Investigation, groundwater levels were measured upon completion in majority of the open boreholes and in the standpipe piezometers at the crossing locations in August 2020. According to the results, the groundwater was 3.0 m below the ground surface at the NLT-1 crossing and 2.5 m and 2.2 m below the ground surface at the Drainage Features C and B crossings, respectively. In the locations where LID measures are generally proposed and groundwater was observed, the groundwater levels ranged from 2.2 to 4.1 m below the ground surface. Throughout the

¹ Rawls, W.J., Brakensiek, D., & Miller, N. (1983). Green-ampt Infiltration Parameters from Soils Data. Journal of Hydraulic Engineering, 109, 62-70.

entire project corridor, where groundwater was observed, the groundwater levels ranged from 1.6 m to 4.1 m below the ground surface.

During the detailed design stage, in-situ infiltration rate measurements should be completed at all proposed LID locations to confirm the soil infiltration rates and groundwater levels.

2.4 Existing Drainage Pattern

Ninth Line between Eglinton Avenue West and Derry Road West has primarily a semi-rural cross-section. The roadway and boulevard surfaces are drained by a network of catchbasins, ditch inlets, ditches, and storm sewers, and discharge to the watercourse crossing, drainage features, and existing municipal storm systems. Refer to the Drainage Plans in **Appendix A** for additional details.

Table 2-1 summarizes the approximate locations and areas for each of the drainage areas.

Table 2-1: Summary of Existing Drainage Areas

Drainage Area ID	Description	Drainage Area (ha)	From Station	To Station	Discharge Location
A-1	From Eglinton Avenue West to Burdette Terrace	3.46	10+100	11+020	Existing storm sewer system (Ninth Line, south of Eglinton Avenue West)
A-2	From Burdette Terrace to 150 m north of Thomas Street	4.61	11+020	12+320	Drainage Feature B (Stormwater Management Pond B)
A-3	From 150 m north of Thomas Street to 30 m south of McDowell Drive	1.50	12+320	12+770	Drainage Feature C (Stormwater Management Pond A)
A-4	From 30 m south of McDowell Drive to 90 m south of Britannia Road	0.87	12+770	13+010	Drainage Feature D
A-5	From 90 m south of Britannia Road to Doug Leavens Boulevard	7.14	13+010	14+960	NLT-1 (Downstream of Osprey Marsh)
A-6	From Doug Leavens Boulevard to 120 m south of Beacham Street	1.61	14+960	15+420	Existing storm sewer system (Doug Leavens Boulevard)
A-7	From 120 m south of Beacham Street to 30 m north of Beacham Street	0.53	15+420	15+570	Existing storm sewer system (Worthview Place)
A-8	From 30 m north of Beacham Street to Derry Road	2.53	15+570	16+230	Existing storm sewer system (Beacham Street)

2.5 Aquatic Resources

The watercourse that exists within the study limits is part of the Sixteen Mile Creek Watershed and is under the jurisdiction of Conservation Halton (CH) and the Ministry of Natural Resources and Forestry (MNRF) Aurora District. The watercourse crossing identified within the study area is NLT-1, which carries outflow from the adjacent Osprey Marsh SWM complex, is classified as warmwater fish habitat. Drainage features B, C, and D are not regulated features and do not support fish passage.

Based on a review of fisheries collection records from the Department of Fisheries Ontario (DFO) Distribution of Fish and Species at Risk maps, Critical Habitat for Silver Shiner is identified for Sixteen Mile Creek, and watercourse NLT-1 acts as contributing habitat to Sixteen Mile Creek by way of the East Lisgar Branch. However, watercourse NLT-1 and the drainage features within the study area are

not identified as species at risk regulated habitat. Accordingly, the watercourse and drainage features are not subject to the regulations of the Endangered Species Act 2007.

2.6 Transverse Crossings

There is one (1) regulated watercourse crossing and two (2) unregulated crossings within the Ninth Line study corridor. Note that Drainage Feature D is not classified as a crossing as it is an outfall of a storm sewer system with an enclosed upstream end.

Table 2-2 summarizes the size, type, and location of the existing culvert structures. Refer to the Drainage Plans in **Appendix A** for additional details.

Table 2-2: Summary of Transverse Crossings

Crossing (Watercourse)	Crossing Location	Culvert Dimensions (Span x Rise, m)	Culvert Description	Culvert Length (m)
C-1 (Drainage Feature B)	1.2 km south of Britannia Road West	2 - 2.4 x 1.8	Twin Concrete Box Culvert	45.0
C-2 (Drainage Feature C)	630 m south of Britannia Road West	2 - 2.4 x 1.8	Twin Concrete Box Culvert	45.0
C-3 (NLT-1)	335 m north of Britannia Road West	3 - 7.0 x 2.4	Triple Cell Cast-In-Place Concrete Box Culvert	22.6

2.6.1 Existing Condition Summary

The Ninth Line EA Draft Structural Assessment Report by HDR (October 2020) provides detailed information regarding the existing condition of the crossing structures within the project limits. A site visit was conducted by HDR structural staff on October 1, 2020.

Table 2-3 provides a summary of the structural conditions of the existing culvert crossings.

Table 2-3: Summary of Transverse Crossings Condition Assessment

Crossing (Watercourse)	Material/ Crossing Type	Overall Condition ¹
C-1 (Drainage Feature B)	Twin Concrete Box Culvert	Good condition
C-2 (Drainage Feature C)	Twin Concrete Box Culvert	Good condition
C-3 (NLT-1)	Triple Cell Cast-In-Place Concrete Box Culvert	Good condition, requiring maintenance rehabilitation

Note 1: Per Structural Assessment Report by HDR (October 9, 2020)

2.6.2 Assessment Criteria

Hydraulic assessments of the transverse crossings within the Ninth Line Class EA study corridor were undertaken in accordance to City of Mississauga Storm Drainage Design Requirements (2020).

Design Flows

Based on the City of Mississauga Storm Drainage Design Requirements (2020), the design flood frequency for arterial roads is the larger of the 100 year or Regional Storm events flows.

Minimum Culvert Sizes

The minimum culvert size for a driveway culvert is 300 mm diameter with a precast headwall as per the City of Mississauga's Storm Drainage Design Requirements.

2.6.3 Hydraulic Assessment of Transverse Crossings

The design peak flows for Crossings C-1 and C-2 (Drainage Features B and C, respectively) were obtained from the HEC-2 output of the Churchill Meadows Stormwater Management Facilities Design Report (Rand Engineering Corporation, December 1997). The design peak flows for Crossing C-3 (NLT-1) were obtained from the VisualOTTHYMO hydrologic modelling results of the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report (Amec Foster Wheeler, April 2020).

It is recommended that during detailed design, the design flows be reviewed and verified to confirm any changes to the land-use and associated hydrologic information that may affect the peak flows presented in this Class EA study.

A summary of the storm design peak flows of the transverse crossings is presented in **Table 2-4**.

Table 2-4: Design Peak Flows - Transverse Crossings

Watercourse/ Drainage Crossing	Type	Peak Flow (m ³ /s)		
		50 Year	100 Year	Regional
C-1 (Drainage Feature B)	Culvert	-	24.53	15.75
C-2 (Drainage Feature C)	Culvert	-	21.94	16.66
C-3 (NLT-1) ¹	Culvert	32.58	40.54	97.42

¹ Flows obtained from hydrograph node 70 of the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report (Amec Foster Wheeler, April 2020)

A hydraulic assessment of the existing crossings was conducted to determine the hydraulic performance under existing conditions. A HY-8 hydraulic model was developed based on the available record drawings and survey data.

The tailwater elevations under the 100 year and Regional storm events were obtained from the Churchill Meadows Stormwater Management Facilities Design Report (Rand Engineering Corporation, December 1997) for Crossings C-1 and C-2 (SWM ponds water levels) and from the HEC-RAS hydraulic model of the East Lisgar Branch (Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report, Amec Foster Wheeler, April 2020) for Crossing C-3.

The culvert capacities were assessed based on the 100 year and Regional design storm as per the City of Mississauga Storm Drainage Design Requirements. **Table 2-5** summarizes the hydraulic analysis results for the crossings along the study corridor. All hydraulic assessment output files are provided in **Appendix B**.

Table 2-5: Hydraulic Analysis Results for the Transverse Culverts (Existing Condition)

Crossing	Type	U/S Invert (m)	D/S Invert (m)	Length (m)	Road Elev. (m)	Water Surface Elev. (m)			Remarks
						50 Yr	100 Yr	Reg.	
C-1 (Drainage Feature B)	Culvert	186.54	186.47	45.0	190.07	-	189.38	189.65	100 year and Regional flows do not overtop road
C-2 (Drainage Feature C)	Culvert	186.79	186.62	45.0	190.20	-	189.24	189.68	100 year and Regional flows do not overtop road
C-3 (NLT-1)	Culvert	187.35	187.25	22.6	190.67	189.56	189.72	191.35	Regional flow overtops road

The results presented in **Table 2-5** indicate that the 100 year and Regional Storm events do not overtop the road at Crossings C-1 and C-2. The Regional Storm event overtops the roadway at Crossing C-3 by 0.68 m, because of the large flows from NLT-1 and the high tailwater levels at the downstream East Lisgar Branch.

3 Proposed Drainage Condition

3.1 Roadway Drainage System

The preferred alternative design concept for Ninth Line from Eglinton Avenue West to Derry Road West recommends widening the road from two to four lanes, urbanization, as well as the addition of in-boulevard cycle tracks and sidewalks on both sides of the road. The design concept also includes intersection improvements at all signalized intersections and streetscaping opportunities along the corridor. As part of the proposed roadway design, localized high points and low points are introduced in the roadway profile. Overall, the existing drainage patterns and discharge locations will not be altered as per the proposed roadway improvements, with the exception of minor localized changes as a result of the proposed roadway profile.

3.1.1 Minor Drainage System

The overall drainage pattern will generally be consistent with the existing conditions. To accommodate the proposed roadway widening, storm sewer upsizing and catchbasin relocations are anticipated, and additional catchbasins are proposed as a result of the proposed urbanized cross-section. The storm sewer system for the ultimate roadway configuration is to be designed for a 10-year storm event as per the City of Mississauga Storm Drainage Design Requirements. Proposed roadway drainage will be collected by a series of catchbasins and will be conveyed by storm sewers to the existing storm outlet locations. There are a number of existing outlets for the runoff from Ninth Line within the study corridor. For the storm sewer discharge locations, refer to the Drainage Plans in **Appendix A**. A summary listing the right-of-way drainage area characteristics is provided in **Table 2-1**.

3.1.2 Major Drainage System

The roadway design should ensure that the major system runoff up to the 100 year storm event can be safely conveyed to outfall locations, and the depth of water shall not exceed the crown of the road, as per City of Mississauga Storm Drainage Design Requirements. At these locations, major system inlets will capture the 100 year flow and direct it to the appropriate outfalls. A spread analysis should be completed at the detailed design stage to ensure that the ponding at low points does not exceed the crown of the road.

For major system flow route details, refer to the Drainage Plans in **Appendix A**.

3.2 Hydraulic Assessment of East Lisgar Branch

Under existing conditions, the Ninth Line roadway is overtopped by the East Lisgar Branch of Sixteen Miles Creek at several locations, as indicated in the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report. There are four locations within the study corridor where the Regional floodplain spills beyond the Subwatershed Study model extent. The existing floodplain extent, as well as the spill locations, are shown on the Drainage Plans in **Appendix A**. A summary of the existing roadway overtopping and description of the spill locations is provided in **Table 3-1**.

Table 3-1: Existing Roadway Overtopping and Spill Locations

Overtopping Location	Description	Spill Location
Sta. 11+830 to Sta. 12+800	From Deepwood Heights to McDowell Drive	Sta. 11+950, Sta. 12+530, and Sta. 12+590.
Sta. 13+180 to Sta. 14+460	From Britannia Road to 360 m north of Foxwood Avenue	from Sta. 13+460 Sta. 13+810

A hydraulic assessment was conducted as part of this study to determine the floodplain impacts as a result of the proposed widening. For this assessment, the existing condition (October 2015) HEC-RAS model for the East Lisgar Branch from the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report was updated to include the proposed Ninth Line roadway profile and cross-section. The updates were applied to HEC-RAS stations 208 to 234 within the study area, where changes to the roadway profile or cross-section would encroach into the existing floodplain. Refer to the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report for the HEC-RAS station locations.

Based on the hydraulic comparison between existing and proposed conditions, the maximum increase in flood levels is 0.01 m at Section 234 under the 25, 50, and 100 year storm events, and 0.01 m at Section 236 under the 100 year storm event, which can be considered as negligible. At the remaining sections within the study area, there was either a negligible decrease (maximum of 0.02 m) or no change in the water surface elevation. Accordingly, the proposed design is not considered to generate a negative impact to flood levels under the full range of storm events.

Overtopping of the Ninth Line roadway was observed at multiple sections within the study corridor, which is consistent with existing conditions, as shown in the Drainage Area Plans in **Appendix A**. The greatest depth of roadway overtopping from the East Lisgar Branch was observed directly north of Britannia Road (Section 223), with a depth of approximately 0.63 m at the crown of the roadway under the Regional storm event.

To reduce the flood depth under Regional storm conditions along the corridor, one option would be to further raise the roadway profile at all locations which are currently overtopped under the Regional storm event. However, this would result in an increase of the upstream Regional flood levels along the East Lisgar Branch. As further discussed in **Section 3.3**, a preliminary hydraulic assessment indicated that raising the roadway profile near Crossing C-3 without increasing the hydraulic capacity of the crossing would increase the upstream Regional flood levels along NLT-1, which is not desirable. Note that the preliminary hydraulic assessment only shows the water levels immediately upstream of the crossing. A more detailed analysis using a HEC-RAS model will be required in the detailed design stage to assess the impact along the upstream reach. During detailed design, opportunities to eliminate or reduce the flood hazards to the extent possible will be explored, and the model to be used in the hydraulic assessment will be confirmed with CH. The flood depth, flood velocity, and depth-velocity product will be evaluated during detailed design when additional floodplain modelling information is available, based on the Ministry of Natural Resources and Forestry (MNRF) Technical Guide on River and Stream Systems Erosion Hazard Limit (2002).

Furthermore, the Draft Ninth Line Lands Scoped Subwatershed Study Phase 2 report (Amec Foster Wheeler, 2020) indicated that reduction of the extent of the Regional floodplain and optimization of the development potential within the Ninth Line Lands could be achieved through a cut-fill balance along the development lands. This approach has received conceptual approval by relevant stakeholders and

Conservation Halton. Accordingly, efforts to reduce the extent of the regulatory floodplain or eliminate overtopping of Ninth Line are to be explored during detailed design and considered in conjunction with the Ninth Line Lands development and/or Transitway study.

The HEC-RAS output for the comparison of water surface elevations between existing and proposed conditions within the applicable HEC-RAS stations is provided in **Appendix B**.

3.3 Transverse Crossings

There is one (1) regulated watercourse crossing and two (2) unregulated crossings within the study corridor. The proposed size, structure and locations of each crossing were determined based on the existing culvert condition assessments, proposed roadway geometry, grading impacts, and hydraulic performance, with the objective of improving the drainage condition at each crossing and addressing any existing deficiencies. Extension of the triple cell concrete box culvert at Crossing C-3 (NLT-1) is required to accommodate the proposed roadway improvements.

The Draft Ninth Line Lands Scoped Subwatershed Study Phase 3 report (Wood, 2020) recommended substantial realignment or relocation and enhancement of the NLT-1 watercourse from the Ninth Line crossing towards Britannia Road. The recommendations from the Phase 3 report include consideration of the proposed Transitway, which is currently underway as part of a separate Class EA. For the purposes of this EA study for the Ninth Line corridor, the recommendations at Crossing C-3 are intended to support the proposed roadway widening and active transportation facilities only. Any proposed watercourse realignment, relocation, or enhancement works are to be investigated during detailed design and/or under separate study.

A summary of the recommended approach for upgrades at each watercourse and drainage feature crossing is provided in **Table 3-1**.

Table 3-2: Transverse Crossing Recommendations

Crossing (Watercourse)	Location	Recommendations for Culvert Upgrades
C-1 (Drainage Feature B)	Sta. 11+945	No upgrades are required at this time.
C-2 (Drainage Feature C)	Sta. 12+520	No upgrades are required at this time.
C-3 (NLT-1)	Sta. 13+480	Culvert extension is required to accommodate roadway improvements. The required extension is 5.0 m on either side of the crossing, for a total culvert length of 32.6 m.

3.3.1 Hydraulic Assessment of Proposed Transverse Crossings

Under proposed conditions, the drainage boundary and design peak flow values for the transverse crossings are considered to remain unchanged compared to the existing conditions. The increase in pavement area as a result of the corridor improvements is negligible in comparison to the large external drainage areas contributing to each watercourse crossing location. Therefore, the design peak flows based on the current land use conditions (obtained from the Churchill Meadows Stormwater Management Design Report HEC-2 output and the Draft Ninth Line Lands Scoped Subwatershed Study Phase 1 Background Report) were used to assess the hydraulic performance of the proposed crossings.

The preliminary hydraulic assessment for the proposed crossings is based on the preliminary proposed horizontal road design and vertical centreline profile design. Note that the proposed inverts of the crossing culverts are to be confirmed during detailed design to accommodate the road design and the roadside ditch grading.

Crossing C-1

Under proposed conditions, no upgrades to the culvert are required to accommodate the proposed roadway widening. Therefore, the hydraulic capacity of this crossing will remain unchanged compared to the existing condition (**Table 2-5**).

Crossing C-2

Under proposed conditions, no upgrades to the culvert are required to accommodate the proposed roadway widening. Therefore, the hydraulic capacity of this crossing will remain unchanged compared to the existing condition (**Table 2-5**).

Crossing C-3 (NLT-1)

Under proposed conditions, the existing triple cell concrete box culvert is recommended to be extended to accommodate the proposed roadway widening. Under existing conditions, the current culvert crossing over NLT-1 is overtopped by the Regional Storm event by approximately 0.68 m at the crossing. Under proposed conditions, the culvert crossing is overtopped by approximately 0.64 m. Extending the length of the culvert to accommodate the proposed road widening will result in a negligible increase of 0.02 m in the upstream Regional storm water level as shown in **Table 3-2**.

Table 3-3: Hydraulic Analysis Results for the Transverse Crossings (Proposed Condition)

Crossing	Type	U/S Invert (m)	D/S Invert (m)	Length (m)	Road Elev. (m)	Water Surface Elev. (m)			Remarks
						50 Yr	100 Yr	Reg.	
C-3 (NLT-1)	Culvert	187.37	187.23	32.6	190.73	189.56	189.72	191.37	Regional flow overtops road

The roadway overtopping is attributed to the large flows from NLT-1 and the high tailwater conditions of the downstream East Lisgar Branch under Regional Storm conditions. To reduce the Regional flood depth over Ninth Line, one option (1A) would be to raise the roadway profile at this location above the Regional tailwater elevation. A preliminary hydraulic assessment showed that this option will result in an increase of approximately 0.08 m in the upstream Regional flood. If the roadway profile is raised further to eliminate overtopping at the crossing (Option 3A), this will result in an increase of approximately 0.09 m in the upstream Regional flood level. This approach would require major grading adjustments along the roadway.

A preliminary hydraulic assessment was completed to consider an increase in the hydraulic capacity at this crossing by adding a cell to the culvert. If the current design profile is maintained and the hydraulic capacity is increased (Option 2), the overtopping depth would be reduced to 0.55 m and there would be no increase in the upstream Regional flood level. If the roadway profile is raised above the Regional tailwater elevation and the hydraulic capacity is increased (Option 1B), the overtopping would be reduced to 0.15 m without increasing the upstream flood elevation. If the roadway profile is raised to eliminate the overtopping and the hydraulic capacity is increased (Option 3B), there would be no increase in the upstream flood elevation. This approach would require major rehabilitation or full replacement of the structure, major grading adjustments along the roadway, and channel realignment to accommodate the increased flow area.

The preliminary hydraulic assessment results for alternate scenarios to reduce or mitigate the overtopping during the Regional storm event are provided in **Table 3-3**. Note that the preliminary hydraulic assessment completed using the HY-8 model only shows the water levels immediately upstream of the crossing. A more detailed analysis using a HEC-RAS model will be required in the detail design stage to assess the impact along the upstream reach.

Additional coordination with both the City of Mississauga and Conservation Halton shall be carried out to finalize the detail design of the culvert and to minimize impacts to the watercourse and surrounding wetlands. The selected alternative will be confirmed during detailed design by completing additional supporting modelling and analysis, using the information available at that time. Updates to the hydraulic modelling, floodplain assessment and revisions to Conservation Halton floodplain mapping shall be completed during detailed design to reflect the final design and grading footprint of the crossing.

Table 3-4: Hydraulic Analysis Results for Alternative Scenarios at C-3 Crossing

Scenario	Description	Road Elev. (m)	U/S Regional Water Surface Elevation (m)	U/S Water Level Increase (m)	Overtopping Depth (m)
1A	Raise roadway profile to Regional tailwater elevation, no increase in hydraulic capacity	191.15	191.43	0.08	0.28
1B	Raise roadway profile to Regional tailwater elevation and increase hydraulic capacity	191.15	191.30	0	0.15
2	Maintain current design profile, increase hydraulic capacity	190.73	191.28	0	0.55
3A	Raising roadway profile to eliminate overtopping, no increase in hydraulic capacity	191.45	191.44	0.09	0
3B	Raise roadway profile to eliminate overtopping and increase hydraulic capacity	191.35	191.30	0	0

4 Stormwater Management Strategy

4.1 Stormwater Management Criteria

The stormwater management plan for the Ninth Line Class EA Study shall be developed to comply with the MECP Stormwater Management Practices Planning and Design Manual, City of Mississauga Storm Drainage Design Criteria, and Conservation Halton Stormwater Management Guidelines.

4.1.1 Water Quality Control

Watercourses within CH's jurisdiction are classified as requiring an "Enhanced" level of protection, which equates to 80% Total Suspended Solids (TSS) removal.

Stormwater management (water quality) measures within the study limits will be designed to provide "Enhanced" water quality treatment, as a minimum, for the increased pavement area as a result of roadway widening/improvements, as per the MECP Response to Notice of Commencement Letter dated April 30, 2020.

During detailed design, a review of the current practice on road salt management and an evaluation of the potential impacts on surface water from the increased salt load of the pre-development versus post-development roadway salt impacts will be conducted.

4.1.2 Water Quantity Control

Storm Sewer Systems

Within the project limits, the stormwater runoff from Ninth Line discharges either into the existing storm sewer systems or outlets at the watercourse crossings. For locations where the runoff discharges into an existing system, the minor system design storm (10 year storm) peak flows must be controlled to the existing peak flows, for which the receiving system was designed. The receiving storm sewer systems within the project limits are City of Mississauga municipal systems, which would have been designed based on a 10 year design storm.

Watercourse Crossings

CH requires post-development peak flows to be controlled to pre-development levels for the full range of storm events. This criterion is applicable to NLT-1, which is regulated by CH.

Unitary Storage and Discharge Criteria

The Draft Ninth Line Lands Scoped Subwater Study Phase 3 report (Wood, 2020) provides unitary storage and discharge criteria to mitigate flooding impacts at key locations within, and downstream of, the Ninth Line Lands. Due to the limited area available for stormwater management facilities within the Ninth Line roadway right-of-way, the cumulative unitary storage volumes cannot be met. The proposed stormwater management strategy for quantity control of the roadway will be to control post-development flows to pre-development levels for the full range of design storm events. As the roadway corridor is located within the Ninth Line Lands, the additional storage required to meet the cumulative unitary storage volumes for the full range of storm events should be accommodated within the stormwater management facilities to be provided within the future Ninth Line Lands development.

Further investigation of the SWM approach shall be conducted during detailed design and/or under separate study to mitigate flood impacts.

4.1.3 Water Balance and Erosion Control

The CH criterion for water balance requires retention of the first 5 mm of runoff. The erosion control requirements are detention of the 4 hour 25 mm rainfall for 48 hours or to the maximum extent possible. This criterion is applicable to increased pavement area as a result of roadway widening/improvements. For this study, the erosion control criteria is considered to be met through extended detention and infiltration of runoff in the proposed LID bioretention cells addressing both the erosion control and water balance criteria. During detailed design, a water balance assessment will be conducted to demonstrate that wetland hydrological function (including hydroperiod) will not be impacted.

Unitary Storage Target

The Draft Ninth Line Lands Scoped Subwatershed Study Phase 3 report (Wood, 2020) provides unitary storage targets to mitigate erosion impacts at key locations within, and downstream of, the Ninth Line Lands. As the roadway corridor is located within the Ninth Line Lands, the required erosion control storage, based on the cumulative unitary storage volumes, will be provided for the increased paved area within the roadway corridor. The proposed stormwater management strategy for erosion control will involve extended detention in the proposed LID bioretention cells.

4.2 Hydrologic Modeling

A hydrologic analysis has been conducted using the Rational Method to calculate the surface runoff under the 2 to 100 year storm events for both the existing and proposed condition scenarios. The Modified Rational Method was then used to calculate the storage volumes required to control the post-development peak flows for the design storm events to the allowable release rates.

City of Mississauga Intensity Duration Frequency (IDF) curves were applied to calculate the peak flows under both existing and proposed conditions, using a minimum inlet time (T_c) of 15 minutes.

4.3 Pavement Area Analysis

A pavement area analysis was performed to determine the increase in impervious surface, which will result from the roadway widening from 2 to 4 lanes and the construction of new in-boulevard cycle tracks and sidewalks.

As a Low Impact Development measure, it is recommended that the boulevard and median areas outside of the active transportation facilities be covered with permeable material (e.g. grass, permeable pavement, etc.) to minimize the overall increase in impervious area along the Ninth Line corridor. Since these are not load bearing surfaces, the use of permeable material will not impact the functionality of the proposed design but will provide water quality and quantity control benefits through runoff reduction. Therefore, the proposed stormwater strategy was developed considering the boulevard and median areas as pervious. Additional details and specifications for the permeable material are to be included in the detailed design stage.

It was determined that the proposed roadway improvements will result in an additional 7.19 hectare increase in pavement area within the Ninth Line study corridor.

Table 4-1: Pavement Area Analysis

Study Corridor	Existing Pavement Area (ha)	Proposed Pavement Area (ha)	Increased Pavement Area (ha)	Percentage Increase
Ninth Line	9.17	16.36	7.19	78%

4.4 Stormwater Best Management Practice Options

Various Best Management Practices (BMPs) for stormwater management were reviewed and assessed for their applicability on this project. An LID screening was completed consistent with the Region of Peel and CVC's LID Implementation Process for Regional Road Right-of-Ways (2014), and the results are presented in **Appendix C**. Due to the nature of this facility (i.e. linear transportation corridor) and the limited space within the roadway right-of-way, a series of bioretention cells integrated with the proposed streetscaping and parallel to storm sewers are proposed for catchments discharging directly to a watercourse or drainage feature for quality treatment, erosion control, and water balance. To provide quantity control throughout the Ninth Line corridor, online storage pipes are proposed. For catchment discharging to a storm sewer system, Oil-Grit Separator (OGS) units are proposed to provide pre-treatment.

4.4.1 Bioretention Cells

Bioretention systems allow for stormwater filtration, infiltration and evapotranspiration from tree and vegetative plantings. For roadway applications, these can take the form of sub-surface modular units that are filled with lightly compacted soil within a trench situated beneath the roadway boulevard areas. The trench unit consists of a filter bed which is a mixture of sand, fines and organic material to support vegetation and promote evapotranspiration by allowing surface runoff to route through a distribution pipe via gravity within the trench. Soil filtration, bioremediation, infiltration, and evapotranspiration will occur as water filtrates through the soil from the perforated distribution pipe.

The facility will also be lined with geotextile fabric and clean granular fill (50 mm clear stone) below the filter bed for storage and infiltration of roadway runoff. In addition to removing TSS particles, the granular filter within the trench reduces water temperature impact and enhances water balance through infiltration. A perforated underdrain pipe can be incorporated in the granular layer for soils with low infiltration rate to collect and direct the excess runoff to an existing storm sewer system. The bioretention cell also contributes to controlling downstream erosion through extended detention and reducing flow velocities.

Discharging the runoff directly into the bioretention systems has the following advantages:

- Boulevard landscaping will receive a supply of rainwater during every rainfall event, thus sustaining their health;
- Stormwater runoff from the roadways could potentially see significant detention within the bioretention systems, which will result in runoff reduction;
- Water quality treatment will be achieved since stormwater can be routed through the bioretention filter media; and

- For smaller rainfall events, the bioretention system can provide (in the long-term) for complete capture of the runoff through infiltration and evapotranspiration.

The design criteria specified in the SWM Planning and Design Guide (MECP, 2003) and LID SWM Planning and Design Guide (STEP, 2020) were applied to determine the depth and footprint area for the bioretention cells. The maximum allowable depth of the stone reservoir below the underdrain pipe can be calculated using the following formula:

$$d_{r \max} = i * t_s / V_r$$

where i is the infiltration rate of the native soils, which was estimated to be 10.3 mm/hr within the project limits based on the Hydrogeological Investigation (**Section 2.3**); t_s is time to drain, which is recommended to be 48 hours; and V_r is void space ratio of the aggregate used, which is typically 0.4 for clear stone. Accordingly, the maximum allowable depth of the reservoir can be calculated to be $d_{\max} = 1236$ mm.

For this project, 2.0 m wide bioretention cells with a 0.5 m filter bed layer, 0.1 m pea gravel choking layer, 0.2 m underdrain pipe, and 0.3 m deep gravel storage layer below the underdrain pipe are proposed, for a total facility depth of 1.1 m. Conceptual plan and profiles of the proposed bioretention cells are provided in **Appendix D**. The footprint area of the bioretention cells can be calculated using the following formula:

$$A_f = WQV / (d_c * V_r)$$

where WQV is the required water quality volume to meet the 'Enhanced' level protection (80% TSS removal), which is determined based on the contributing drainage area and the imperviousness using Table 3.2 of the SWM Planning and Design Manual (MECP, 2003); d_c is the depth of the bioretention cell, and V_r is the void space ratio for the filter bed and gravel storage layer, which is typically 0.4. In addition to providing quality treatment, the provided gravel storage volume beneath the invert of the underdrain pipe will retain water to meet the water balance and erosion control targets. Additionally, the ratio of the impervious drainage area to footprint area of the bioretention cells should be between 5:1 and 20:1 to limit the rate of accumulation of fine sediments and thereby prevent clogging.

The bottom of the bioretention cells should be one (1) metre above the seasonally high water table. According to the Hydrogeological Investigation (**Section 2.3**), the groundwater table ranges from 2.2 to 4.1 m below the ground surface where groundwater was observed, and LID measures are generally proposed. This should provide adequate separation between the groundwater table and the bottom of the proposed facilities. Further investigation should be completed during the detailed design stage to confirm adequate separation from the proposed facilities at each location and determine the percolation rate of the native soils using in-situ infiltration testing to ensure the maximum allowable depth of the reservoir is not exceeded.

The bioretention cells are proposed for Drainage Areas A-2 to A-5, where runoff discharges directly into a natural watercourse or a drainage feature. In addition to providing 'Enhanced' level protection (80% TSS removal), the provided storage volume within the bioretention cells includes the volume required to retain the first 5 mm of rainfall to meet the CH water balance target. The CH erosion control target and the Ninth Line Lands Scoped Subwater Study unitary erosion control storage target will be achieved through extended detention within the bioretention cells. Pre-treatment of the runoff directed to the bioretention cells using catchbasin inserts (e.g. CB Shield) is recommended.

The bioretention cells are designed to provide water quality treatment for pavement areas equivalent to the total increase in pavement area along the Ninth Line corridor. For Drainage Areas A-2 and A-3, the bioretention cells are sized to provide treatment for the increased pavement area, as quality treatment is already provided by the existing stormwater management ponds west of Ninth Line. For Drainage Areas A-4 and A-5, the bioretention cells are sized to provide treatment for the entire paved area to meet the total increase in pavement area within the project limits.

Table 4-2 lists the details of the bioretention cells proposed along the Ninth Line corridor. For locations of the proposed bioretention cells, refer to the Drainage Plans provided in **Appendix A**. Detailed calculations are provided in **Appendix E**.

Table 4-2: Summary of Proposed Water Quality Treatment Strategy

Drainage Area ID	Proposed Pavement Area (ha)	Additional Pavement Area (ha)	Req'd Water Quality Volume (m ³)	Req'd Water Balance Storage ¹ (m ³)	Proposed Length (m)	Treated Area (m ²)	Provided Water Balance Volume ² (m ³)	Req'd Erosion Control Volume ³ (m ³)	Provided Quality and Erosion Control Volume (m ³)
A2	3.53	1.53	77	77	481	1.53	115	422	423
A3	1.15	0.48	24	24	156	0.48	37	133	137
A4	0.72	0.31	28	36	203	0.72	49	84	179
A5	5.07	2.23	180	253	1287	5.07	309	614	1133
Total	10.47	4.56	309	390	2127	7.81	510	1254	1872

¹ Based on the retention of the first 5 mm of rainfall

² Provided storage volume below underdrain

³ Based on Draft Ninth Line Lands Scoped Subwatershed Study unitary storage volumes (Wood, 2020)

Through the proposed water quality treatment strategy, a total of 7.81 ha of pavement area will receive water quality control through the use of the bioretention facilities, which exceeds the 7.19 ha increase in pavement area across the Ninth Line corridor. A total of 510 m³ and 1872 m³ of water balance and water quality/erosion control storage volumes are respectively proposed using the facilities, which exceeds the required storage volumes based on MECP and CH criteria as well as the unitary storage volumes determined in the relevant subwatershed study. During detailed design, the location and performance characteristics of the bioretention facilities will need to be confirmed to ensure that all bioretention cell design criteria can be met.

4.4.2 Oil-Grit Separator Units

Oil/grit separator (OGS) units combine a storage chamber for sediment trapping and oil separation with drainage inlets for intercepting or receiving roadway stormwater runoff. At locations where the roadway drainage area is less than 2.0 ha, oil-grit separator units can be used for water quality control. It should be noted that some agencies only accept a sediment removal efficiency of 50% for oil-grit separator (OGS) units. Consequently, additional mitigation measures shall be considered in series with each oil-grit separator to achieve the “Enhanced” protection (Level 1) water quality target.

For drainage areas that discharge to a storm sewer system, pre-treatment using catchbasin inserts (e.g. CB Shield) and OGS units is recommended, to achieve the required quality control in combination with the existing end-of-pipe facilities.

4.4.3 Online Storage Pipes

At existing storm system connections, consideration should be given to providing over-sized storage pipes with flow control devices (e.g. orifice plate) upstream of the discharge location to provide peak flow control in combination with allowable surface ponding for major flows.

For locations where the runoff discharges into an existing system, the minor system design storm (10 year storm) peak flows must be controlled to the existing peak flows. CH requires post-development peak flows to be controlled to pre-development levels for the full range of storm events. The required storage can be provided as a combination of underground storage and surface ponding. The required storage is considered as the largest of the storage required to control the peak flow from all storm events, up to the 100 year storm event, to the existing levels. As previously discussed, due to the limited area available within the Ninth Line roadway right-of-way, the cumulative unitary storage volumes from the Draft Ninth Line Lands Scoped Subwatershed Study (Wood, 2020) cannot be met. Accordingly, the additional storage required to meet the cumulative unitary storage volumes for the full range of storm events should be accommodated within the stormwater management facilities to be provided within the future Ninth Line Lands development.

The required storage volumes to achieve the quantity control targets for each catchment are summarized in **Table 4-3**. Online storage pipes shall be designed in combination with surface ponding to provide the required storage in the detailed design stage. Detailed calculations are provided in **Appendix E**.

Table 4-3: Summary of Proposed Water Quantity Treatment Strategy

Drainage Area ID	Drainage Area (ha)	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Required Storage to Control Minor Flows ¹ (m ³)	Required Storage to Control Major Flows ² (m ³)
A1	3.46	1.58	0.99	161	286
A2	4.61	2.00	1.53	249	442
A3	1.50	0.66	0.48	79	140
A4	0.87	0.41	0.31	50	88
A5	7.14	2.83	2.23	363	643
A6	1.61	0.56	0.62	100	177
A7	0.53	0.25	0.17	28	50
A8	2.53	0.87	0.84	137	243
Total	22.25	9.17	7.19	1167	2070

¹ Based on the capacity of the receiving storm sewer system (up to 10 year storm)

² CH requirements (up to 100 year storm)

Through the proposed water quantity control strategy, a total of 7.19 ha of pavement area will receive quantity control through the proposed online storage pipes. A total of 1167 m³ of storage volume will need to be provided to attenuate minor peak flows and a total of 2070 m³ will need to be provided to attenuate major peak flows to existing levels. During detailed design, the location, pipe sizing, and orifice sizing of the online storage pipes will need to be determined to ensure that the water quantity control criteria can be met.

4.4.4 Supplemental BMP Measures

Through discussions with MNRF and CH, opportunities to implement supplemental stormwater best management practice (BMP) measures to augment the treatment proposed by the bioretention cells and OGS units using a treatment train approach, including measures to mitigate water temperature impacts, are to be considered.

The supplemental BMP measures shall be designed based on the site conditions and further geotechnical and hydrogeological investigations are to be undertaken during the next phase of design. Any low impact development measures shall meet the design criteria as per the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (2010).

A list of potential LID measures to support the treatment train approach that may be considered for implementation within the study corridor during the detailed design is provided as follows:

Infiltration Trenches

Infiltration trenches are linear conveyance facilities lined with geotextile fabric and clean granular fill (50 mm clear stone) for quality treatment of roadway runoff. In addition to removing TSS particles, the granular filter within the trench reduces water temperature impact and enhances water balance through infiltration. It also contributes to controlling downstream erosion by reducing flow velocities.

Vegetated Filter Strips and Plunge Pool

Vegetated filter strips operate through a combination of sedimentation and infiltration. Shallow flows are routed over grassed areas, which allow the filter strips to function by slowing down the runoff velocity and filter out suspended sediment and associated pollutants and allowing infiltration into underlying soils. Filter strips are applicable where there are low, flat vegetated areas that will allow runoff to disperse over a wide area.

Plunge pools are designated depression areas at the base of storm outfalls to prevent scouring and erosion due to the high velocity of the flow at the outfall pipe locations. The plunge pool also functions as a level spreader that reduces the concentrated flow from the outfall and spreads the flow onto a natural vegetated floodplain area.

Vegetative filter strips and plunge pools should be considered at the storm outfall locations to disperse the energy of the flow and to provide additional water quality control in series with the bioretention cells as a treatment train system.

4.5 Erosion and Sediment Control during Construction

Erosion and sediment control measures should be implemented and monitored through the construction period. Construction activities should be conducted during periods that are least likely to result in in-stream impacts to fish habitat.

Detailed erosion and sediment control plans will be required as part of the detailed design component for all phases of the construction. The erosion and sediment control plans will be subject to review and approval by the various external agencies involved in the project, including the Conservation Authorities.

During construction, disturbances to watercourse riparian vegetation should be minimized. If riparian vegetation is removed or disturbed, erosion and sediment control measures such as silt fences, rock

flow check dams and sedimentation ponds should be utilized to provide a maximum protection of local and downstream aquatic resources. These measures should be maintained during construction and until disturbed areas have been stabilized with seed and mulch. Additionally, topsoil should not be stockpiled close to the watercourses and water should not be withdrawn from these sensitive streams for construction purposes.

The site engineer and contractor will be responsible for delineating work areas and ensuring that erosion and sediment control measures are functional. In addition, the engineer will ensure that provisions related to fisheries and watercourse protection is met and that any required fish habitat compensation measures are implemented in accordance with the terms and conditions of the Fisheries Act Authorization.

4.6 Stormwater Management Plan Summary

The proposed stormwater management plan for the project has been developed by examining the opportunities and constraints within the entire study corridor. Runoff from the paved roadway area will be conveyed to the proposed oil-grit separators and bioretention systems and roadway storm sewer systems and discharge into either existing storm sewer systems, natural watercourse, or drainage features. As per **Section 4.3**, the total roadway pavement area will increase by 7.19 ha, including the cycle tracks and sidewalks within the boulevard areas. Enhanced level water quality, water balance, and erosion control treatment will be provided for 7.81 ha of pavement area, exceeding the MECP requirement of providing treatment to the increased pavement area. The stormwater management plan for this project is presented on the Drainage Plans in **Appendix A**. **Table 4-4** provides a summary of the water quality treatment and quantity control strategies proposed to mitigate the increase in impervious surface within the project limits, where road widening is proposed.

Table 4-4: Summary of Stormwater Management Plan

Drainage Area ID	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Pavement Area Receiving Quality Treatment (ha)	Quality Storage Volume Provided ² (m ³)	Required Storage to Control Minor Flows ³ (m ³)	Required Storage to Control Major Flows ⁴ (m ³)
A-1	1.58	0.99	N/A	N/A	161	286
A-2	2.00	1.53	1.53	423	249	442
A-3	0.66	0.48	0.48	137	79	140
A-4 ¹	0.41	0.31	0.72	179	50	88
A-5 ¹	2.83	2.23	5.07	1133	363	643
A-6	0.56	0.62	N/A	N/A	100	177
A-7	0.25	0.17	N/A	N/A	28	50
A-8	0.87	0.84	N/A	N/A	137	243
Total	9.17	7.19	7.81	1872	1167	2070

¹ Total pavement area is treated in order to meet MECP requirements of treating the overall increased pavement area in the corridor

² Areas discharging to municipal systems will be treated using catchbasin inserts and OGS units

³ Based on the capacity of the receiving storm sewer system (up to 10 year storm)

⁴ Based on CH requirement (up to 100 year storm)

5 Conclusions

The Ninth Line corridor between Eglinton Avenue West and Derry Road West is proposed to be widened from 2 to 4 lanes, urbanized and with the addition of in-boulevard cycle tracks and sidewalks on both sides of the road. The proposed design will also include upgrades to the existing subsurface road drainage system, consisting of storm sewer systems with catchbasins along the curb lines to convey stormwater runoff to the various outfall locations along the corridor.

The study area is within the area regulated by CH and CVC and a portion of the corridor is within the regulatory floodplain. Under existing conditions, the Ninth Line roadway is overtopped at several locations, and a hydraulic assessment was conducted to determine the floodplain impacts as a result of the proposed works. Based on a hydraulic assessment to compare the existing and proposed conditions, the increase in flood levels as the result of the proposed work is negligible. The previous Draft Subwatershed Study indicated that reduction of the extent of the Regional floodplain and optimization of the development potential within the Ninth Line Lands could be conducted through a cut-fill balance along the development lands. Accordingly, it is recommended that efforts to reduce the extent of the regulatory floodplain or eliminate overtopping of Ninth Line are to be explored during detailed design in conjunction with the Ninth Line Lands development and/or Transitway study.

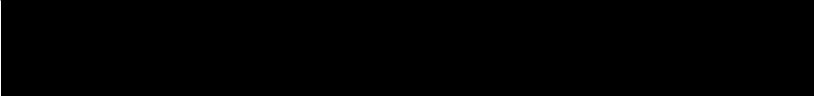
A total of one (1) regulated watercourse crossing and two (2) unregulated crossings are located within the project limits. As per the proposed roadway improvements and widening, no upgrades are proposed to the unregulated crossings (Drainage Features B and C), and extension is proposed for the watercourse crossing at NLT-1, which is located downstream of Osprey Marsh. Hydraulic analyses were completed for the existing and proposed conditions at the transverse crossings to investigate if the proposed structures will negatively impact the upstream flood levels and will meet the requirements of the City of Mississauga Storm Drainage Design Requirements.

Based on the results of the hydraulic modeling for the crossings at Drainage Features B and C, the 100 year and the Regional floods do not overtop the road, meeting the City of Mississauga's requirements. The proposed works will not generate an increase in upstream water surface levels, and accordingly no upgrades are proposed at the two crossings.

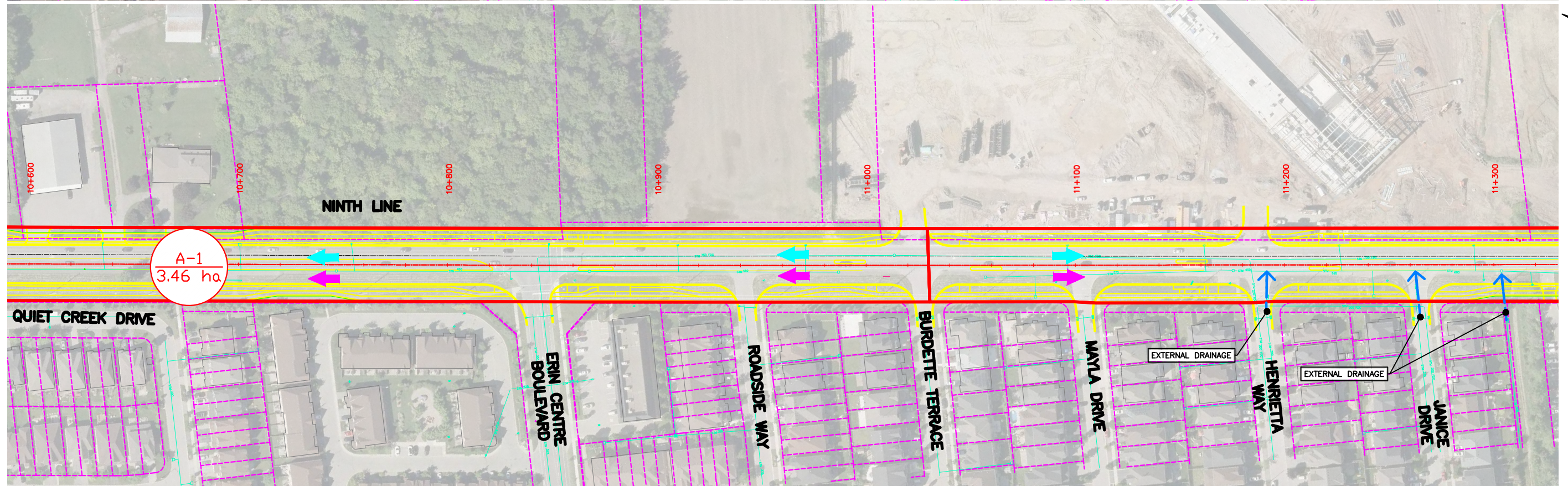
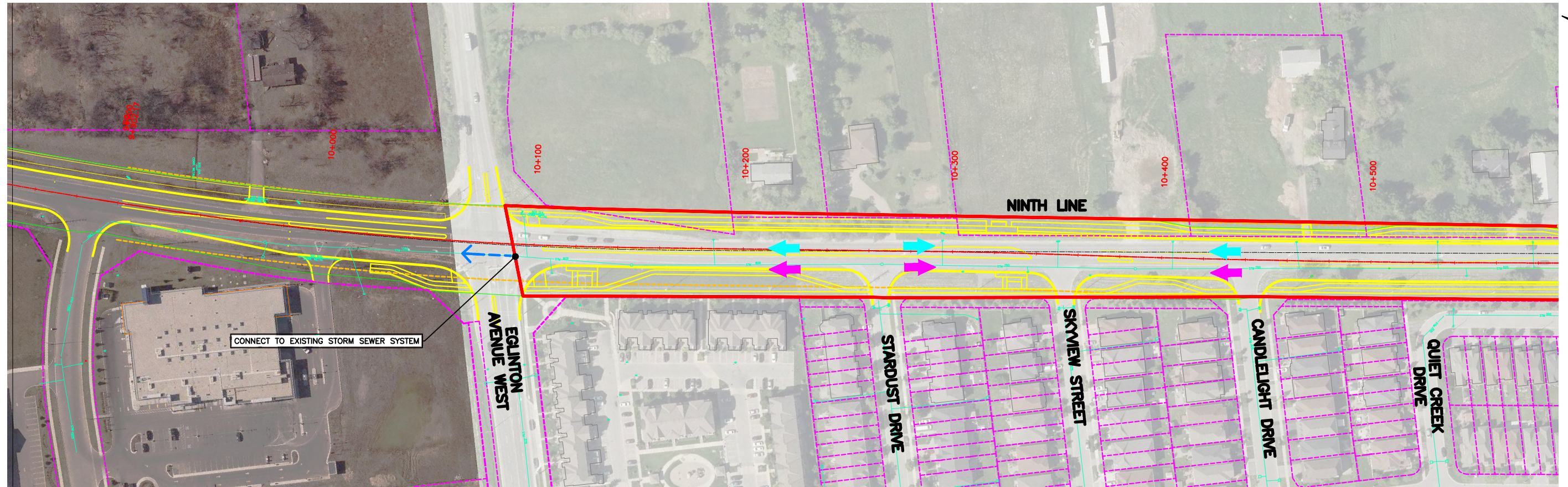
Under proposed conditions, the triple cell concrete box culvert over NLT-1 is proposed to be extended to accommodate the proposed roadway widening. Ninth Line is overtopped by the Regional storm event by approximately 0.68 m at this location under existing conditions, and 0.64 m under proposed conditions. Extending the length of the culvert to accommodate the proposed road widening will result in a 0.02 m increase in the Regional upstream flood level, which can be considered negligible. The preliminary hydraulic assessment indicated that the overtopping could be eliminated at this crossing by either raising the road profile, which would increase upstream flooding impacts, or by raising the road profile and increasing the hydraulic capacity, without increasing the upstream Regional water level. This approach would require major rehabilitation or full replacement of the structure, major grading adjustments along the roadway, and channel realignment to accommodate the increased flow area. A more detailed analysis using a HEC-RAS model based on available information at the time of detailed design will be required to confirm the results of the preliminary assessment and assess the impact along the upstream reach of the watercourse.

Stormwater best management practices, including catchbasin inserts, oil-grit separators, bioretention systems, and online storage pipes, are proposed to provide storm water quality treatment, water balance, erosion control, and quantity control of the increased runoff from the roadway right-of-way.

The proposed road improvements will result in an additional pavement area of 7.19 ha. As part of the SWM strategy, a total of 7.81 ha of pavement area will receive quality treatment through the proposed bioretention cells, which exceeds the MECF requirement of providing treatment to the increased pavement area. The bioretention cells will also provide 510 m³ of water balance storage and 1872 m³ of water quality and erosion control storage volume, which exceeds the required volumes determined by CH and the Draft Ninth Line Lands Scoped Subwatershed Study (Wood, 2020). A total of 7.19 ha of pavement area will receive quantity control through the proposed online storage pipes. Opportunities to implement supplemental BMP measures to provide additional water quality control, water temperature mitigation, and support a treatment train approach will be considered during the next phases of design in series with the proposed measures to enhance the overall water quality objectives. In addition, a review of road salt management and evaluation of potential impacts comparing proposed and existing conditions, a water balance assessment, and further investigation into the SWM approach as it relates to unitary storage and discharge criteria to mitigate flood impacts, will be considered during detailed design.



Appendix A: Drainage Area Plans



LEGEND

- PROPOSED R.O.W.
- EXISTING PROPERTY LINE
- EXISTING CL ALIGNMENT
- PROPOSED CL ALIGNMENT
- PROPOSED CATCHMENT BOUNDARY
- EXISTING STORM SEWER
- PROPOSED STORM SEWER

- ROADWAY DESIGN AND GRADING
- PROPOSED BIOTENTION CELL

- A DRAINAGE AREA ID
- xx ha AREA (ha)

- ➡ PROPOSED OVERLAND FLOW DIRECTION
- ➡ EXISTING OVERLAND FLOW DIRECTION

- REGIONAL FLOODPLAIN (AMECFW, 2015)

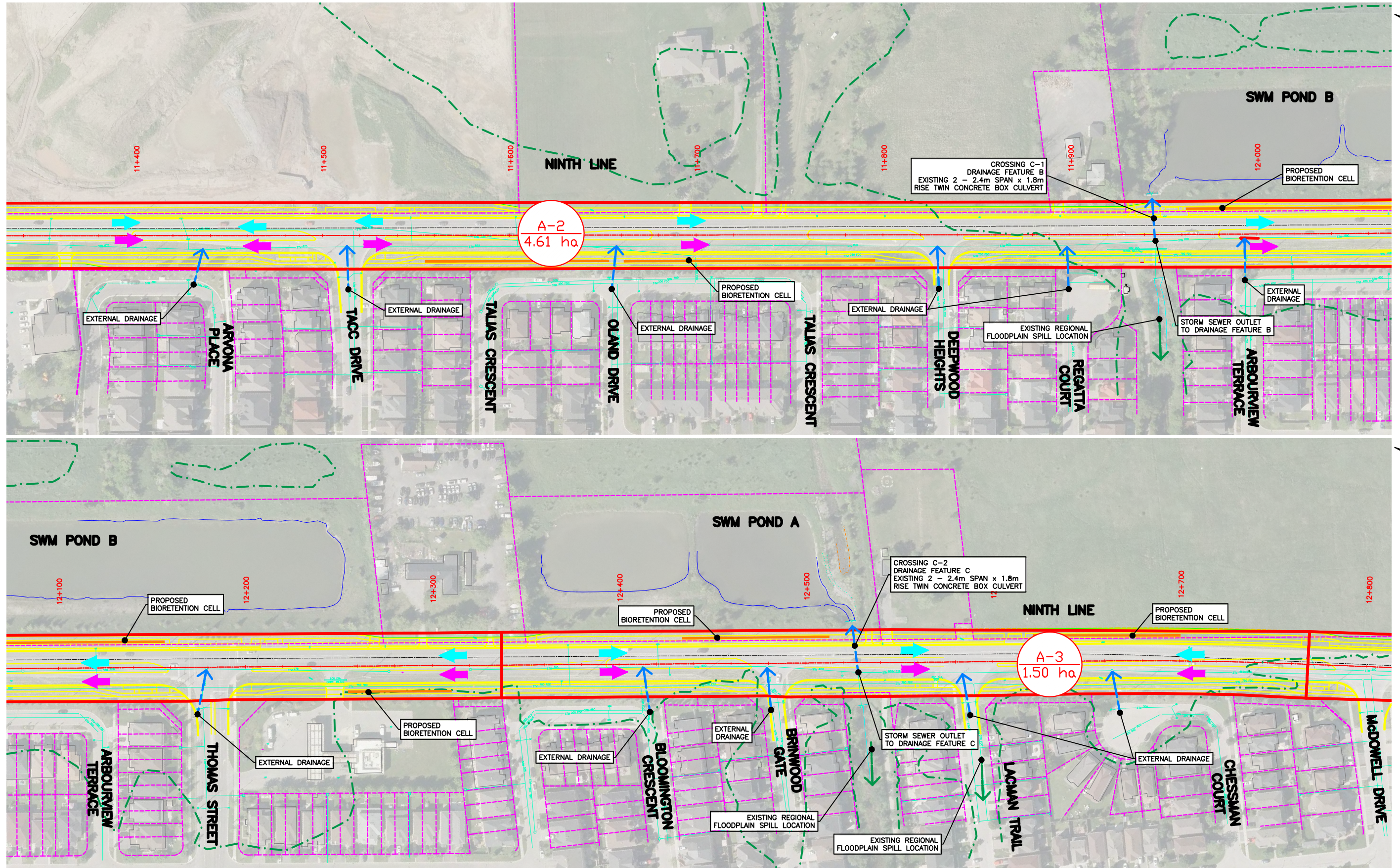


NINTH LINE
(EGLINTON ROAD WEST TO DERRY ROAD WEST)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 9+850 TO 11+330

SHEET NO.
DP-01

JUNE, 2021

SCALES
1:2000



LEGEND

- | | | | |
|--|--|---|---|
| <ul style="list-style-type: none"> --- PROPOSED R.O.W. --- EXISTING PROPERTY LINE --- EXISTING CL ALIGNMENT --- PROPOSED CL ALIGNMENT --- PROPOSED CATCHMENT BOUNDARY --- EXISTING STORM SEWER --- PROPOSED STORM SEWER | <ul style="list-style-type: none"> --- ROADWAY DESIGN AND GRADING --- PROPOSED BIORETENTION CELL | <ul style="list-style-type: none"> → PROPOSED OVERLAND FLOW DIRECTION → EXISTING OVERLAND FLOW DIRECTION | <ul style="list-style-type: none"> --- REGIONAL FLOODPLAIN (AMECFW, 2015) |
|--|--|---|---|

A DRAINAGE AREA ID
xx ha AREA (ha)

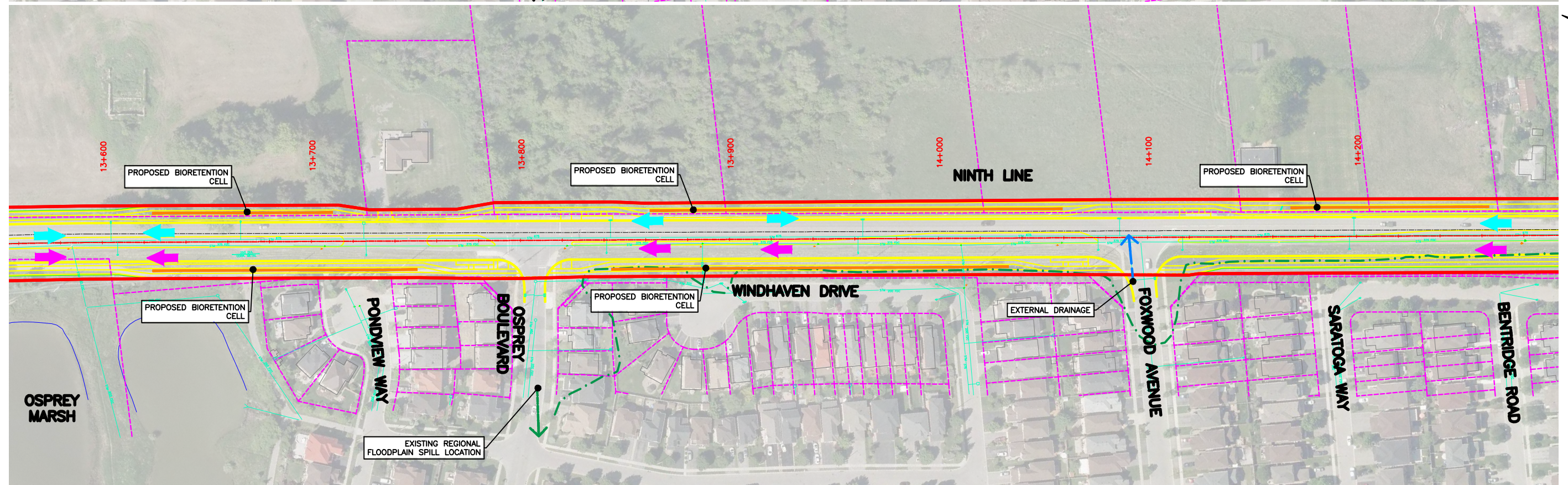
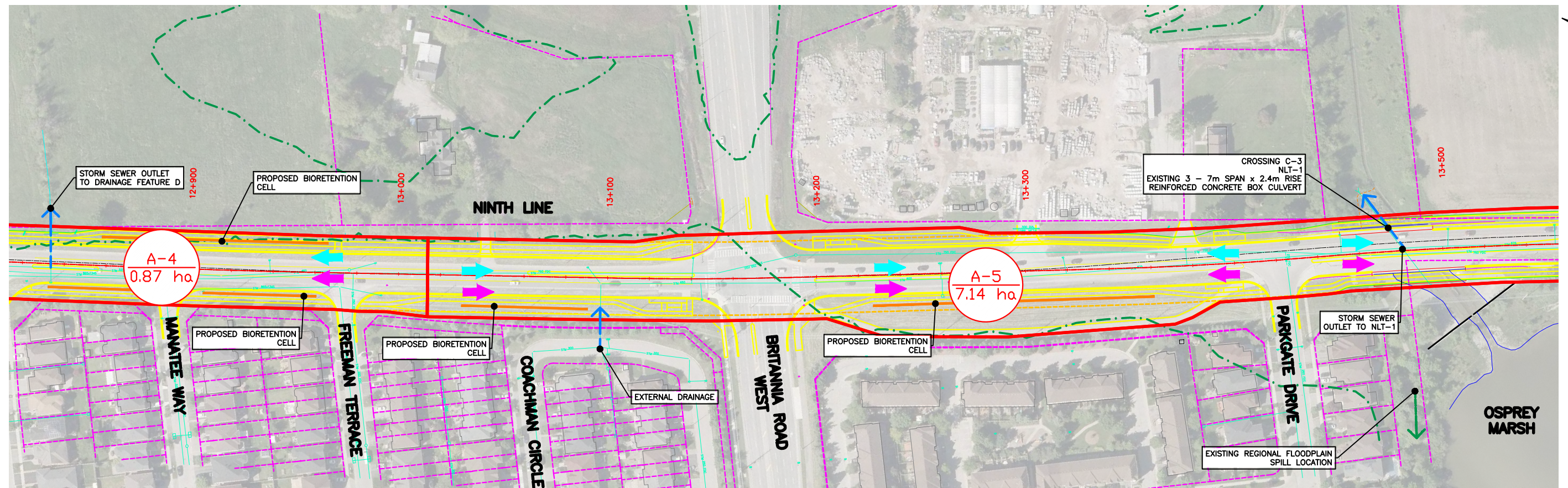


NINTH LINE
 (EGLINTON ROAD WEST TO DERRY ROAD WEST)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
 STA. 11+330 TO 12+810

SHEET NO.
 DP-02

JUNE, 2021

SCALES
 1:2000



LEGEND

- PROPOSED R.O.W.
- EXISTING PROPERTY LINE
- EXISTING CL ALIGNMENT
- PROPOSED CL ALIGNMENT
- PROPOSED CATCHMENT BOUNDARY
- EXISTING STORM SEWER
- PROPOSED STORM SEWER

- ROADWAY DESIGN AND GRADING
- PROPOSED BIORETENTION CELL

A
xx ha
DRAINAGE AREA ID
AREA (ha)

- PROPOSED OVERLAND FLOW DIRECTION
- EXISTING OVERLAND FLOW DIRECTION

- REGIONAL FLOODPLAIN (AMECFW, 2015)

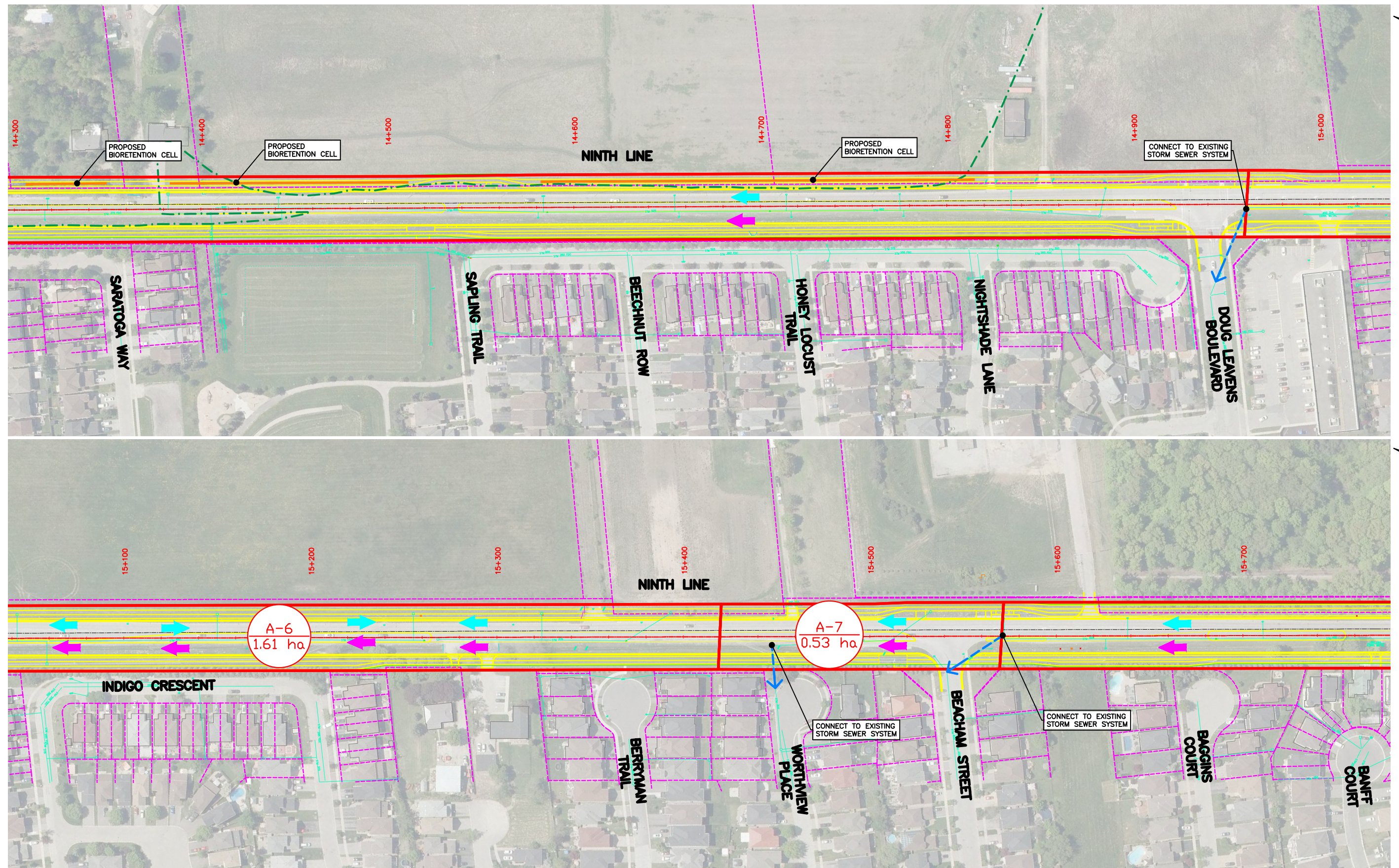


NINTH LINE
(EGLINTON ROAD WEST TO DERRY ROAD WEST)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 12+810 TO 14+300

SHEET NO.
DP-03

JUNE, 2021

SCALES
1:2000



SCALES
1:2000

LEGEND

- PROPOSED R.O.W.
- EXISTING PROPERTY LINE
- EXISTING CL ALIGNMENT
- PROPOSED CL ALIGNMENT
- PROPOSED CATCHMENT BOUNDARY
- EXISTING STORM SEWER
- PROPOSED STORM SEWER

- ROADWAY DESIGN AND GRADING
- PROPOSED BIORETENTION CELL

A
xx ha
DRAINAGE AREA ID
AREA (ha)

- PROPOSED OVERLAND FLOW DIRECTION
- EXISTING OVERLAND FLOW DIRECTION

- REGIONAL FLOODPLAIN (AMECFW, 2015)

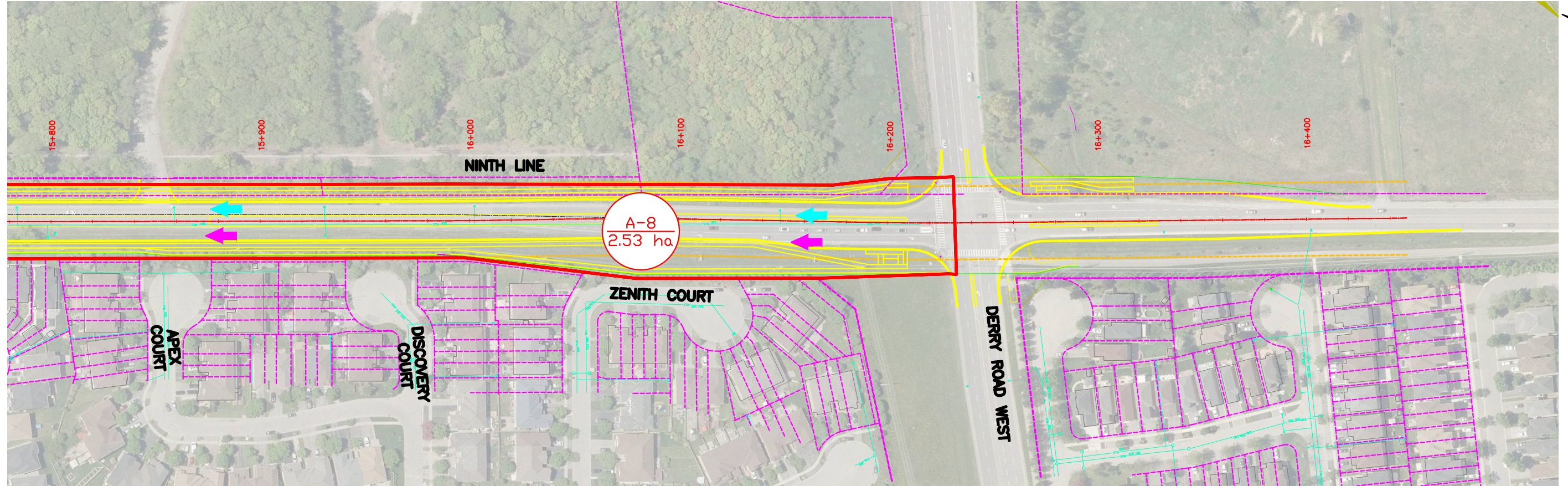


NINTH LINE
(EGLINTON ROAD WEST TO DERRY ROAD WEST)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 14+300 TO 15+780

SHEET NO.
DP-04

JUNE, 2021

FILENAME: C:\working\condo01\0122592\10215415-C001-004_SF44.dwg
PLOTDATE: Jun 11, 2021 - 5:11pm
PLOTTED BY: JLOOK



METRIC

SCALES
1:2000

LEGEND

PROPOSED R.O.W.
EXISTING PROPERTY LINE
EXISTING CL ALIGNMENT
PROPOSED CL ALIGNMENT
PROPOSED CATCHMENT BOUNDARY
EXISTING STORM SEWER
PROPOSED STORM SEWER

ROADWAY DESIGN AND GRADING
PROPOSED BIOTENTION CELL

DRAINAGE AREA ID
AREA (ha)

PROPOSED OVERLAND
FLOW DIRECTION
EXISTING OVERLAND
FLOW DIRECTION

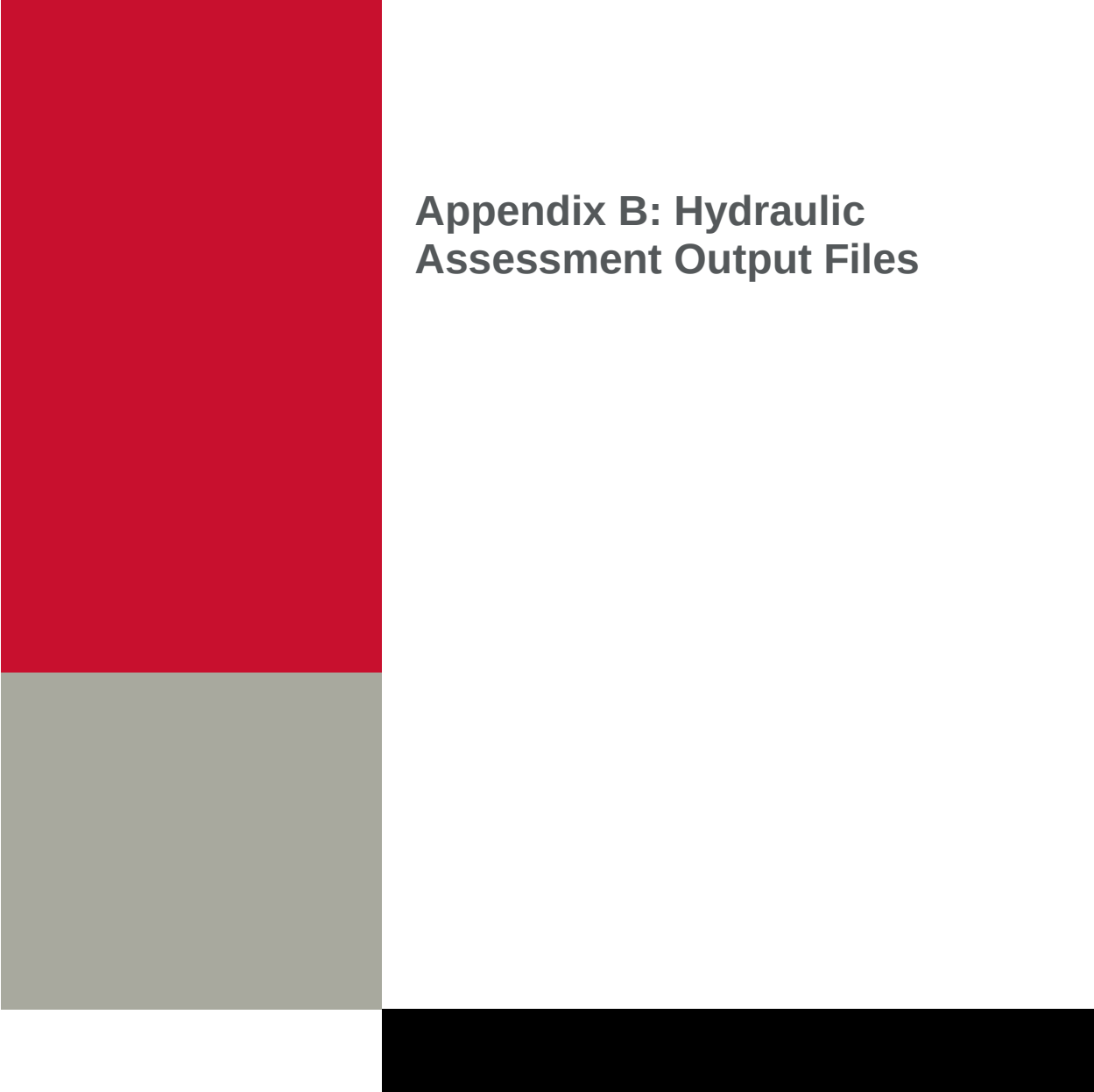
REGIONAL FLOODPLAIN (AMECFW, 2015)



NINTH LINE
(EGLINTON ROAD WEST TO DERRY ROAD WEST)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 15+780 TO 16+400

SHEET NO.
DP-05

JUNE, 2021



Appendix B: Hydraulic Assessment Output Files

HY-8 Culvert Analysis Report

Crossing Discharge Data
Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Existing C-1 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
188.66	Zero	0.00	0.00	0.00	1
189.38	100 Year	24.53	24.53	0.00	1
190.07	Overtopping	34.26	34.26	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-1 100 Year

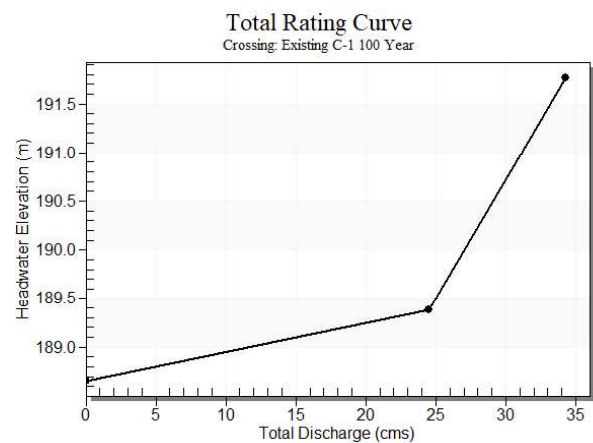
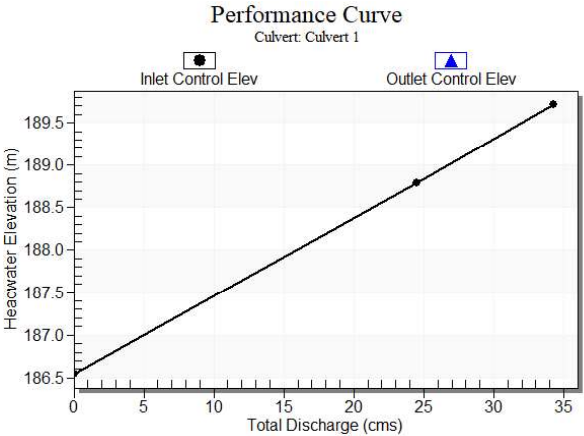


Table 2 - Culvert Summary Table: Culvert 1

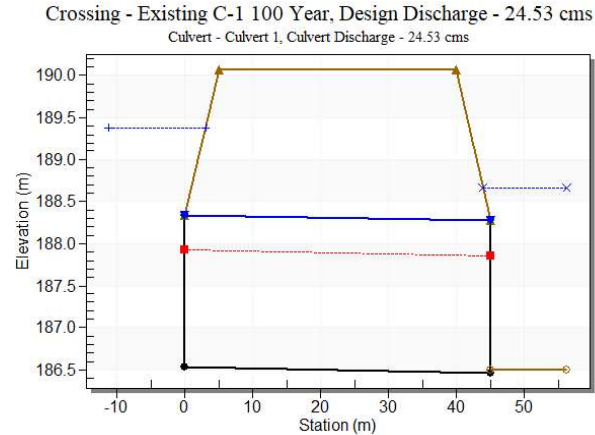
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	188.66	0.003	2.119	4-FF	0.001	0.002	1.800	2.160	0.000	0.000
100 Year	24.53	24.53	189.38	2.246	2.842	4-FF	1.800	1.386	1.800	2.160	2.839	0.000

Straight Culvert
Inlet Elevation (invert): 186.54 m, Outlet Elevation (invert): 186.47 m
Culvert Length: 45.00 m, Culvert Slope: 0.0016

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.54 m
Outlet Station: 45.00 m
Outlet Elevation: 186.47 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Existing C-1 100 Year)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	188.66	2.16
24.53	188.66	2.16

Tailwater Channel Data - Existing C-1 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 188.66 m

Roadway Data for Crossing: Existing C-1 100 Year

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.07 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 4 - Summary of Culvert Flows at Crossing: Existing C-1 Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
189.35	Zero	0.00	0.00	0.00	1
189.65	Regional	15.75	15.75	0.00	1
190.07	Overtopping	24.48	24.48	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-1 Regional

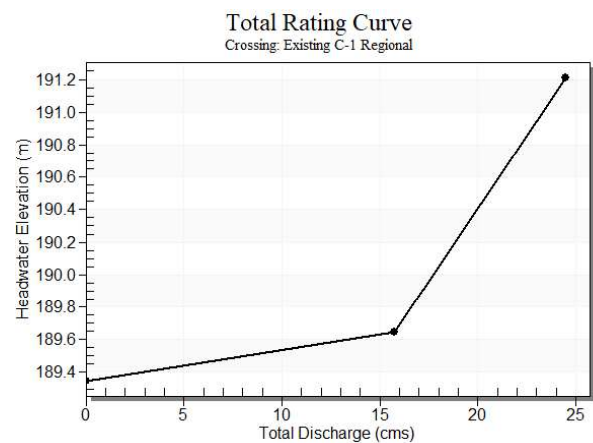
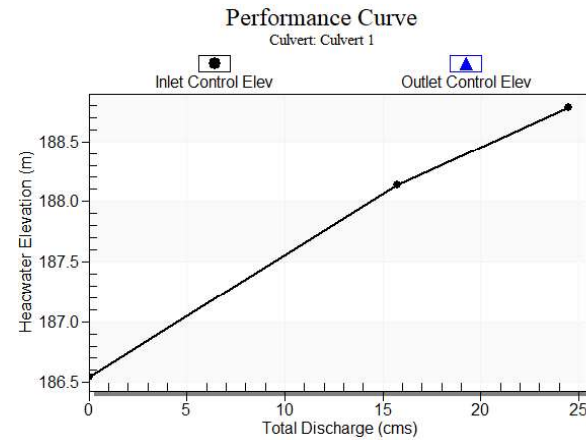


Table 5 - Culvert Summary Table: Culvert 1

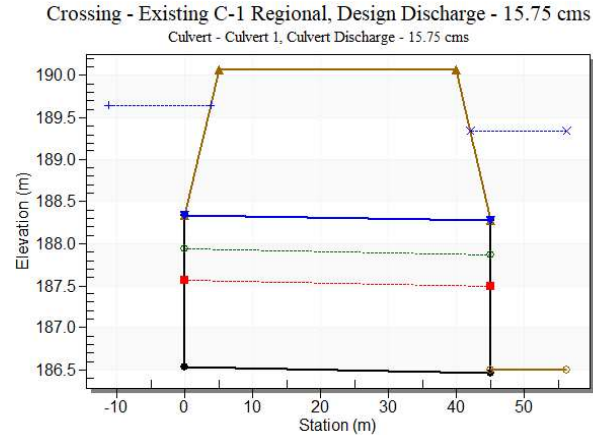
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.35	0.003	2.809	4-FF	0.001	0.002	1.800	2.850	0.000	0.000
Region	15.75	15.75	189.65	1.597	3.107	4-FF	1.397	1.031	1.800	2.850	1.823	0.000

Straight Culvert
Inlet Elevation (invert): 186.54 m, Outlet Elevation (invert): 186.47 m
Culvert Length: 45.00 m, Culvert Slope: 0.0016

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.54 m
Outlet Station: 45.00 m
Outlet Elevation: 186.47 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Existing C-1 Regional)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.35	2.85
15.75	188.35	2.85

Tailwater Channel Data - Existing C-1 Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.35 m

Roadway Data for Crossing: Existing C-1 Regional

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.07 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 7 - Summary of Culvert Flows at Crossing: Existing C-2 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
188.66	Zero	0.00	0.00	0.00	1
189.24	100 Year	21.94	21.94	0.00	1
190.20	Overtopping	35.80	35.80	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-2 100 Year

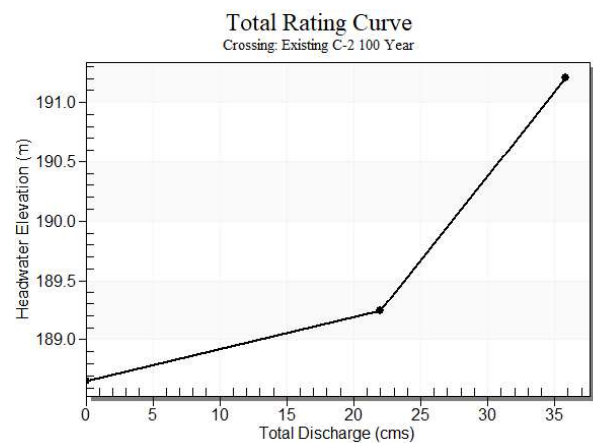
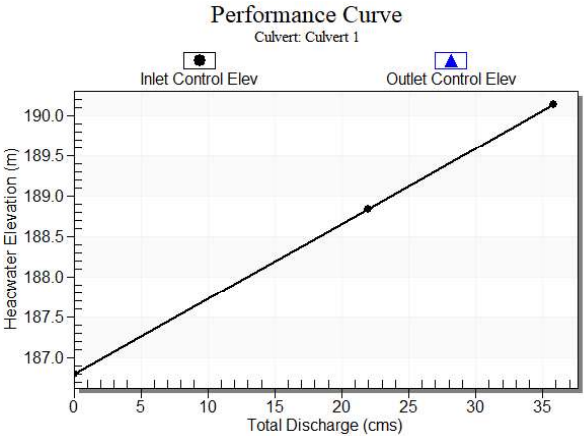


Table 8 - Culvert Summary Table: Culvert 1

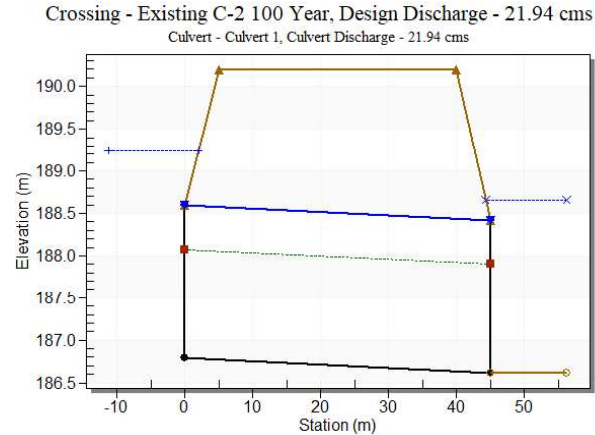
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	188.66	0.003	1.870	4-FF	0.000	0.002	1.800	2.039	0.000	0.000
100 Year	21.94	21.94	189.24	2.041	2.448	4-FF	1.285	1.286	1.800	2.039	2.539	0.000

Straight Culvert
Inlet Elevation (invert): 186.79 m, Outlet Elevation (invert): 186.62 m
Culvert Length: 45.00 m, Culvert Slope: 0.0038

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.79 m
Outlet Station: 45.00 m
Outlet Elevation: 186.62 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: Existing C-2 100 Year)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	188.66	2.04
21.94	188.66	2.04

Tailwater Channel Data - Existing C-2 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 188.66 m

Roadway Data for Crossing: Existing C-2 100 Year

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.20 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 10 - Summary of Culvert Flows at Crossing: Existing C-2 Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.35	Zero	0.00	0.00	0.00	1
189.68	Regional	16.66	16.66	0.00	1
190.20	Overtopping	26.60	26.60	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-2 Regional

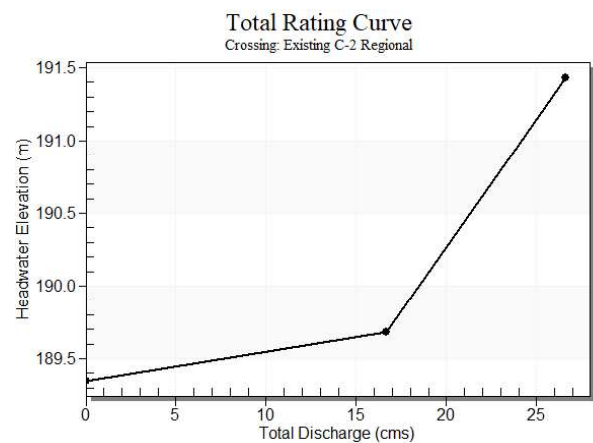
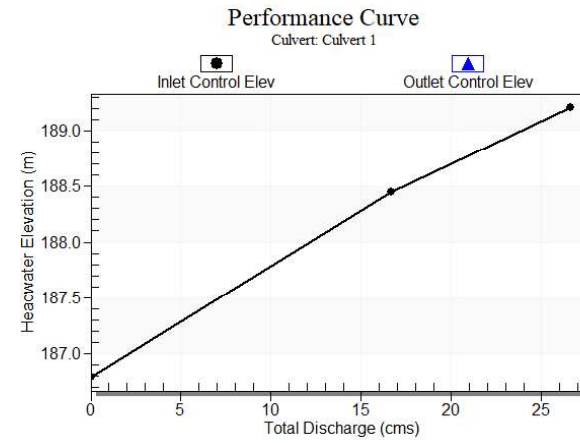


Table 11 - Culvert Summary Table: Culvert 1

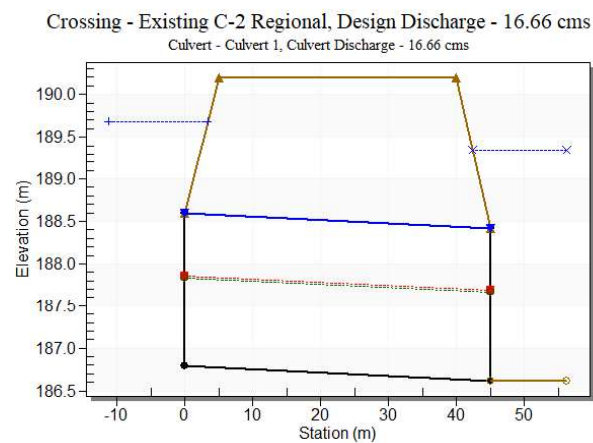
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.35	0.003	2.560	4-FF	0.000	0.002	1.800	2.729	0.000	0.000
Region	16.66	16.66	189.68	1.659	2.893	4-FF	1.046	1.071	1.800	2.729	1.928	0.000

Straight Culvert
Inlet Elevation (invert): 186.79 m, Outlet Elevation (invert): 186.62 m
Culvert Length: 45.00 m, Culvert Slope: 0.0038

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.79 m
Outlet Station: 45.00 m
Outlet Elevation: 186.62 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: Existing C-2 Regional)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.35	2.73
16.66	189.35	2.73

Tailwater Channel Data - Existing C-2 Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.35 m

Roadway Data for Crossing: Existing C-2 Regional

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.20 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 13 - Summary of Culvert Flows at Crossing: Existing C-3 50 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.52	Zero	0.00	0.00	0.00	1
189.56	50 Year	32.58	32.58	0.00	1
190.67	Overtopping	167.57	167.57	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-3 50 Year

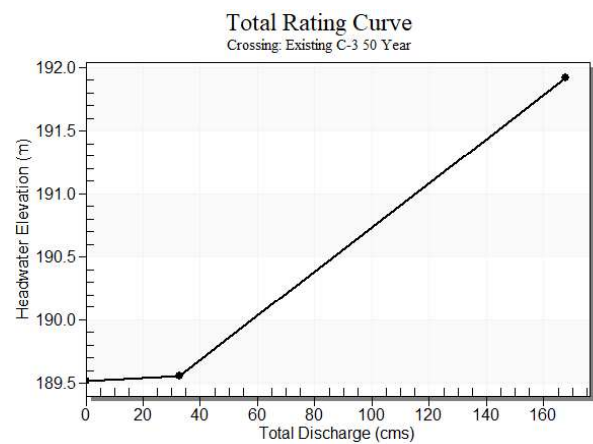
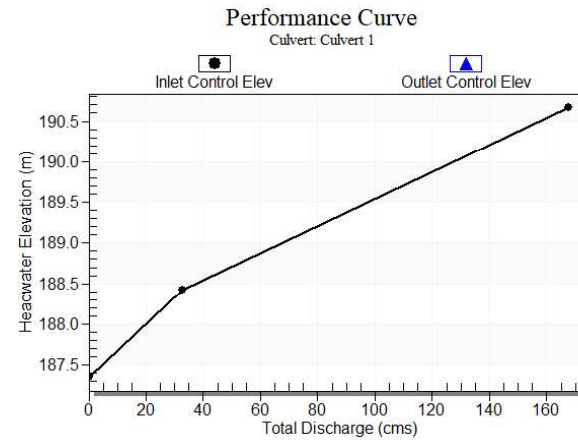


Table 14 - Culvert Summary Table: Culvert 1

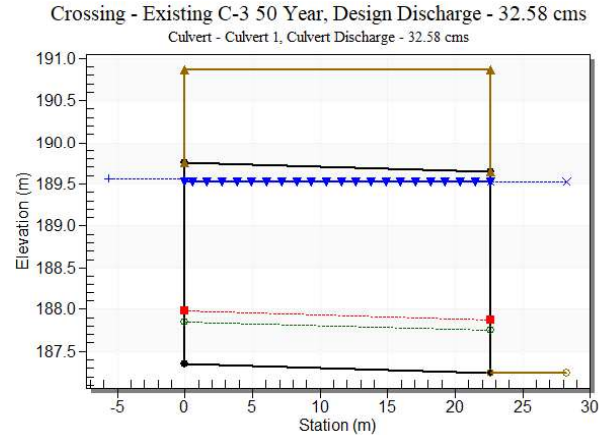
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.52	0.001	2.170	1-S1	0.000	0.001	2.270	2.270	0.000	0.000
50 Year	32.58	32.58	189.56	1.070	2.208	1-S1	0.502	0.626	2.270	2.270	0.683	0.000

Straight Culvert
Inlet Elevation (invert): 187.35 m, Outlet Elevation (invert): 187.25 m
Culvert Length: 22.60 m, Culvert Slope: 0.0044

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 187.35 m
Outlet Station: 22.60 m
Outlet Elevation: 187.25 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: Existing C-3 50 Year)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.52	2.27
32.58	189.52	2.27

Tailwater Channel Data - Existing C-3 50 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.52 m

Roadway Data for Crossing: Existing C-3 50 Year

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 22.60 m

Table 16 - Summary of Culvert Flows at Crossing: Existing C-3 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.67	Zero	0.00	0.00	0.00	1
189.72	100 Year	40.54	40.54	0.00	1
190.67	Overtopping	167.57	167.57	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-3 100 Year

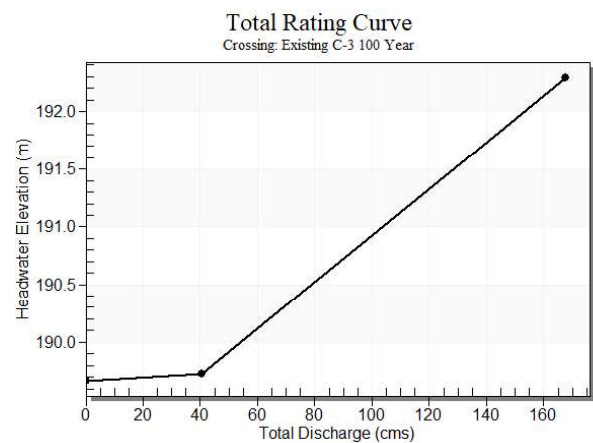
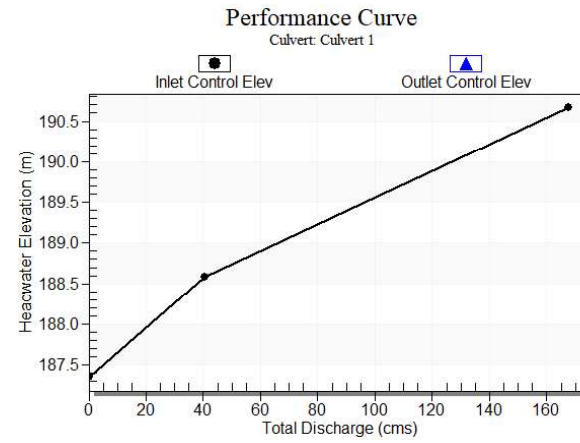


Table 17 - Culvert Summary Table: Culvert 1

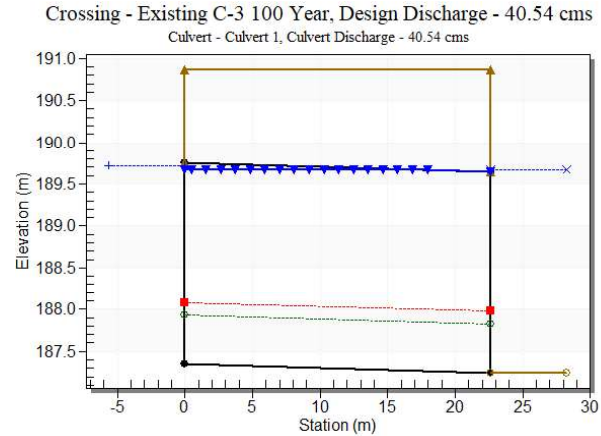
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.67	0.001	2.320	1-S1	0.000	0.001	2.400	2.420	0.000	0.000
100 Year	40.54	40.54	189.72	1.237	2.373	1-S1	0.577	0.724	2.400	2.420	0.804	0.000

Straight Culvert
Inlet Elevation (invert): 187.35 m, Outlet Elevation (invert): 187.25 m
Culvert Length: 22.60 m, Culvert Slope: 0.0044

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 187.35 m
Outlet Station: 22.60 m
Outlet Elevation: 187.25 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: Existing C-3 100 Year)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.67	2.42
40.54	189.67	2.42

Tailwater Channel Data - Existing C-3 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.67 m

Roadway Data for Crossing: Existing C-3 100 Year

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 22.60 m

Table 19 - Summary of Culvert Flows at Crossing: Existing C-3 Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.14	Zero	0.00	0.03	0.00	2
191.35	Regional	97.42	82.12	15.41	8
190.67	Overtopping	-1177468105936 50.00	-1177468105936 50.00	0.00	Overtopping

Rating Curve Plot for Crossing: Existing C-3 Regional

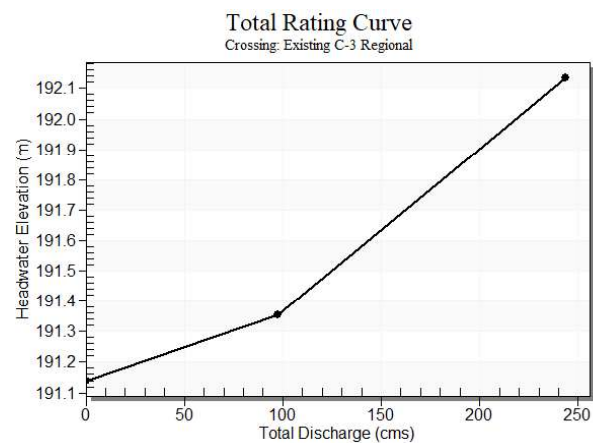
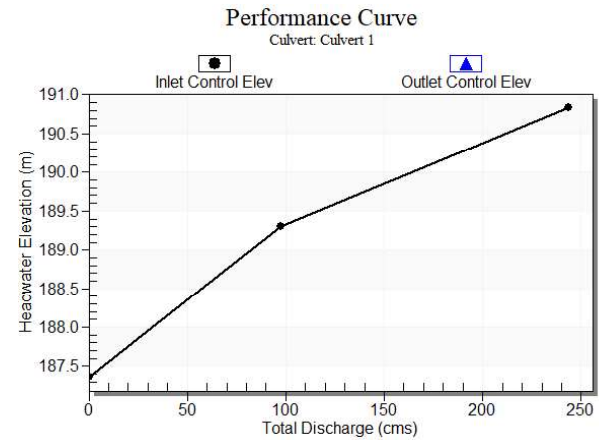


Table 20 - Culvert Summary Table: Culvert 1

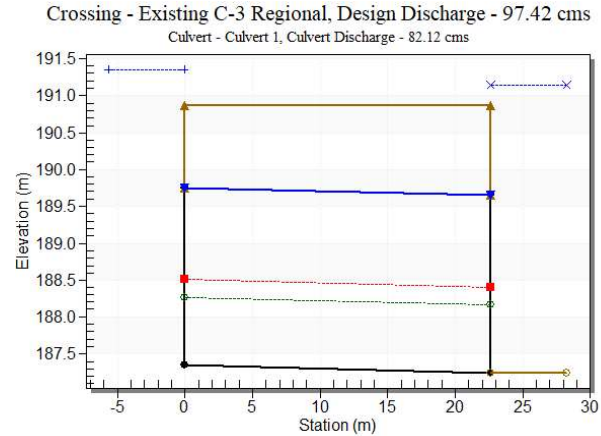
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.03	191.14	0.010	3.790	4-FF	0.002	0.006	2.400	3.890	0.001	0.000
Region	97.42	82.12	191.35	1.957	4.005	4-FF	0.910	1.159	2.400	3.890	1.629	0.000

Straight Culvert
Inlet Elevation (invert): 187.35 m, Outlet Elevation (invert): 187.25 m
Culvert Length: 22.60 m, Culvert Slope: 0.0044

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 187.35 m
Outlet Station: 22.60 m
Outlet Elevation: 187.25 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: Existing C-3 Regional)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.14	3.89
97.42	191.14	3.89

Tailwater Channel Data - Existing C-3 Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.14 m

Roadway Data for Crossing: Existing C-3 Regional

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 22.60 m

Table 22 - Summary of Culvert Flows at Crossing: Proposed C-1 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
188.66	Zero	0.00	0.00	0.00	1
189.38	100 Year	24.53	24.53	0.00	1
190.07	Overtopping	34.26	34.26	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-1 100 Year

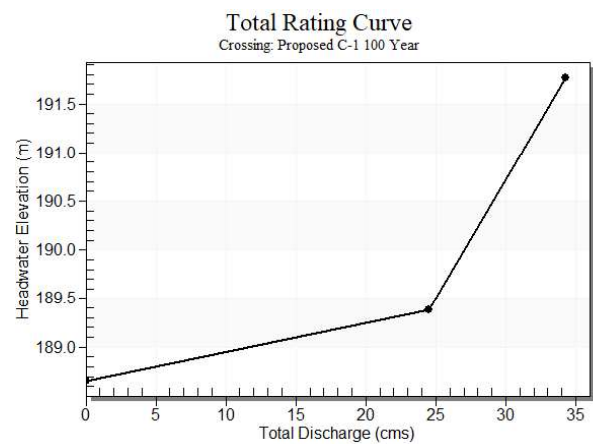
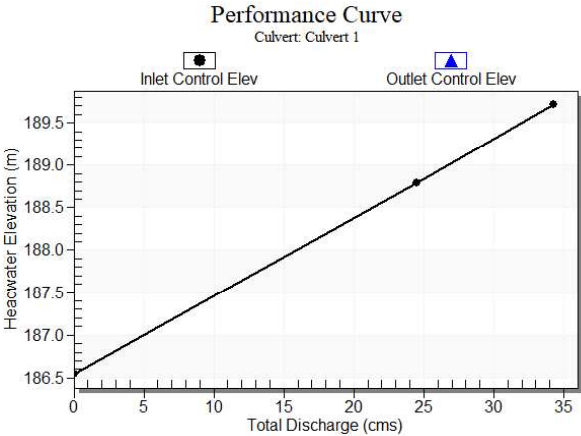


Table 23 - Culvert Summary Table: Culvert 1

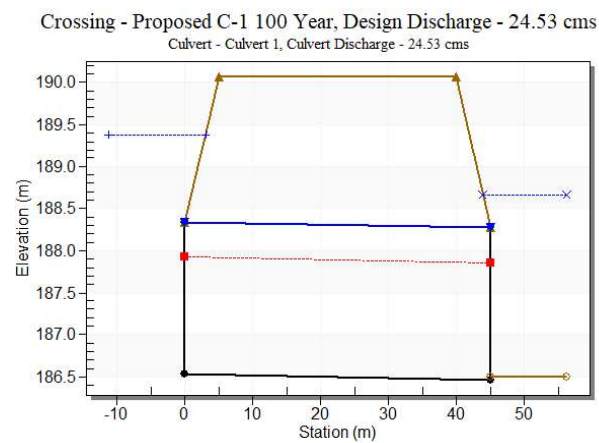
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	188.66	0.003	2.119	4-FF	0.001	0.002	1.800	2.160	0.000	0.000
100 Year	24.53	24.53	189.38	2.246	2.842	4-FF	1.800	1.386	1.800	2.160	2.839	0.000

Straight Culvert
Inlet Elevation (invert): 186.54 m, Outlet Elevation (invert): 186.47 m
Culvert Length: 45.00 m, Culvert Slope: 0.0016

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.54 m
Outlet Station: 45.00 m
Outlet Elevation: 186.47 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: Proposed C-1 100 Ye

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	188.66	2.16
24.53	188.66	2.16

Tailwater Channel Data - Proposed C-1 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 188.66 m

Roadway Data for Crossing: Proposed C-1 100 Year

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.07 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 25 - Summary of Culvert Flows at Crossing: Proposed C-1 Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.35	Zero	0.00	0.00	0.00	1
189.65	Regional	15.75	15.75	0.00	1
190.07	Overtopping	24.48	24.48	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-1 Regional

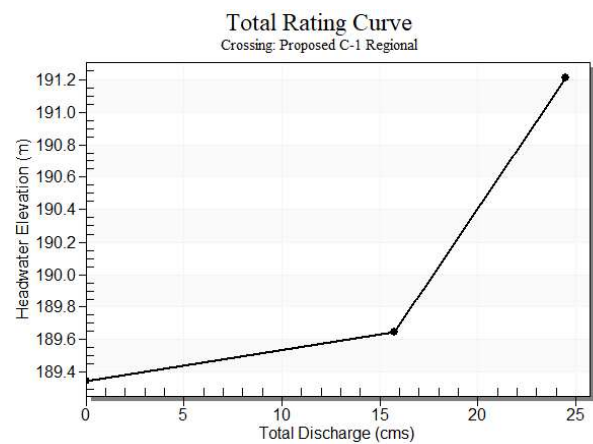
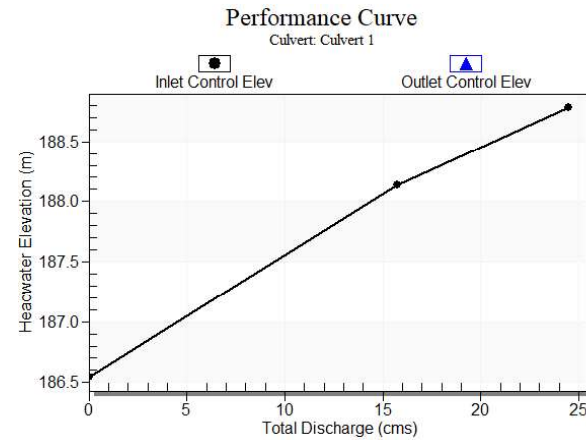


Table 26 - Culvert Summary Table: Culvert 1

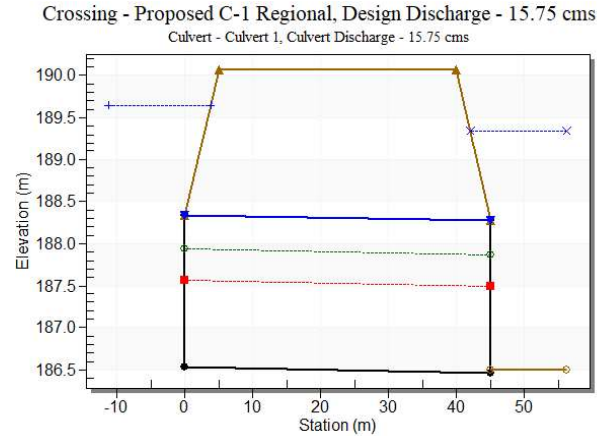
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.35	0.003	2.809	4-FF	0.001	0.002	1.800	2.850	0.000	0.000
Region	15.75	15.75	189.65	1.597	3.107	4-FF	1.397	1.031	1.800	2.850	1.823	0.000

Straight Culvert
Inlet Elevation (invert): 186.54 m, Outlet Elevation (invert): 186.47 m
Culvert Length: 45.00 m, Culvert Slope: 0.0016

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.54 m
Outlet Station: 45.00 m
Outlet Elevation: 186.47 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: Proposed C-1 Region

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.35	2.85
15.75	189.35	2.85

Tailwater Channel Data - Proposed C-1 Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.35 m

Roadway Data for Crossing: Proposed C-1 Regional

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.07 m
Roadway Surface: Paved
Roadway Top Width: 35.00 m

Table 28 - Summary of Culvert Flows at Crossing: Proposed C-2 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
188.66	Zero	0.00	0.00	0.00	1
189.24	100 Year	21.94	21.94	0.00	1
190.20	Overtopping	35.80	35.80	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-2 100 Year

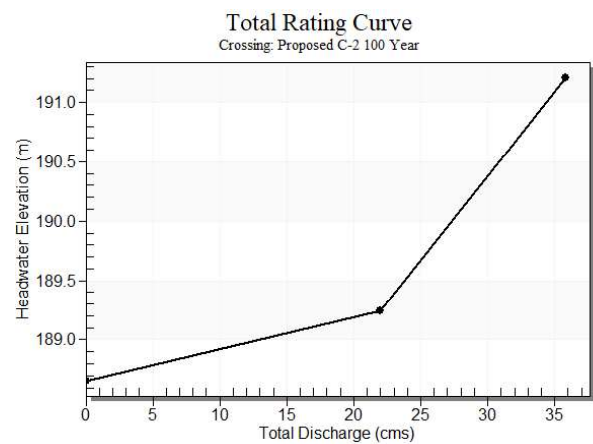
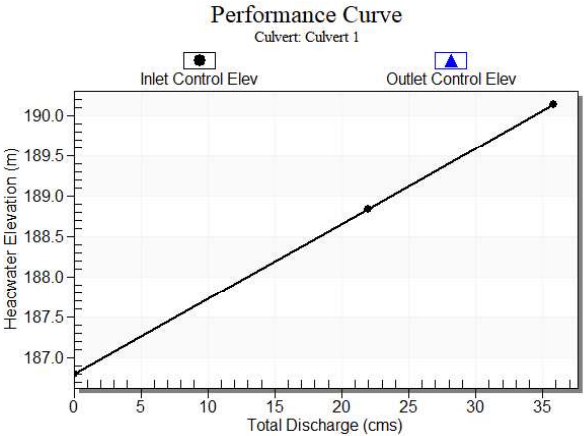


Table 29 - Culvert Summary Table: Culvert 1

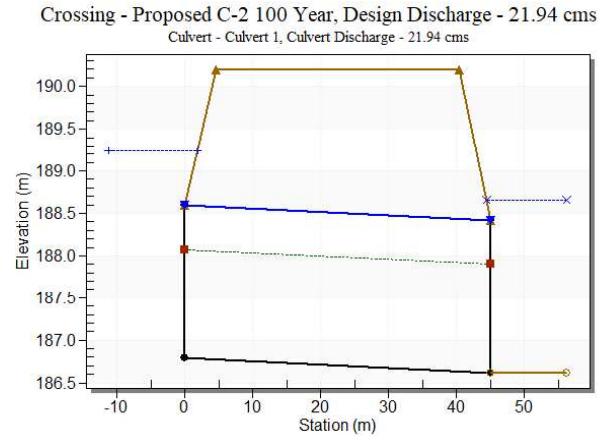
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	188.66	0.003	1.870	4-FF	0.000	0.002	1.800	2.039	0.000	0.000
100 Year	21.94	21.94	189.24	2.041	2.448	4-FF	1.285	1.286	1.800	2.039	2.539	0.000

Straight Culvert
Inlet Elevation (invert): 186.79 m, Outlet Elevation (invert): 186.62 m
Culvert Length: 45.00 m, Culvert Slope: 0.0038

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.79 m
Outlet Station: 45.00 m
Outlet Elevation: 186.62 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: Proposed C-2 100 Ye

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	188.66	2.04
21.94	188.66	2.04

Tailwater Channel Data - Proposed C-2 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 188.66 m

Roadway Data for Crossing: Proposed C-2 100 Year

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.20 m
Roadway Surface: Paved
Roadway Top Width: 36.00 m

Table 31 - Summary of Culvert Flows at Crossing: Proposed C-2 A Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
189.35	Zero	0.00	0.00	0.00	1
189.68	Regional	16.66	16.66	0.00	1
190.20	Overtopping	26.60	26.60	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-2 A Regional

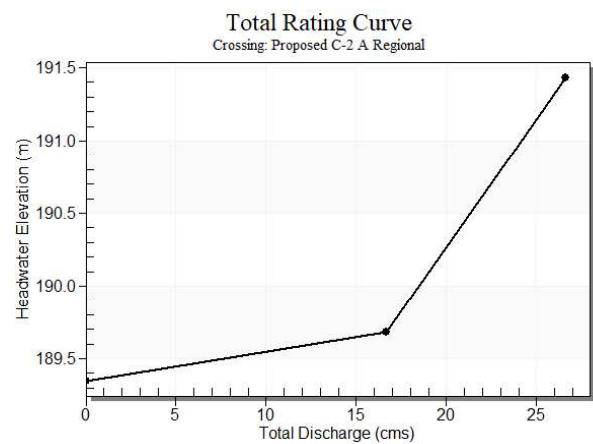
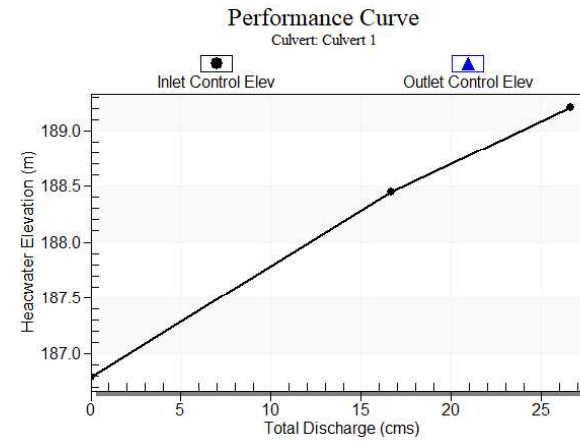


Table 32 - Culvert Summary Table: Culvert 1

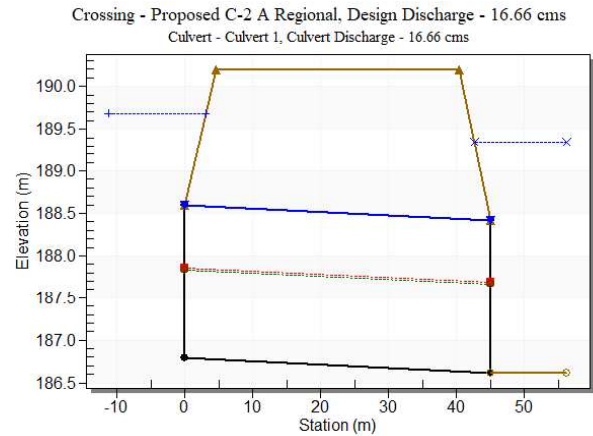
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.35	0.003	2.560	4-FF	0.000	0.002	1.800	2.729	0.000	0.000
Region	16.66	16.66	189.68	1.659	2.893	4-FF	1.046	1.071	1.800	2.729	1.928	0.000

Straight Culvert
Inlet Elevation (invert): 186.79 m, Outlet Elevation (invert): 186.62 m
Culvert Length: 45.00 m, Culvert Slope: 0.0038

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 m
Inlet Elevation: 186.79 m
Outlet Station: 45.00 m
Outlet Elevation: 186.62 m
Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 2400.00 mm
Barrel Rise: 1800.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (30-75° flare) Wingwall
Inlet Depression: None

Table 33 - Downstream Channel Rating Curve (Crossing: Proposed C-2 A Regional)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.35	2.73
16.66	189.35	2.73

Tailwater Channel Data - Proposed C-2 A Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.35 m

Roadway Data for Crossing: Proposed C-2 A Regional

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 20.00 m
Crest Elevation: 190.20 m
Roadway Surface: Paved
Roadway Top Width: 36.00 m

Table 34 - Summary of Culvert Flows at Crossing: Proposed C-3 50 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.52	Zero	0.00	0.00	0.00	1
189.56	50 Year	32.58	32.58	0.00	1
190.73	Overtopping	169.78	169.78	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-3 50 Year

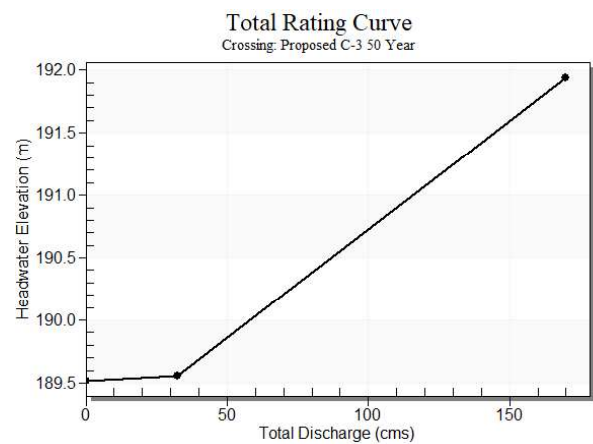
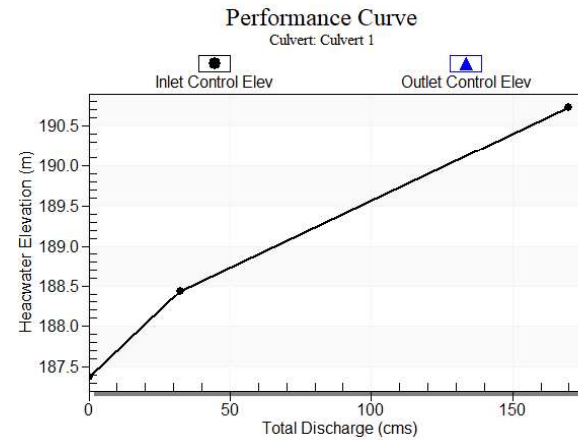


Table 35 - Culvert Summary Table: Culvert 1

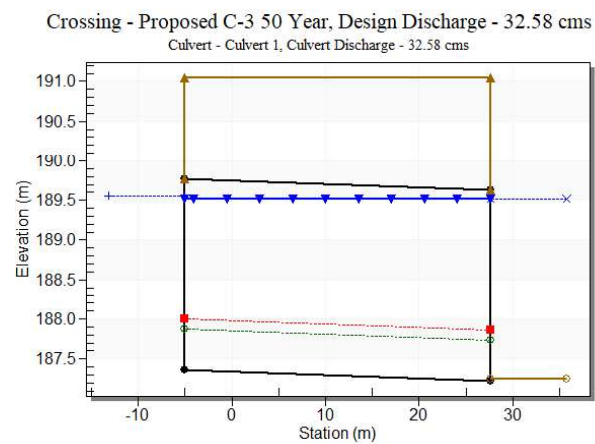
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.52	0.001	2.150	1-S1	0.000	0.001	2.290	2.270	0.000	0.000
50 Yea	32.58	32.58	189.56	1.070	2.188	1-S1	0.507	0.626	2.290	2.270	0.678	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 36 - Downstream Channel Rating Curve (Crossing: Proposed C-3 50 Yea

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.52	2.27
32.58	189.52	2.27

Tailwater Channel Data - Proposed C-3 50 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.52 m

Roadway Data for Crossing: Proposed C-3 50 Year

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Table 37 - Summary of Culvert Flows at Crossing: Proposed C-3 100 Year

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
189.67	Zero	0.00	0.00	0.00	1
189.72	100 Year	40.54	40.54	0.00	1
190.73	Overtopping	169.77	169.77	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-3 100 Year

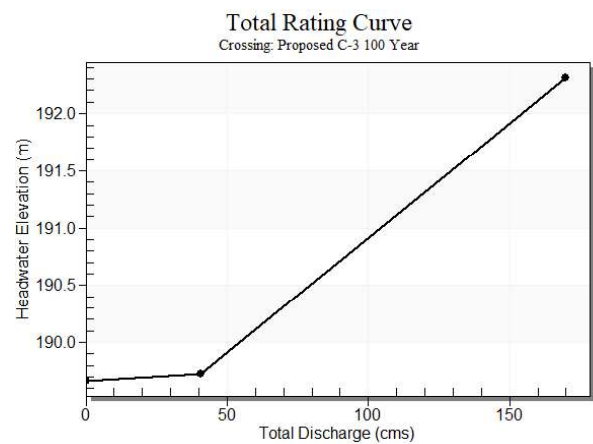
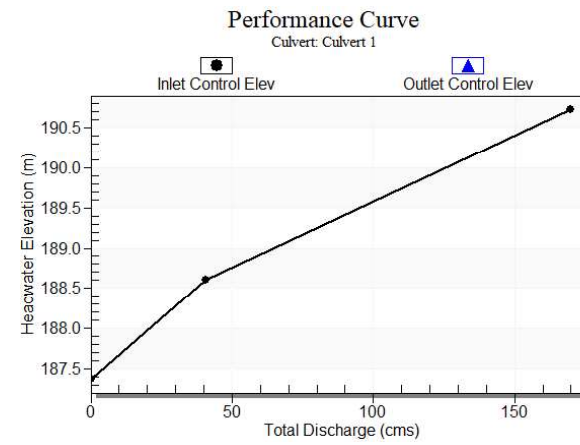


Table 38 - Culvert Summary Table: Culvert 1

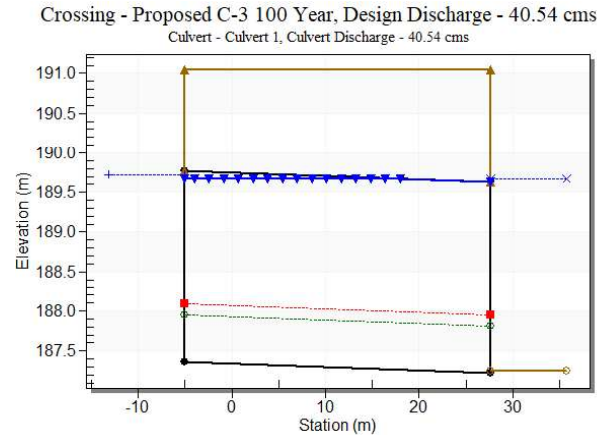
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	189.67	0.001	2.300	1-S1	0.000	0.001	2.400	2.420	0.000	0.000
100 Year	40.54	40.54	189.72	1.237	2.354	1-S1	0.582	0.724	2.400	2.420	0.804	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 39 - Downstream Channel Rating Curve (Crossing: Proposed C-3 100 Ye

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	189.67	2.42
40.54	189.67	2.42

Tailwater Channel Data - Proposed C-3 100 Year

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 189.67 m

Roadway Data for Crossing: Proposed C-3 100 Year

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Table 40 - Summary of Culvert Flows at Crossing: Proposed C-3 Regional

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.13	Zero	0.00	0.04	0.00	2
191.37	Regional	97.42	85.79	11.68	8
190.73	Overtopping	-229583337365	-229583337365	0.00	Overtopping

Rating Curve Plot for Crossing: Proposed C-3 Regional

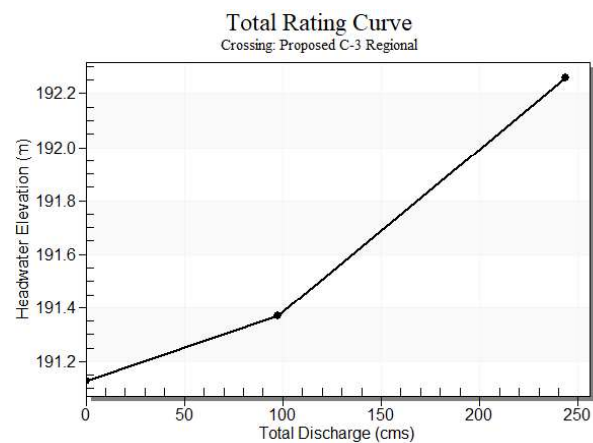
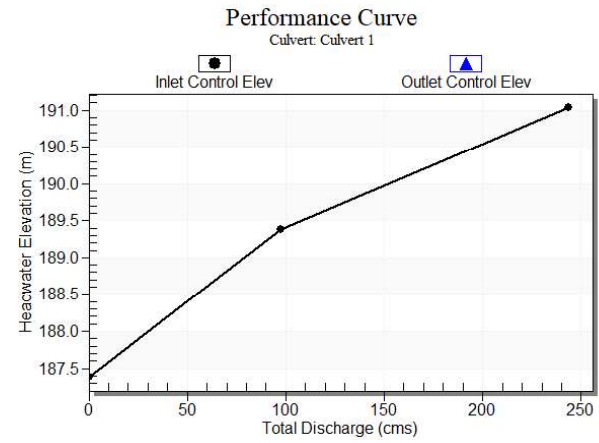


Table 41 - Culvert Summary Table: Culvert 1

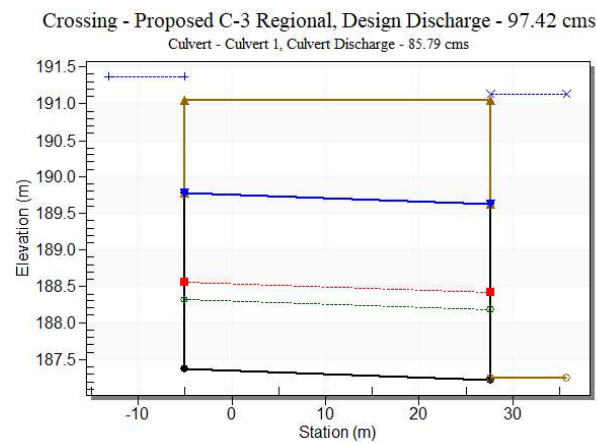
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.04	191.13	0.012	3.760	4-FF	0.002	0.007	2.400	3.880	0.001	0.000
Region	97.42	85.79	191.37	2.014	4.000	4-FF	0.946	1.194	2.400	3.880	1.702	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 42 - Downstream Channel Rating Curve (Crossing: Proposed C-3 Region

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Proposed C-3 Regional

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Proposed C-3 Regional

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

East Lisgar Branch HEC-RAS Hydraulic Analysis

HEC-RAS River: RIVER-2 Reach: Reach-1

Reach	River Sta	Profile	Plan	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Reach-1	247	(Ex) - 2Y	Ex-Oct 2015	2.15	195.95	196.84	196.09	196.84	0.000086	0.19	11.24	14.93	0.06
Reach-1	247	(Ex) - 2Y	HDR Pr Mar 2021	2.15	195.95	196.84	196.09	196.84	0.000086	0.19	11.24	14.93	0.06
Reach-1	247	(Ex) - 5Y	Ex-Oct 2015	4.51	195.95	197.10	196.19	197.11	0.000163	0.31	14.49	15.60	0.09
Reach-1	247	(Ex) - 5Y	HDR Pr Mar 2021	4.51	195.95	197.10	196.19	197.11	0.000163	0.31	14.49	15.60	0.09
Reach-1	247	(Ex) - 10Y	Ex-Oct 2015	7.62	195.95	197.33	196.29	197.34	0.000252	0.44	17.41	16.20	0.12
Reach-1	247	(Ex) - 10Y	HDR Pr Mar 2021	7.62	195.95	197.33	196.29	197.34	0.000252	0.44	17.41	16.20	0.12
Reach-1	247	(Ex) - 25Y	Ex-Oct 2015	10.06	195.95	197.48	196.35	197.49	0.000315	0.52	19.24	16.58	0.14
Reach-1	247	(Ex) - 25Y	HDR Pr Mar 2021	10.06	195.95	197.48	196.35	197.49	0.000315	0.52	19.24	16.58	0.14
Reach-1	247	(Ex) - 50Y	Ex-Oct 2015	12.79	195.95	197.62	196.42	197.63	0.000381	0.61	20.99	17.06	0.15
Reach-1	247	(Ex) - 50Y	HDR Pr Mar 2021	12.79	195.95	197.62	196.42	197.63	0.000381	0.61	20.99	17.06	0.15
Reach-1	247	(Ex) - 100Y	Ex-Oct 2015	15.67	195.95	197.74	196.49	197.77	0.000446	0.69	22.61	18.33	0.17
Reach-1	247	(Ex) - 100Y	HDR Pr Mar 2021	15.67	195.95	197.74	196.49	197.77	0.000446	0.69	22.61	18.33	0.17
Reach-1	247	(Ex) - Regional	Ex-Oct 2015	40.02	195.95	198.47	196.96	198.55	0.000934	1.26	31.79	25.29	0.25
Reach-1	247	(Ex) - Regional	HDR Pr Mar 2021	40.02	195.95	198.47	196.96	198.55	0.000934	1.26	31.79	25.29	0.25
Reach-1	246	(Ex) - 2Y	Ex-Oct 2015	2.15	195.90	196.81	196.46	196.83	0.001896	0.62	4.19	13.01	0.26
Reach-1	246	(Ex) - 2Y	HDR Pr Mar 2021	2.15	195.90	196.81	196.46	196.83	0.001896	0.62	4.19	13.01	0.26
Reach-1	246	(Ex) - 5Y	Ex-Oct 2015	4.51	195.90	197.05	196.65	197.07	0.001985	0.80	7.77	16.51	0.29
Reach-1	246	(Ex) - 5Y	HDR Pr Mar 2021	4.51	195.90	197.05	196.65	197.07	0.001985	0.80	7.77	16.51	0.29
Reach-1	246	(Ex) - 10Y	Ex-Oct 2015	7.62	195.90	197.26	196.83	197.30	0.002098	0.97	11.53	18.38	0.31
Reach-1	246	(Ex) - 10Y	HDR Pr Mar 2021	7.62	195.90	197.26	196.83	197.30	0.002098	0.97	11.53	18.38	0.31
Reach-1	246	(Ex) - 25Y	Ex-Oct 2015	10.06	195.90	197.40	196.93	197.44	0.002174	1.07	14.10	19.55	0.32
Reach-1	246	(Ex) - 25Y	HDR Pr Mar 2021	10.06	195.90	197.40	196.93	197.44	0.002174	1.07	14.10	19.55	0.32
Reach-1	246	(Ex) - 50Y	Ex-Oct 2015	12.79	195.90	197.53	197.02	197.58	0.002255	1.17	16.73	20.69	0.33
Reach-1	246	(Ex) - 50Y	HDR Pr Mar 2021	12.79	195.90	197.53	197.02	197.58	0.002255	1.17	16.73	20.69	0.33
Reach-1	246	(Ex) - 100Y	Ex-Oct 2015	15.67	195.90	197.65	197.10	197.71	0.002337	1.26	19.29	21.76	0.34
Reach-1	246	(Ex) - 100Y	HDR Pr Mar 2021	15.67	195.90	197.65	197.10	197.71	0.002337	1.26	19.29	21.76	0.34
Reach-1	246	(Ex) - Regional	Ex-Oct 2015	40.02	195.90	198.35	197.59	198.46	0.002871	1.83	36.73	28.21	0.40
Reach-1	246	(Ex) - Regional	HDR Pr Mar 2021	40.02	195.90	198.35	197.59	198.46	0.002871	1.83	36.73	28.21	0.40
Reach-1	245.5	(Ex) - 2Y	Ex-Oct 2015	2.15	195.50	196.41	196.18	196.46	0.004747	0.98	2.92	10.39	0.42
Reach-1	245.5	(Ex) - 2Y	HDR Pr Mar 2021	2.15	195.50	196.41	196.18	196.46	0.004747	0.98	2.92	10.39	0.42
Reach-1	245.5	(Ex) - 5Y	Ex-Oct 2015	4.51	195.50	196.66	196.43	196.71	0.004259	1.18	6.16	15.53	0.42
Reach-1	245.5	(Ex) - 5Y	HDR Pr Mar 2021	4.51	195.50	196.66	196.43	196.71	0.004259	1.18	6.16	15.53	0.42
Reach-1	245.5	(Ex) - 10Y	Ex-Oct 2015	7.62	195.50	196.87	196.61	196.93	0.004126	1.36	9.82	18.99	0.43
Reach-1	245.5	(Ex) - 10Y	HDR Pr Mar 2021	7.62	195.50	196.87	196.61	196.93	0.004126	1.36	9.82	18.99	0.43
Reach-1	245.5	(Ex) - 25Y	Ex-Oct 2015	10.06	195.50	197.00	196.70	197.07	0.004089	1.47	12.45	21.13	0.44
Reach-1	245.5	(Ex) - 25Y	HDR Pr Mar 2021	10.06	195.50	197.00	196.70	197.07	0.004089	1.47	12.45	21.13	0.44
Reach-1	245.5	(Ex) - 50Y	Ex-Oct 2015	12.79	195.50	197.13	196.79	197.20	0.004056	1.57	15.26	23.19	0.44
Reach-1	245.5	(Ex) - 50Y	HDR Pr Mar 2021	12.79	195.50	197.13	196.79	197.20	0.004056	1.57	15.26	23.19	0.44
Reach-1	245.5	(Ex) - 100Y	Ex-Oct 2015	15.67	195.50	197.25	196.87	197.33	0.004033	1.66	18.08	25.10	0.45
Reach-1	245.5	(Ex) - 100Y	HDR Pr Mar 2021	15.67	195.50	197.25	196.87	197.33	0.004033	1.66	18.08	25.10	0.45
Reach-1	245.5	(Ex) - Regional	Ex-Oct 2015	40.02	195.50	197.95	197.36	198.06	0.003579	2.05	39.20	47.09	0.45
Reach-1	245.5	(Ex) - Regional	HDR Pr Mar 2021	40.02	195.50	197.95	197.36	198.06	0.003579	2.05	39.20	47.09	0.45
Reach-1	245	(Ex) - 2Y	Ex-Oct 2015	2.15	195.00	196.01	195.69	196.04	0.002903	0.84	3.47	11.56	0.34
Reach-1	245	(Ex) - 2Y	HDR Pr Mar 2021	2.15	195.00	196.01	195.69	196.04	0.002903	0.84	3.47	11.56	0.34
Reach-1	245	(Ex) - 5Y	Ex-Oct 2015	4.51	195.00	196.24	195.95	196.29	0.003201	1.08	6.87	17.35	0.37
Reach-1	245	(Ex) - 5Y	HDR Pr Mar 2021	4.51	195.00	196.24	195.95	196.29	0.003201	1.08	6.87	17.35	0.37
Reach-1	245	(Ex) - 10Y	Ex-Oct 2015	7.62	195.00	196.44	196.14	196.50	0.003382	1.28	10.56	19.97	0.39
Reach-1	245	(Ex) - 10Y	HDR Pr Mar 2021	7.62	195.00	196.44	196.14	196.50	0.003382	1.28	10.56	19.97	0.39
Reach-1	245	(Ex) - 25Y	Ex-Oct 2015	10.06	195.00	196.56	196.26	196.62	0.003504	1.40	13.09	21.58	0.41
Reach-1	245	(Ex) - 25Y	HDR Pr Mar 2021	10.06	195.00	196.56	196.26	196.62	0.003504	1.40	13.09	21.58	0.41
Reach-1	245	(Ex) - 50Y	Ex-Oct 2015	12.79	195.00	196.68	196.33	196.75	0.003585	1.51	15.74	23.04	0.42
Reach-1	245	(Ex) - 50Y	HDR Pr Mar 2021	12.79	195.00	196.68	196.33	196.75	0.003585	1.51	15.74	23.04	0.42
Reach-1	245	(Ex) - 100Y	Ex-Oct 2015	15.67	195.00	196.79	196.42	196.87	0.003660	1.61	18.33	24.32	0.43
Reach-1	245	(Ex) - 100Y	HDR Pr Mar 2021	15.67	195.00	196.79	196.42	196.87	0.003660	1.61	18.33	24.32	0.43
Reach-1	245	(Ex) - Regional	Ex-Oct 2015	40.02	195.00	197.45	196.88	197.57	0.004306	2.25	38.05	37.96	0.50
Reach-1	245	(Ex) - Regional	HDR Pr Mar 2021	40.02	195.00	197.45	196.88	197.57	0.004306	2.25	38.05	37.96	0.50
Reach-1	244	(Ex) - 2Y	Ex-Oct 2015	2.15	194.40	194.89	194.89	195.01	0.033428	1.57	1.37	5.66	1.01
Reach-1	244	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.40	194.89	194.89	195.01	0.033428	1.57	1.37	5.66	1.01
Reach-1	244	(Ex) - 5Y	Ex-Oct 2015	4.51	194.40	195.05	195.05	195.22	0.030231	1.83	2.47	7.46	1.02
Reach-1	244	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.40	195.05	195.05	195.22	0.030231	1.83	2.47	7.46	1.02
Reach-1	244	(Ex) - 10Y	Ex-Oct 2015	7.62	194.40	195.20	195.20	195.42	0.027933	2.06	3.71	8.86	1.01
Reach-1	244	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.40	195.20	195.20	195.42	0.027933	2.06	3.71	8.86	1.01
Reach-1	244	(Ex) - 25Y	Ex-Oct 2015	10.06	194.40	195.30	195.30	195.54	0.026152	2.16	4.65	9.79	1.00
Reach-1	244	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.40	195.30	195.30	195.54	0.026152	2.16	4.65	9.79	1.00
Reach-1	244	(Ex) - 50Y	Ex-Oct 2015	12.79	194.40	195.40	195.40	195.66	0.025287	2.28	5.61	10.65	1.00
Reach-1	244	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.40	195.40	195.40	195.66	0.025287	2.28	5.61	10.65	1.00
Reach-1	244	(Ex) - 100Y	Ex-Oct 2015	15.67	194.40	195.49	195.49	195.77	0.024542	2.38	6.59	11.46	1.00
Reach-1	244	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.40	195.49	195.49	195.77	0.024542	2.38	6.59	11.46	1.00
Reach-1	244	(Ex) - Regional	Ex-Oct 2015	40.02	194.40	196.00	196.00	196.46	0.018306	3.00	14.20	18.84	0.95
Reach-1	244	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.40	196.00	196.00	196.46	0.018306	3.00	14.20	18.84	0.95
Reach-1	243	(Ex) - 2Y	Ex-Oct 2015	2.15	194.20	194.73		194.73	0.000024	0.07	31.64	63.96	0.03
Reach-1	243	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.20	194.73		194.73	0.000024	0.07	31.64	63.96	0.03
Reach-1	243	(Ex) - 5Y	Ex-Oct 2015	4.51	194.20	194.92		194.92	0.000038	0.10	43.70	67.29	0.04
Reach-1	243	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.20	194.92		194.92	0.000038	0.10	43.70	67.29	0.04
Reach-1	243	(Ex) - 10Y	Ex-Oct 2015	7.62	194.20	195.08		195.08	0.000053	0.14	55.24	70.47	0.05
Reach-1	243	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.20	195.08		195.08	0.000053	0.14	55.24	70.47	0.05
Reach-1	243	(Ex) - 25Y	Ex-Oct 2015	10.06	194.20	195.19		195.19	0.000063	0.16	62.68	72.45	0.06
Reach-1	243	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.20	195.19		195.19	0.000063	0.16	62.68	72.45	0.06
Reach-1	243	(Ex) - 50Y	Ex-Oct 2015	12.79	194.20	195.29		195.29	0.000074	0.18	69.96	74.34	0.06
Reach-1	243	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.20	195.29		195.29	0.000074	0.18	69.96	74.34	0.06
Reach-1	243	(Ex) - 100Y	Ex-Oct 2015	15.67	194.20	195.38		195.38	0.000083	0.20	76.93	76.10	0.06
Reach-1	243	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.20	195.38		195.38	0.000083	0.20	76.93	76.10	0.06

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	243	(Ex) - Regional	Ex-Oct 2015	40.02	194.20	195.92		195.92	0.000143	0.33	120.06	85.18	0.09
Reach-1	243	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.20	195.92		195.92	0.000143	0.33	120.06	85.18	0.09
Reach-1	242	(Ex) - 2Y	Ex-Oct 2015	2.15	194.20	194.73		194.73	0.000018	0.06	36.14	72.81	0.03
Reach-1	242	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.20	194.73		194.73	0.000018	0.06	36.14	72.81	0.03
Reach-1	242	(Ex) - 5Y	Ex-Oct 2015	4.51	194.20	194.91		194.91	0.000029	0.09	49.73	75.95	0.04
Reach-1	242	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.20	194.91		194.91	0.000029	0.09	49.73	75.95	0.04
Reach-1	242	(Ex) - 10Y	Ex-Oct 2015	7.62	194.20	195.08		195.08	0.000041	0.12	62.59	78.81	0.04
Reach-1	242	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.20	195.08		195.08	0.000041	0.12	62.59	78.81	0.04
Reach-1	242	(Ex) - 25Y	Ex-Oct 2015	10.06	194.20	195.18		195.18	0.000049	0.14	70.82	80.58	0.05
Reach-1	242	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.20	195.18		195.18	0.000049	0.14	70.82	80.58	0.05
Reach-1	242	(Ex) - 50Y	Ex-Oct 2015	12.79	194.20	195.28		195.28	0.000056	0.16	78.82	81.90	0.05
Reach-1	242	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.20	195.28		195.28	0.000056	0.16	78.82	81.90	0.05
Reach-1	242	(Ex) - 100Y	Ex-Oct 2015	15.67	194.20	195.37		195.37	0.000063	0.18	86.40	83.05	0.06
Reach-1	242	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.20	195.37		195.37	0.000063	0.18	86.40	83.05	0.06
Reach-1	242	(Ex) - Regional	Ex-Oct 2015	40.02	194.20	195.90		195.91	0.000111	0.30	132.33	89.96	0.08
Reach-1	242	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.20	195.90		195.91	0.000111	0.30	132.33	89.96	0.08
Reach-1	241	(Ex) - 2Y	Ex-Oct 2015	2.15	194.20	194.61	194.61	194.72	0.034960	1.44	1.49	7.24	1.01
Reach-1	241	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.20	194.61	194.61	194.72	0.034960	1.44	1.49	7.24	1.01
Reach-1	241	(Ex) - 5Y	Ex-Oct 2015	4.51	194.20	194.75	194.75	194.90	0.031662	1.67	2.70	9.74	1.01
Reach-1	241	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.20	194.75	194.75	194.90	0.031662	1.67	2.70	9.74	1.01
Reach-1	241	(Ex) - 10Y	Ex-Oct 2015	7.62	194.20	194.88	194.88	195.06	0.029352	1.85	4.11	12.03	1.01
Reach-1	241	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.20	194.88	194.88	195.06	0.029352	1.85	4.11	12.03	1.01
Reach-1	241	(Ex) - 25Y	Ex-Oct 2015	10.06	194.20	194.96	194.96	195.16	0.028331	1.96	5.13	13.44	1.01
Reach-1	241	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.20	194.96	194.96	195.16	0.028331	1.96	5.13	13.44	1.01
Reach-1	241	(Ex) - 50Y	Ex-Oct 2015	12.79	194.20	195.04	195.04	195.26	0.026747	2.04	6.28	14.86	1.00
Reach-1	241	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.20	195.04	195.04	195.26	0.026747	2.04	6.28	14.86	1.00
Reach-1	241	(Ex) - 100Y	Ex-Oct 2015	15.67	194.20	195.11	195.11	195.35	0.026756	2.14	7.31	16.04	1.01
Reach-1	241	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.20	195.11	195.11	195.35	0.026756	2.14	7.31	16.04	1.01
Reach-1	241	(Ex) - Regional	Ex-Oct 2015	40.02	194.20	195.53	195.53	195.87	0.023135	2.57	15.60	23.42	1.00
Reach-1	241	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.20	195.53	195.53	195.87	0.023135	2.57	15.60	23.42	1.00
Reach-1	240	(Ex) - 2Y	Ex-Oct 2015	2.15	194.00	194.60	194.04	194.60	0.000006	0.04	57.43	99.76	0.02
Reach-1	240	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.00	194.60	194.04	194.60	0.000006	0.04	57.43	99.76	0.02
Reach-1	240	(Ex) - 5Y	Ex-Oct 2015	4.51	194.00	194.72	194.06	194.72	0.000014	0.06	69.67	101.22	0.02
Reach-1	240	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.00	194.72	194.06	194.72	0.000014	0.06	69.67	101.22	0.02
Reach-1	240	(Ex) - 10Y	Ex-Oct 2015	7.62	194.00	194.83	194.09	194.83	0.000024	0.09	81.36	102.59	0.03
Reach-1	240	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.00	194.83	194.09	194.83	0.000024	0.09	81.36	102.59	0.03
Reach-1	240	(Ex) - 25Y	Ex-Oct 2015	10.06	194.00	194.91	194.10	194.91	0.000032	0.11	88.86	103.44	0.04
Reach-1	240	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.00	194.91	194.10	194.91	0.000032	0.11	88.86	103.44	0.04
Reach-1	240	(Ex) - 50Y	Ex-Oct 2015	12.79	194.00	194.98	194.13	194.98	0.000040	0.13	96.23	104.03	0.04
Reach-1	240	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.00	194.98	194.13	194.98	0.000040	0.13	96.23	104.03	0.04
Reach-1	240	(Ex) - 100Y	Ex-Oct 2015	15.67	194.00	195.05	194.14	195.05	0.000048	0.15	103.28	104.59	0.05
Reach-1	240	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.00	195.04	194.14	195.05	0.000048	0.15	103.26	104.59	0.05
Reach-1	240	(Ex) - Regional	Ex-Oct 2015	40.02	194.00	195.48	194.27	195.48	0.000095	0.27	149.48	108.21	0.07
Reach-1	240	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.00	195.48	194.27	195.48	0.000095	0.27	149.48	108.21	0.07
Reach-1	239	(Ex) - 2Y	Ex-Oct 2015	2.15	194.00	194.60		194.60	0.000005	0.03	64.90	111.91	0.01
Reach-1	239	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.00	194.60		194.60	0.000005	0.03	64.90	111.91	0.01
Reach-1	239	(Ex) - 5Y	Ex-Oct 2015	4.51	194.00	194.72		194.72	0.000011	0.06	78.47	113.04	0.02
Reach-1	239	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.00	194.72		194.72	0.000011	0.06	78.47	113.04	0.02
Reach-1	239	(Ex) - 10Y	Ex-Oct 2015	7.62	194.00	194.83		194.83	0.000019	0.08	91.32	114.09	0.03
Reach-1	239	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.00	194.83		194.83	0.000019	0.08	91.32	114.09	0.03
Reach-1	239	(Ex) - 25Y	Ex-Oct 2015	10.06	194.00	194.90		194.90	0.000025	0.10	99.52	114.76	0.03
Reach-1	239	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.00	194.90		194.90	0.000025	0.10	99.52	114.76	0.03
Reach-1	239	(Ex) - 50Y	Ex-Oct 2015	12.79	194.00	194.97		194.97	0.000032	0.12	107.56	115.41	0.04
Reach-1	239	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.00	194.97		194.97	0.000032	0.12	107.56	115.41	0.04
Reach-1	239	(Ex) - 100Y	Ex-Oct 2015	15.67	194.00	195.04		195.04	0.000038	0.14	115.26	116.03	0.04
Reach-1	239	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.00	195.04		195.04	0.000038	0.14	115.23	116.03	0.04
Reach-1	239	(Ex) - Regional	Ex-Oct 2015	40.02	194.00	195.47		195.47	0.000077	0.24	165.66	119.90	0.07
Reach-1	239	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.00	195.47		195.47	0.000077	0.24	165.66	119.90	0.07
Reach-1	238	(Ex) - 2Y	Ex-Oct 2015	2.15	194.00	194.60		194.60	0.000001	0.02	117.50	199.14	0.01
Reach-1	238	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.00	194.60		194.60	0.000001	0.02	117.50	199.14	0.01
Reach-1	238	(Ex) - 5Y	Ex-Oct 2015	4.51	194.00	194.72		194.72	0.000003	0.03	141.57	199.90	0.01
Reach-1	238	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.00	194.72		194.72	0.000003	0.03	141.57	199.90	0.01
Reach-1	238	(Ex) - 10Y	Ex-Oct 2015	7.62	194.00	194.83		194.83	0.000006	0.05	164.20	200.61	0.02
Reach-1	238	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.00	194.83		194.83	0.000006	0.05	164.20	200.61	0.02
Reach-1	238	(Ex) - 25Y	Ex-Oct 2015	10.06	194.00	194.90		194.90	0.000008	0.06	178.59	201.06	0.02
Reach-1	238	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.00	194.90		194.90	0.000008	0.06	178.59	201.06	0.02
Reach-1	238	(Ex) - 50Y	Ex-Oct 2015	12.79	194.00	194.97		194.97	0.000009	0.07	192.65	201.50	0.02
Reach-1	238	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.00	194.97		194.97	0.000009	0.07	192.65	201.50	0.02
Reach-1	238	(Ex) - 100Y	Ex-Oct 2015	15.67	194.00	195.04		195.04	0.000011	0.08	206.05	201.92	0.02
Reach-1	238	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.00	195.04		195.04	0.000011	0.08	206.00	201.91	0.02
Reach-1	238	(Ex) - Regional	Ex-Oct 2015	40.02	194.00	195.47		195.47	0.000023	0.14	292.92	204.61	0.04
Reach-1	238	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.00	195.47		195.47	0.000023	0.14	292.92	204.61	0.04
Reach-1	237	(Ex) - 2Y	Ex-Oct 2015	2.15	194.00	194.60	194.02	194.60	0.000001	0.02	116.28	197.82	0.01
Reach-1	237	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.00	194.60	194.02	194.60	0.000001	0.02	116.28	197.82	0.01
Reach-1	237	(Ex) - 5Y	Ex-Oct 2015	4.51	194.00	194.72	194.04	194.72	0.000003	0.03	140.15	198.92	0.01
Reach-1	237	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.00	194.72	194.04	194.72	0.000003	0.03	140.15	198.92	0.01
Reach-1	237	(Ex) - 10Y	Ex-Oct 2015	7.62	194.00	194.83	194.05	194.83	0.000006	0.05	162.63	199.94	0.02
Reach-1	237	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.00	194.83	194.05	194.83	0.000006	0.05	162.63	199.94	0.02
Reach-1	237	(Ex) - 25Y	Ex-Oct 2015	10.06	194.00	194.90	194.06	194.90	0.000008	0.06	176.92	200.59	0.02
Reach-1	237	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.00	194.90	194.06	194.90	0.000008	0.06	176.92	200.59	0.02
Reach-1	237	(Ex) - 50Y	Ex-Oct 2015	12.79	194.00	194.97	194.08	194.97	0.000010	0.07	190.90	201.23	0.02

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	237	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.00	194.97	194.08	194.97	0.000010	0.07	190.90	201.23	0.02
Reach-1	237	(Ex) - 100Y	Ex-Oct 2015	15.67	194.00	195.04	194.09	195.04	0.000012	0.08	204.24	201.90	0.02
Reach-1	237	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.00	195.04	194.09	195.04	0.000012	0.08	204.19	201.89	0.02
Reach-1	237	(Ex) - Regional	Ex-Oct 2015	40.02	194.00	195.46	194.16	195.46	0.000024	0.14	291.17	206.58	0.04
Reach-1	237	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.00	195.46	194.16	195.46	0.000024	0.14	291.17	206.58	0.04
Reach-1	236	(Ex) - 2Y	Ex-Oct 2015	2.15	194.30	194.52	194.52	194.59	0.038571	1.14	1.89	14.15	1.00
Reach-1	236	(Ex) - 2Y	HDR Pr Mar 2021	2.15	194.30	194.52	194.52	194.59	0.038571	1.14	1.89	14.15	1.00
Reach-1	236	(Ex) - 5Y	Ex-Oct 2015	4.51	194.30	194.61	194.61	194.71	0.034728	1.35	3.33	17.99	1.00
Reach-1	236	(Ex) - 5Y	HDR Pr Mar 2021	4.51	194.30	194.61	194.61	194.71	0.034728	1.35	3.33	17.99	1.00
Reach-1	236	(Ex) - 10Y	Ex-Oct 2015	7.62	194.30	194.70	194.70	194.82	0.032470	1.52	5.01	22.31	1.00
Reach-1	236	(Ex) - 10Y	HDR Pr Mar 2021	7.62	194.30	194.70	194.70	194.82	0.032470	1.52	5.01	22.31	1.00
Reach-1	236	(Ex) - 25Y	Ex-Oct 2015	10.06	194.30	194.75	194.75	194.89	0.030992	1.62	6.20	24.68	1.00
Reach-1	236	(Ex) - 25Y	HDR Pr Mar 2021	10.06	194.30	194.75	194.75	194.89	0.030992	1.62	6.20	24.68	1.00
Reach-1	236	(Ex) - 50Y	Ex-Oct 2015	12.79	194.30	194.81	194.81	194.95	0.029613	1.71	7.47	26.90	1.00
Reach-1	236	(Ex) - 50Y	HDR Pr Mar 2021	12.79	194.30	194.81	194.81	194.95	0.029613	1.71	7.47	26.90	1.00
Reach-1	236	(Ex) - 100Y	Ex-Oct 2015	15.67	194.30	194.85	194.85	195.02	0.027627	1.80	8.72	28.12	0.98
Reach-1	236	(Ex) - 100Y	HDR Pr Mar 2021	15.67	194.30	194.86	194.85	195.02	0.025829	1.76	8.91	28.31	0.95
Reach-1	236	(Ex) - Regional	Ex-Oct 2015	40.02	194.30	195.16	195.16	195.43	0.022256	2.34	17.57	39.81	0.97
Reach-1	236	(Ex) - Regional	HDR Pr Mar 2021	40.02	194.30	195.16	195.16	195.43	0.022256	2.34	17.57	39.81	0.97
Reach-1	235	(Ex) - 2Y	Ex-Oct 2015	2.59	193.20	193.71	193.54	193.73	0.003797	0.55	4.68	18.17	0.35
Reach-1	235	(Ex) - 2Y	HDR Pr Mar 2021	2.59	193.20	193.71	193.54	193.73	0.003797	0.55	4.68	18.17	0.35
Reach-1	235	(Ex) - 5Y	Ex-Oct 2015	5.06	193.20	193.83	193.64	193.85	0.004950	0.73	6.91	21.92	0.41
Reach-1	235	(Ex) - 5Y	HDR Pr Mar 2021	5.06	193.20	193.83	193.64	193.85	0.004964	0.73	6.91	21.91	0.41
Reach-1	235	(Ex) - 10Y	Ex-Oct 2015	8.20	193.20	193.89	193.74	193.94	0.007545	0.99	8.30	23.68	0.52
Reach-1	235	(Ex) - 10Y	HDR Pr Mar 2021	8.20	193.20	193.89	193.74	193.94	0.007666	1.00	8.25	23.62	0.53
Reach-1	235	(Ex) - 25Y	Ex-Oct 2015	10.89	193.20	193.93	193.80	194.00	0.009270	1.18	9.34	24.86	0.59
Reach-1	235	(Ex) - 25Y	HDR Pr Mar 2021	10.89	193.20	193.93	193.80	194.00	0.009494	1.19	9.27	24.78	0.59
Reach-1	235	(Ex) - 50Y	Ex-Oct 2015	13.72	193.20	193.97	193.85	194.06	0.010703	1.35	10.37	25.94	0.64
Reach-1	235	(Ex) - 50Y	HDR Pr Mar 2021	13.72	193.20	193.96	193.85	194.06	0.011242	1.37	10.21	25.77	0.66
Reach-1	235	(Ex) - 100Y	Ex-Oct 2015	16.73	193.20	194.00	193.91	194.12	0.012542	1.53	11.24	26.82	0.70
Reach-1	235	(Ex) - 100Y	HDR Pr Mar 2021	16.73	193.20	194.00	193.91	194.12	0.013298	1.56	11.02	26.60	0.72
Reach-1	235	(Ex) - Regional	Ex-Oct 2015	46.48	193.20	194.65	194.28	194.78	0.004753	1.66	35.26	50.20	0.50
Reach-1	235	(Ex) - Regional	HDR Pr Mar 2021	46.48	193.20	194.65	194.28	194.78	0.004760	1.66	35.24	50.18	0.50
Reach-1	234	(Ex) - 2Y	Ex-Oct 2015	2.59	191.80	192.17	192.17	192.26	0.034915	1.37	1.89	9.88	1.00
Reach-1	234	(Ex) - 2Y	HDR Pr Mar 2021	2.59	191.80	192.17	192.17	192.26	0.034915	1.37	1.89	9.88	1.00
Reach-1	234	(Ex) - 5Y	Ex-Oct 2015	5.06	191.80	192.34	192.28	192.42	0.017088	1.28	3.97	14.41	0.75
Reach-1	234	(Ex) - 5Y	HDR Pr Mar 2021	5.06	191.80	192.34	192.28	192.42	0.017122	1.28	3.97	14.41	0.75
Reach-1	234	(Ex) - 10Y	Ex-Oct 2015	8.20	191.80	192.54	192.39	192.61	0.008093	1.18	7.35	19.30	0.56
Reach-1	234	(Ex) - 10Y	HDR Pr Mar 2021	8.20	191.80	192.54	192.39	192.61	0.007922	1.18	7.41	19.37	0.55
Reach-1	234	(Ex) - 25Y	Ex-Oct 2015	10.89	191.80	192.66	192.46	192.73	0.006118	1.21	9.96	22.12	0.51
Reach-1	234	(Ex) - 25Y	HDR Pr Mar 2021	10.89	191.80	192.67	192.46	192.74	0.005966	1.20	10.05	22.22	0.50
Reach-1	234	(Ex) - 50Y	Ex-Oct 2015	13.72	191.80	192.78	192.52	192.86	0.005019	1.24	12.74	24.79	0.47
Reach-1	234	(Ex) - 50Y	HDR Pr Mar 2021	13.72	191.80	192.79	192.52	192.86	0.004775	1.22	12.99	25.01	0.46
Reach-1	234	(Ex) - 100Y	Ex-Oct 2015	16.73	191.80	192.89	192.59	192.96	0.004217	1.25	17.02	32.93	0.44
Reach-1	234	(Ex) - 100Y	HDR Pr Mar 2021	16.73	191.80	192.90	192.59	192.97	0.004013	1.23	17.36	33.08	0.43
Reach-1	234	(Ex) - Regional	Ex-Oct 2015	46.48	191.80	193.04	193.04	193.38	0.016727	2.79	22.10	35.02	0.91
Reach-1	234	(Ex) - Regional	HDR Pr Mar 2021	46.48	191.80	193.04	193.04	193.38	0.016727	2.79	22.10	35.02	0.91
Reach-1	233	(Ex) - 2Y	Ex-Oct 2015	2.59	190.30	190.99	190.69	191.01	0.002067	0.56	4.66	11.78	0.28
Reach-1	233	(Ex) - 2Y	HDR Pr Mar 2021	2.59	190.30	190.99	190.69	191.01	0.002067	0.56	4.66	11.78	0.28
Reach-1	233	(Ex) - 5Y	Ex-Oct 2015	5.06	190.30	191.12	190.83	191.15	0.003223	0.83	6.31	14.54	0.36
Reach-1	233	(Ex) - 5Y	HDR Pr Mar 2021	5.06	190.30	191.12	190.83	191.15	0.003223	0.83	6.31	14.54	0.36
Reach-1	233	(Ex) - 10Y	Ex-Oct 2015	8.20	190.30	191.18	190.96	191.26	0.005739	1.20	7.29	15.96	0.49
Reach-1	233	(Ex) - 10Y	HDR Pr Mar 2021	8.20	190.30	191.18	190.96	191.25	0.005890	1.21	7.22	15.87	0.50
Reach-1	233	(Ex) - 25Y	Ex-Oct 2015	10.89	190.30	191.22	191.04	191.33	0.008057	1.48	7.96	16.81	0.59
Reach-1	233	(Ex) - 25Y	HDR Pr Mar 2021	10.89	190.30	191.22	191.04	191.33	0.008436	1.50	7.82	16.64	0.60
Reach-1	233	(Ex) - 50Y	Ex-Oct 2015	13.72	190.30	191.25	191.12	191.41	0.011171	1.79	8.38	17.31	0.70
Reach-1	233	(Ex) - 50Y	HDR Pr Mar 2021	13.72	190.30	191.23	191.12	191.40	0.012359	1.84	8.06	16.93	0.73
Reach-1	233	(Ex) - 100Y	Ex-Oct 2015	16.73	190.30	191.26	191.21	191.49	0.015465	2.13	8.62	17.58	0.82
Reach-1	233	(Ex) - 100Y	HDR Pr Mar 2021	16.73	190.30	191.24	191.21	191.48	0.017384	2.21	8.24	17.14	0.87
Reach-1	233	(Ex) - Regional	Ex-Oct 2015	46.48	190.30	191.60	191.60	191.61	0.001705	0.92	145.08	368.48	0.29
Reach-1	233	(Ex) - Regional	HDR Pr Mar 2021	46.48	190.30	191.60	191.60	191.61	0.001794	0.95	140.54	354.56	0.30
Reach-1	232	(Ex) - 2Y	Ex-Oct 2015	2.59	189.90	190.63	190.39	190.65	0.003873	0.70	4.52	47.72	0.37
Reach-1	232	(Ex) - 2Y	HDR Pr Mar 2021	2.59	189.90	190.63	190.39	190.65	0.003873	0.70	4.52	47.75	0.37
Reach-1	232	(Ex) - 5Y	Ex-Oct 2015	5.06	189.90	190.78	190.54	190.80	0.002279	0.64	16.54	103.56	0.30
Reach-1	232	(Ex) - 5Y	HDR Pr Mar 2021	5.06	189.90	190.78	190.54	190.80	0.002279	0.64	16.85	109.89	0.30
Reach-1	232	(Ex) - 10Y	Ex-Oct 2015	8.20	189.90	190.91	190.74	190.91	0.001356	0.58	40.88	247.57	0.24
Reach-1	232	(Ex) - 10Y	HDR Pr Mar 2021	8.20	189.90	190.90	190.74	190.91	0.001330	0.57	42.08	260.77	0.24
Reach-1	232	(Ex) - 25Y	Ex-Oct 2015	10.89	189.90	190.95	190.77	190.96	0.001265	0.59	52.96	256.18	0.23
Reach-1	232	(Ex) - 25Y	HDR Pr Mar 2021	10.89	189.90	190.95	190.77	190.96	0.001226	0.57	54.46	265.44	0.23
Reach-1	232	(Ex) - 50Y	Ex-Oct 2015	13.72	189.90	191.00	190.80	191.01	0.001172	0.59	65.87	273.77	0.23
Reach-1	232	(Ex) - 50Y	HDR Pr Mar 2021	13.72	189.90	191.00	190.80	191.00	0.001108	0.57	67.17	270.16	0.22
Reach-1	232	(Ex) - 100Y	Ex-Oct 2015	16.73	189.90	191.04	190.80	191.05	0.001139	0.61	77.19	281.20	0.23
Reach-1	232	(Ex) - 100Y	HDR Pr Mar 2021	16.73	189.90	191.04	190.80	191.05	0.001081	0.59	79.05	283.17	0.22
Reach-1	232	(Ex) - Regional	Ex-Oct 2015	46.48	189.90	191.38	190.99	191.39	0.000779	0.64	184.66	346.95	0.20
Reach-1	232	(Ex) - Regional	HDR Pr Mar 2021	46.48	189.90	191.37	190.98	191.38	0.000767	0.64	183.04	334.31	0.20
Reach-1	231	(Ex) - 2Y	Ex-Oct 2015	2.59	189.50	190.31	189.98	190.32	0.001977	0.56	4.64	11.35	0.27
Reach-1	231	(Ex) - 2Y	HDR Pr Mar 2021	2.59	189.50	190.31	189.98	190.32	0.001977	0.56	4.64	11.35	0.27
Reach-1	231	(Ex) - 5Y	Ex-Oct 2015	5.06	189.50	190.52	190.13	190.55	0.001882	0.72	7.44	14.29	0.28
Reach-1	231	(Ex) - 5Y	HDR Pr Mar 2021	5.06	189.50	190.52	190.13	190.55	0.001882	0.72	7.44	14.29	0.28
Reach-1	231	(Ex) - 10Y	Ex-Oct 2015	8.20	189.50	190.70	190.26	190.73	0.001722	0.81	20.51	201.82	0.28
Reach-1	231	(Ex) - 10Y	HDR Pr Mar 2021	8.20	189.50	190.70	190.26	190.73	0.001722	0.81	20.51	201.84	0.28

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	231	(Ex) - 25Y	Ex-Oct 2015	10.89	189.50	190.79	190.35	190.81	0.001321	0.76	38.27	217.07	0.25
Reach-1	231	(Ex) - 25Y	HDR Pr Mar 2021	10.89	189.50	190.79	190.35	190.81	0.001321	0.76	38.28	217.59	0.25
Reach-1	231	(Ex) - 50Y	Ex-Oct 2015	13.72	189.50	190.86	190.44	190.88	0.001101	0.73	56.98	275.24	0.23
Reach-1	231	(Ex) - 50Y	HDR Pr Mar 2021	13.72	189.50	190.86	190.44	190.88	0.001101	0.73	57.05	276.18	0.23
Reach-1	231	(Ex) - 100Y	Ex-Oct 2015	16.73	189.50	190.91	190.51	190.93	0.000994	0.71	71.72	282.36	0.22
Reach-1	231	(Ex) - 100Y	HDR Pr Mar 2021	16.73	189.50	190.91	190.51	190.93	0.000993	0.71	71.83	283.62	0.22
Reach-1	231	(Ex) - Regional	Ex-Oct 2015	46.48	189.50	191.30	190.91	191.31	0.000601	0.69	193.22	347.18	0.18
Reach-1	231	(Ex) - Regional	HDR Pr Mar 2021	46.48	189.50	191.29	190.91	191.30	0.000603	0.69	189.82	330.10	0.18
Reach-1	230	(Ex) - 2Y	Ex-Oct 2015	2.59	189.20	190.03	189.73	190.05	0.002645	0.61	4.23	10.62	0.31
Reach-1	230	(Ex) - 2Y	HDR Pr Mar 2021	2.59	189.20	190.03	189.73	190.05	0.002645	0.61	4.23	10.62	0.31
Reach-1	230	(Ex) - 5Y	Ex-Oct 2015	5.06	189.20	190.26	189.89	190.29	0.002607	0.72	7.04	13.77	0.32
Reach-1	230	(Ex) - 5Y	HDR Pr Mar 2021	5.06	189.20	190.26	189.89	190.29	0.002607	0.72	7.04	13.77	0.32
Reach-1	230	(Ex) - 10Y	Ex-Oct 2015	8.20	189.20	190.44	190.03	190.48	0.002785	0.83	10.79	27.32	0.34
Reach-1	230	(Ex) - 10Y	HDR Pr Mar 2021	8.20	189.20	190.44	190.03	190.48	0.002785	0.83	10.79	27.32	0.34
Reach-1	230	(Ex) - 25Y	Ex-Oct 2015	10.89	189.20	190.55	190.12	190.59	0.002961	0.91	14.00	36.69	0.36
Reach-1	230	(Ex) - 25Y	HDR Pr Mar 2021	10.89	189.20	190.55	190.12	190.59	0.002961	0.91	14.00	36.69	0.36
Reach-1	230	(Ex) - 50Y	Ex-Oct 2015	13.72	189.20	190.62	190.21	190.67	0.003320	1.01	17.46	82.22	0.38
Reach-1	230	(Ex) - 50Y	HDR Pr Mar 2021	13.72	189.20	190.62	190.21	190.67	0.003320	1.01	17.46	82.22	0.38
Reach-1	230	(Ex) - 100Y	Ex-Oct 2015	16.73	189.20	190.67	190.29	190.72	0.003744	1.10	21.75	89.42	0.41
Reach-1	230	(Ex) - 100Y	HDR Pr Mar 2021	16.73	189.20	190.67	190.29	190.72	0.003744	1.10	21.75	89.42	0.41
Reach-1	230	(Ex) - Regional	Ex-Oct 2015	46.48	189.20	191.20	190.87	191.22	0.000989	0.81	146.49	323.65	0.23
Reach-1	230	(Ex) - Regional	HDR Pr Mar 2021	46.48	189.20	191.19	190.87	191.21	0.001044	0.83	142.89	307.24	0.24
Reach-1	229	(Ex) - 2Y	Ex-Oct 2015	2.59	188.60	189.47		189.49	0.001933	0.56	4.71	12.48	0.27
Reach-1	229	(Ex) - 2Y	HDR Pr Mar 2021	2.59	188.60	189.47		189.49	0.001933	0.56	4.71	12.48	0.27
Reach-1	229	(Ex) - 5Y	Ex-Oct 2015	5.06	188.60	189.68		189.70	0.002118	0.69	8.10	20.25	0.29
Reach-1	229	(Ex) - 5Y	HDR Pr Mar 2021	5.06	188.60	189.68		189.70	0.002118	0.69	8.10	20.25	0.29
Reach-1	229	(Ex) - 10Y	Ex-Oct 2015	8.20	188.60	189.86		189.89	0.002008	0.81	13.44	48.21	0.30
Reach-1	229	(Ex) - 10Y	HDR Pr Mar 2021	8.20	188.60	189.86		189.89	0.002008	0.81	13.44	48.21	0.30
Reach-1	229	(Ex) - 25Y	Ex-Oct 2015	10.89	188.60	189.97		190.00	0.001909	0.86	22.03	107.13	0.30
Reach-1	229	(Ex) - 25Y	HDR Pr Mar 2021	10.89	188.60	189.97		190.00	0.001909	0.86	22.03	107.13	0.30
Reach-1	229	(Ex) - 50Y	Ex-Oct 2015	13.72	188.60	190.05		190.08	0.001699	0.87	34.29	171.91	0.29
Reach-1	229	(Ex) - 50Y	HDR Pr Mar 2021	13.72	188.60	190.05		190.08	0.001699	0.87	34.29	171.91	0.29
Reach-1	229	(Ex) - 100Y	Ex-Oct 2015	16.73	188.60	190.13		190.15	0.001482	0.85	48.85	209.82	0.27
Reach-1	229	(Ex) - 100Y	HDR Pr Mar 2021	16.73	188.60	190.13		190.15	0.001482	0.85	48.85	209.82	0.27
Reach-1	229	(Ex) - Regional	Ex-Oct 2015	46.48	188.60	191.16		191.16	0.000089	0.33	380.02	421.13	0.07
Reach-1	229	(Ex) - Regional	HDR Pr Mar 2021	46.48	188.60	191.15		191.16	0.000084	0.32	369.65	378.51	0.07
Reach-1	228	(Ex) - 2Y	Ex-Oct 2015	2.59	188.50	189.23		189.25	0.002395	0.59	4.46	12.17	0.30
Reach-1	228	(Ex) - 2Y	HDR Pr Mar 2021	2.59	188.50	189.23		189.25	0.002395	0.59	4.46	12.17	0.30
Reach-1	228	(Ex) - 5Y	Ex-Oct 2015	5.06	188.50	189.42		189.45	0.002392	0.76	7.10	15.38	0.32
Reach-1	228	(Ex) - 5Y	HDR Pr Mar 2021	5.06	188.50	189.42		189.45	0.002392	0.76	7.10	15.38	0.32
Reach-1	228	(Ex) - 10Y	Ex-Oct 2015	8.20	188.50	189.61		189.65	0.002372	0.91	11.19	37.06	0.33
Reach-1	228	(Ex) - 10Y	HDR Pr Mar 2021	8.20	188.50	189.61		189.65	0.002372	0.91	11.19	37.06	0.33
Reach-1	228	(Ex) - 25Y	Ex-Oct 2015	10.89	188.50	189.71		189.75	0.002530	1.02	15.59	55.93	0.35
Reach-1	228	(Ex) - 25Y	HDR Pr Mar 2021	10.89	188.50	189.71		189.75	0.002530	1.02	15.59	55.93	0.35
Reach-1	228	(Ex) - 50Y	Ex-Oct 2015	13.72	188.50	189.81		189.86	0.002292	1.05	22.64	77.03	0.34
Reach-1	228	(Ex) - 50Y	HDR Pr Mar 2021	13.72	188.50	189.81		189.86	0.002292	1.05	22.64	77.04	0.34
Reach-1	228	(Ex) - 100Y	Ex-Oct 2015	16.73	188.50	189.93		189.97	0.001892	1.02	32.66	99.43	0.31
Reach-1	228	(Ex) - 100Y	HDR Pr Mar 2021	16.73	188.50	189.93		189.97	0.001892	1.02	32.66	99.42	0.31
Reach-1	228	(Ex) - Regional	Ex-Oct 2015	46.48	188.50	191.15		191.15	0.000059	0.30	412.46	390.07	0.06
Reach-1	228	(Ex) - Regional	HDR Pr Mar 2021	46.48	188.50	191.15		191.15	0.000062	0.30	392.06	354.75	0.06
Reach-1	227	(Ex) - 2Y	Ex-Oct 2015	2.59	188.10	188.72	188.55	188.75	0.005802	0.78	3.31	10.62	0.44
Reach-1	227	(Ex) - 2Y	HDR Pr Mar 2021	2.59	188.10	188.72	188.55	188.75	0.005802	0.78	3.31	10.62	0.44
Reach-1	227	(Ex) - 5Y	Ex-Oct 2015	5.06	188.10	188.84	188.69	188.90	0.007445	1.09	4.73	12.55	0.53
Reach-1	227	(Ex) - 5Y	HDR Pr Mar 2021	5.06	188.10	188.84	188.69	188.90	0.007445	1.09	4.73	12.55	0.53
Reach-1	227	(Ex) - 10Y	Ex-Oct 2015	8.20	188.10	188.94		189.04	0.009688	1.43	6.05	14.11	0.63
Reach-1	227	(Ex) - 10Y	HDR Pr Mar 2021	8.20	188.10	188.94		189.04	0.009688	1.43	6.05	14.11	0.63
Reach-1	227	(Ex) - 25Y	Ex-Oct 2015	10.89	188.10	189.11		189.21	0.006493	1.41	8.68	17.19	0.54
Reach-1	227	(Ex) - 25Y	HDR Pr Mar 2021	10.89	188.10	189.11		189.21	0.006493	1.41	8.68	17.19	0.54
Reach-1	227	(Ex) - 50Y	Ex-Oct 2015	13.72	188.10	189.55		189.60	0.001587	0.96	20.71	43.38	0.29
Reach-1	227	(Ex) - 50Y	HDR Pr Mar 2021	13.72	188.10	189.55		189.60	0.001587	0.96	20.71	43.38	0.29
Reach-1	227	(Ex) - 100Y	Ex-Oct 2015	16.73	188.10	189.71		189.75	0.001351	0.97	28.19	55.33	0.27
Reach-1	227	(Ex) - 100Y	HDR Pr Mar 2021	16.73	188.10	189.71		189.75	0.001351	0.97	28.19	55.33	0.27
Reach-1	227	(Ex) - Regional	Ex-Oct 2015	46.48	188.10	191.15		191.15	0.000047	0.30	449.16	402.73	0.06
Reach-1	227	(Ex) - Regional	HDR Pr Mar 2021	46.48	188.10	191.14		191.14	0.000047	0.30	432.44	365.55	0.06
Reach-1	226	(Ex) - 2Y	Ex-Oct 2015	2.59	187.80	188.20		188.22	0.004048	0.67	4.48	19.67	0.37
Reach-1	226	(Ex) - 2Y	HDR Pr Mar 2021	2.59	187.80	188.20		188.22	0.004048	0.67	4.48	19.67	0.37
Reach-1	226	(Ex) - 5Y	Ex-Oct 2015	5.06	187.80	188.38		188.41	0.002912	0.77	8.46	23.30	0.34
Reach-1	226	(Ex) - 5Y	HDR Pr Mar 2021	5.06	187.80	188.38		188.41	0.002912	0.77	8.46	23.30	0.34
Reach-1	226	(Ex) - 10Y	Ex-Oct 2015	8.20	187.80	188.66		188.68	0.001501	0.74	15.46	27.47	0.26
Reach-1	226	(Ex) - 10Y	HDR Pr Mar 2021	8.20	187.80	188.66		188.68	0.001501	0.74	15.46	27.47	0.26
Reach-1	226	(Ex) - 25Y	Ex-Oct 2015	10.89	187.80	189.00		189.01	0.000674	0.63	25.68	32.54	0.19
Reach-1	226	(Ex) - 25Y	HDR Pr Mar 2021	10.89	187.80	189.00		189.01	0.000674	0.63	25.68	32.54	0.19
Reach-1	226	(Ex) - 50Y	Ex-Oct 2015	13.72	187.80	189.53		189.54	0.000196	0.44	61.97	97.15	0.11
Reach-1	226	(Ex) - 50Y	HDR Pr Mar 2021	13.72	187.80	189.53		189.54	0.000196	0.44	61.97	97.15	0.11
Reach-1	226	(Ex) - 100Y	Ex-Oct 2015	16.73	187.80	189.68		189.69	0.000187	0.45	77.91	111.56	0.11
Reach-1	226	(Ex) - 100Y	HDR Pr Mar 2021	16.73	187.80	189.68		189.69	0.000187	0.45	77.91	111.56	0.11
Reach-1	226	(Ex) - Regional	Ex-Oct 2015	46.48	187.80	191.14		191.14	0.000025	0.25	538.61	403.56	0.04
Reach-1	226	(Ex) - Regional	HDR Pr Mar 2021	46.48	187.80	191.13		191.14	0.000029	0.26	511.57	398.67	0.05
Reach-1	225	(Ex) - 2Y	Ex-Oct 2015	2.59	187.30	187.91		187.92	0.000767	0.36	8.91	29.47	0.17
Reach-1	225	(Ex) - 2Y	HDR Pr Mar 2021	2.59	187.30	187.91		187.92	0.000767	0.36	8.91	29.47	0.17
Reach-1	225	(Ex) - 5Y	Ex-Oct 2015	5.06	187.30	188.24		188.25	0.000354	0.35	19.83	37.30	0.13

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	225	(Ex) - 5Y	HDR Pr Mar 2021	5.06	187.30	188.24		188.25	0.000354	0.35	19.83	37.30	0.13
Reach-1	225	(Ex) - 10Y	Ex-Oct 2015	8.20	187.30	188.57		188.58	0.000232	0.36	33.64	45.24	0.11
Reach-1	225	(Ex) - 10Y	HDR Pr Mar 2021	8.20	187.30	188.57		188.58	0.000232	0.36	33.64	45.24	0.11
Reach-1	225	(Ex) - 25Y	Ex-Oct 2015	10.89	187.30	188.96		188.96	0.000126	0.32	52.91	59.18	0.08
Reach-1	225	(Ex) - 25Y	HDR Pr Mar 2021	10.89	187.30	188.96		188.96	0.000126	0.32	52.91	59.18	0.08
Reach-1	225	(Ex) - 50Y	Ex-Oct 2015	13.72	187.30	189.52		189.52	0.000051	0.26	96.96	104.23	0.06
Reach-1	225	(Ex) - 50Y	HDR Pr Mar 2021	13.72	187.30	189.52		189.52	0.000051	0.26	96.96	104.23	0.06
Reach-1	225	(Ex) - 100Y	Ex-Oct 2015	16.73	187.30	189.67		189.67	0.000054	0.28	115.12	136.67	0.06
Reach-1	225	(Ex) - 100Y	HDR Pr Mar 2021	16.73	187.30	189.67		189.67	0.000054	0.28	115.12	136.67	0.06
Reach-1	225	(Ex) - Regional	Ex-Oct 2015	46.48	187.30	191.14		191.14	0.000016	0.21	576.33	354.82	0.03
Reach-1	225	(Ex) - Regional	HDR Pr Mar 2021	46.48	187.30	191.13		191.13	0.000016	0.21	570.83	354.46	0.04
Reach-1	224	(Ex) - 2Y	Ex-Oct 2015	6.67	187.03	187.82	187.50	187.83	0.000582	0.45	35.47	89.17	0.16
Reach-1	224	(Ex) - 2Y	HDR Pr Mar 2021	6.67	187.03	187.82	187.50	187.83	0.000582	0.45	35.47	89.17	0.16
Reach-1	224	(Ex) - 5Y	Ex-Oct 2015	16.12	187.03	188.18	187.65	188.18	0.000464	0.51	68.71	97.17	0.16
Reach-1	224	(Ex) - 5Y	HDR Pr Mar 2021	16.12	187.03	188.18	187.65	188.18	0.000464	0.51	68.71	97.17	0.16
Reach-1	224	(Ex) - 10Y	Ex-Oct 2015	26.72	187.03	188.53	187.72	188.53	0.000372	0.55	103.36	104.54	0.15
Reach-1	224	(Ex) - 10Y	HDR Pr Mar 2021	26.72	187.03	188.53	187.72	188.53	0.000372	0.55	103.36	104.54	0.15
Reach-1	224	(Ex) - 25Y	Ex-Oct 2015	35.64	187.03	188.93	187.78	188.93	0.000247	0.53	151.23	127.71	0.12
Reach-1	224	(Ex) - 25Y	HDR Pr Mar 2021	35.64	187.03	188.93	187.78	188.93	0.000247	0.53	151.23	127.71	0.12
Reach-1	224	(Ex) - 50Y	Ex-Oct 2015	44.65	187.03	189.50	187.82	189.50	0.000117	0.43	238.76	178.34	0.09
Reach-1	224	(Ex) - 50Y	HDR Pr Mar 2021	44.65	187.03	189.50	187.82	189.50	0.000117	0.43	238.76	178.34	0.09
Reach-1	224	(Ex) - 100Y	Ex-Oct 2015	54.81	187.03	189.65	187.87	189.66	0.000132	0.48	266.17	190.33	0.10
Reach-1	224	(Ex) - 100Y	HDR Pr Mar 2021	54.81	187.03	189.65	187.87	189.66	0.000132	0.48	266.17	190.33	0.10
Reach-1	224	(Ex) - Regional	Ex-Oct 2015	158.24	187.03	191.13	188.24	191.13	0.000133	0.65	679.66	372.19	0.10
Reach-1	224	(Ex) - Regional	HDR Pr Mar 2021	158.24	187.03	191.12	188.24	191.12	0.000135	0.66	680.50	376.76	0.10
Reach-1	223	(Ex) - 2Y	Ex-Oct 2015	6.67	186.81	187.62	187.27	187.64	0.001844	0.63	10.65	20.04	0.27
Reach-1	223	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.81	187.62	187.27	187.64	0.001844	0.63	10.65	20.04	0.27
Reach-1	223	(Ex) - 5Y	Ex-Oct 2015	16.12	186.81	187.97	187.48	188.01	0.002052	0.90	17.90	22.02	0.31
Reach-1	223	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.81	187.97	187.48	188.01	0.002052	0.90	17.90	22.02	0.31
Reach-1	223	(Ex) - 10Y	Ex-Oct 2015	26.72	186.81	188.33	187.65	188.39	0.001730	1.05	25.52	24.13	0.30
Reach-1	223	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.81	188.33	187.65	188.39	0.001730	1.05	25.52	24.13	0.30
Reach-1	223	(Ex) - 25Y	Ex-Oct 2015	35.64	186.81	188.78	187.77	188.84	0.001073	1.02	35.00	26.30	0.25
Reach-1	223	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.81	188.78	187.77	188.84	0.001073	1.02	35.00	26.30	0.25
Reach-1	223	(Ex) - 50Y	Ex-Oct 2015	44.65	186.81	189.41	187.88	189.46	0.000579	0.93	48.22	35.15	0.20
Reach-1	223	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.81	189.41	187.88	189.46	0.000579	0.93	48.22	35.15	0.20
Reach-1	223	(Ex) - 100Y	Ex-Oct 2015	54.81	186.81	189.54	188.00	189.60	0.000729	1.08	50.89	43.20	0.22
Reach-1	223	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.81	189.54	188.00	189.60	0.000729	1.08	50.89	43.20	0.22
Reach-1	223	(Ex) - Regional	Ex-Oct 2015	158.24	186.81	190.96	188.91	191.07	0.000887	1.57	192.89	215.98	0.26
Reach-1	223	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.81	190.96	188.91	191.06	0.000883	1.57	194.94	218.05	0.26
Reach-1	222.5			Bridge									
Reach-1	222	(Ex) - 2Y	Ex-Oct 2015	6.67	186.60	187.52		187.54	0.001231	0.57	11.75	50.75	0.23
Reach-1	222	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.60	187.52		187.54	0.001231	0.57	11.75	50.75	0.23
Reach-1	222	(Ex) - 5Y	Ex-Oct 2015	16.12	186.60	187.85		187.89	0.001896	0.88	18.30	57.16	0.30
Reach-1	222	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.60	187.85		187.89	0.001896	0.88	18.30	57.16	0.30
Reach-1	222	(Ex) - 10Y	Ex-Oct 2015	26.72	186.60	188.23		188.28	0.001564	1.02	26.25	64.64	0.29
Reach-1	222	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.60	188.23		188.28	0.001564	1.02	26.25	64.64	0.29
Reach-1	222	(Ex) - 25Y	Ex-Oct 2015	35.64	186.60	188.72		188.77	0.000920	0.97	36.59	72.54	0.24
Reach-1	222	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.60	188.72		188.77	0.000920	0.97	36.59	72.54	0.24
Reach-1	222	(Ex) - 50Y	Ex-Oct 2015	44.65	186.60	189.38		189.42	0.000496	0.89	50.41	83.86	0.18
Reach-1	222	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.60	189.38		189.42	0.000496	0.89	50.41	83.86	0.18
Reach-1	222	(Ex) - 100Y	Ex-Oct 2015	54.81	186.60	189.49		189.55	0.000638	1.04	52.86	85.92	0.21
Reach-1	222	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.60	189.49		189.55	0.000638	1.04	52.86	85.92	0.21
Reach-1	222	(Ex) - Regional	Ex-Oct 2015	158.24	186.60	190.04	188.77	190.35	0.002757	2.46	64.39	170.60	0.45
Reach-1	222	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.60	190.04	188.77	190.35	0.002754	2.46	64.41	171.46	0.45
Reach-1	221	(Ex) - 2Y	Ex-Oct 2015	6.67	186.20	187.47		187.48	0.000447	0.51	25.33	42.24	0.15
Reach-1	221	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.20	187.47		187.48	0.000447	0.51	25.33	42.24	0.15
Reach-1	221	(Ex) - 5Y	Ex-Oct 2015	16.12	186.20	187.75		187.77	0.000894	0.83	38.07	47.12	0.22
Reach-1	221	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.20	187.75		187.77	0.000894	0.83	38.07	47.12	0.22
Reach-1	221	(Ex) - 10Y	Ex-Oct 2015	26.72	186.20	188.15		188.17	0.000761	0.91	57.86	51.29	0.22
Reach-1	221	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.20	188.15		188.17	0.000761	0.91	57.86	51.29	0.22
Reach-1	221	(Ex) - 25Y	Ex-Oct 2015	35.64	186.20	188.68		188.70	0.000434	0.81	86.51	56.64	0.17
Reach-1	221	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.20	188.68		188.70	0.000434	0.81	86.51	56.64	0.17
Reach-1	221	(Ex) - 50Y	Ex-Oct 2015	44.65	186.20	189.36		189.37	0.000228	0.70	127.45	63.95	0.13
Reach-1	221	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.20	189.36		189.37	0.000228	0.70	127.45	63.95	0.13
Reach-1	221	(Ex) - 100Y	Ex-Oct 2015	54.81	186.20	189.48		189.49	0.000293	0.81	136.02	77.57	0.15
Reach-1	221	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.20	189.48		189.49	0.000293	0.81	134.86	65.55	0.15
Reach-1	221	(Ex) - Regional	Ex-Oct 2015	158.24	186.20	190.02		190.08	0.001180	1.81	189.09	116.16	0.30
Reach-1	221	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.20	190.01		190.08	0.001227	1.84	179.44	107.76	0.31
Reach-1	220	(Ex) - 2Y	Ex-Oct 2015	6.67	186.20	187.44		187.44	0.000505	0.53	28.26	54.78	0.16
Reach-1	220	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.20	187.44		187.44	0.000505	0.53	28.26	54.78	0.16
Reach-1	220	(Ex) - 5Y	Ex-Oct 2015	16.12	186.20	187.69		187.71	0.000966	0.84	43.25	62.41	0.23
Reach-1	220	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.20	187.69		187.71	0.000966	0.84	43.25	62.41	0.23
Reach-1	220	(Ex) - 10Y	Ex-Oct 2015	26.72	186.20	188.11		188.12	0.000644	0.82	70.59	67.17	0.20
Reach-1	220	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.20	188.11		188.12	0.000644	0.82	70.59	67.17	0.20
Reach-1	220	(Ex) - 25Y	Ex-Oct 2015	35.64	186.20	188.66		188.67	0.000317	0.69	109.31	72.89	0.14
Reach-1	220	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.20	188.66		188.67	0.000317	0.69	109.31	72.89	0.14
Reach-1	220	(Ex) - 50Y	Ex-Oct 2015	44.65	186.20	189.35		189.36	0.000159	0.58	161.99	81.53	0.11
Reach-1	220	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.20	189.35		189.36	0.000159	0.58	162.13	82.14	0.11
Reach-1	220	(Ex) - 100Y	Ex-Oct 2015	54.81	186.20	189.47		189.47	0.000206	0.68	171.32	85.17	0.12
Reach-1	220	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.20	189.47		189.47	0.000206	0.68	171.48	84.76	0.12
Reach-1	220	(Ex) - Regional	Ex-Oct 2015	158.24	186.20	189.96		190.00	0.000896	1.56	217.61	108.90	0.26

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	220	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.20	189.96		190.00	0.000900	1.56	216.39	103.05	0.26
Reach-1	219	(Ex) - 2Y	Ex-Oct 2015	6.67	186.20	187.41		187.41	0.000103	0.23	74.03	148.41	0.07
Reach-1	219	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.20	187.41		187.41	0.000103	0.23	74.03	148.41	0.07
Reach-1	219	(Ex) - 5Y	Ex-Oct 2015	16.12	186.20	187.65		187.65	0.000185	0.36	109.15	152.24	0.10
Reach-1	219	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.20	187.65		187.65	0.000185	0.36	109.15	152.24	0.10
Reach-1	219	(Ex) - 10Y	Ex-Oct 2015	26.72	186.20	188.09		188.09	0.000112	0.34	177.28	157.74	0.08
Reach-1	219	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.20	188.09		188.09	0.000112	0.34	177.28	157.74	0.08
Reach-1	219	(Ex) - 25Y	Ex-Oct 2015	35.64	186.20	188.65		188.65	0.000054	0.28	268.61	164.54	0.06
Reach-1	219	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.20	188.65		188.65	0.000054	0.28	268.61	164.54	0.06
Reach-1	219	(Ex) - 50Y	Ex-Oct 2015	44.65	186.20	189.35		189.35	0.000027	0.24	397.62	235.26	0.04
Reach-1	219	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.20	189.35		189.35	0.000027	0.24	395.03	226.95	0.04
Reach-1	219	(Ex) - 100Y	Ex-Oct 2015	54.81	186.20	189.46		189.46	0.000034	0.28	424.38	247.65	0.05
Reach-1	219	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.20	189.46		189.46	0.000034	0.28	420.85	238.88	0.05
Reach-1	219	(Ex) - Regional	Ex-Oct 2015	158.24	186.20	189.94		189.94	0.000196	0.73	560.68	296.67	0.12
Reach-1	219	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.20	189.93		189.94	0.000198	0.73	551.53	285.89	0.12
Reach-1	218	(Ex) - 2Y	Ex-Oct 2015	6.67	186.20	187.40		187.40	0.000084	0.21	85.82	179.91	0.07
Reach-1	218	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.20	187.40		187.40	0.000084	0.21	85.82	179.91	0.07
Reach-1	218	(Ex) - 5Y	Ex-Oct 2015	16.12	186.20	187.62		187.63	0.000148	0.32	126.42	183.06	0.09
Reach-1	218	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.20	187.62		187.63	0.000148	0.32	126.42	183.06	0.09
Reach-1	218	(Ex) - 10Y	Ex-Oct 2015	26.72	186.20	188.07		188.07	0.000082	0.29	210.03	189.39	0.07
Reach-1	218	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.20	188.07		188.07	0.000082	0.29	210.03	189.39	0.07
Reach-1	218	(Ex) - 25Y	Ex-Oct 2015	35.64	186.20	188.65		188.65	0.000038	0.24	321.35	206.42	0.05
Reach-1	218	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.20	188.65		188.65	0.000038	0.24	321.35	206.42	0.05
Reach-1	218	(Ex) - 50Y	Ex-Oct 2015	44.65	186.20	189.35		189.35	0.000022	0.22	530.62	331.88	0.04
Reach-1	218	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.20	189.35		189.35	0.000022	0.22	527.62	322.40	0.04
Reach-1	218	(Ex) - 100Y	Ex-Oct 2015	54.81	186.20	189.46		189.46	0.000027	0.25	567.28	335.70	0.04
Reach-1	218	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.20	189.46		189.46	0.000027	0.24	563.14	323.58	0.04
Reach-1	218	(Ex) - Regional	Ex-Oct 2015	158.24	186.20	189.92		189.92	0.000112	0.55	727.79	361.53	0.09
Reach-1	218	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.20	189.91		189.92	0.000106	0.53	714.25	352.80	0.09
Reach-1	217	(Ex) - 2Y	Ex-Oct 2015	6.67	186.20	187.40		187.40	0.000047	0.16	105.64	189.70	0.05
Reach-1	217	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.20	187.40		187.40	0.000047	0.16	105.64	189.70	0.05
Reach-1	217	(Ex) - 5Y	Ex-Oct 2015	16.12	186.20	187.62		187.62	0.000096	0.25	148.04	193.18	0.07
Reach-1	217	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.20	187.62		187.62	0.000096	0.25	148.04	193.18	0.07
Reach-1	217	(Ex) - 10Y	Ex-Oct 2015	26.72	186.20	188.07		188.07	0.000060	0.25	236.73	200.28	0.06
Reach-1	217	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.20	188.07		188.07	0.000060	0.25	236.73	200.28	0.06
Reach-1	217	(Ex) - 25Y	Ex-Oct 2015	35.64	186.20	188.65		188.65	0.000031	0.21	365.87	262.69	0.04
Reach-1	217	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.20	188.65		188.65	0.000031	0.21	365.87	262.69	0.04
Reach-1	217	(Ex) - 50Y	Ex-Oct 2015	44.65	186.20	189.35		189.35	0.000017	0.19	576.81	340.04	0.03
Reach-1	217	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.20	189.35		189.35	0.000017	0.19	575.87	329.40	0.03
Reach-1	217	(Ex) - 100Y	Ex-Oct 2015	54.81	186.20	189.46		189.46	0.000021	0.22	614.67	349.77	0.04
Reach-1	217	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.20	189.46		189.46	0.000021	0.21	612.09	330.34	0.04
Reach-1	217	(Ex) - Regional	Ex-Oct 2015	158.24	186.20	189.91		189.92	0.000096	0.50	789.73	404.73	0.09
Reach-1	217	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.20	189.91		189.91	0.000099	0.51	779.75	404.61	0.09
Reach-1	216	(Ex) - 2Y	Ex-Oct 2015	6.67	186.10	187.39		187.39	0.000032	0.14	112.77	161.45	0.04
Reach-1	216	(Ex) - 2Y	HDR Pr Mar 2021	6.67	186.10	187.39		187.39	0.000032	0.14	112.77	161.45	0.04
Reach-1	216	(Ex) - 5Y	Ex-Oct 2015	16.12	186.10	187.61		187.61	0.000080	0.24	148.13	168.09	0.07
Reach-1	216	(Ex) - 5Y	HDR Pr Mar 2021	16.12	186.10	187.61		187.61	0.000080	0.24	148.13	168.09	0.07
Reach-1	216	(Ex) - 10Y	Ex-Oct 2015	26.72	186.10	188.06		188.06	0.000060	0.25	227.81	182.80	0.06
Reach-1	216	(Ex) - 10Y	HDR Pr Mar 2021	26.72	186.10	188.06		188.06	0.000060	0.25	227.81	182.80	0.06
Reach-1	216	(Ex) - 25Y	Ex-Oct 2015	35.64	186.10	188.64		188.64	0.000033	0.23	352.89	229.96	0.05
Reach-1	216	(Ex) - 25Y	HDR Pr Mar 2021	35.64	186.10	188.64		188.64	0.000033	0.23	352.89	229.96	0.05
Reach-1	216	(Ex) - 50Y	Ex-Oct 2015	44.65	186.10	189.34		189.34	0.000017	0.20	574.85	352.53	0.04
Reach-1	216	(Ex) - 50Y	HDR Pr Mar 2021	44.65	186.10	189.34		189.34	0.000017	0.20	574.29	344.76	0.04
Reach-1	216	(Ex) - 100Y	Ex-Oct 2015	54.81	186.10	189.45		189.45	0.000021	0.22	613.71	358.51	0.04
Reach-1	216	(Ex) - 100Y	HDR Pr Mar 2021	54.81	186.10	189.45		189.45	0.000021	0.22	612.39	354.89	0.04
Reach-1	216	(Ex) - Regional	Ex-Oct 2015	158.24	186.10	189.90		189.90	0.000094	0.51	782.28	391.01	0.09
Reach-1	216	(Ex) - Regional	HDR Pr Mar 2021	158.24	186.10	189.90		189.90	0.000094	0.51	781.12	389.31	0.09
Reach-1	215	(Ex) - 2Y	Ex-Oct 2015	7.53	186.00	187.39		187.39	0.000013	0.09	175.75	200.05	0.03
Reach-1	215	(Ex) - 2Y	HDR Pr Mar 2021	7.53	186.00	187.39		187.39	0.000013	0.09	175.75	200.05	0.03
Reach-1	215	(Ex) - 5Y	Ex-Oct 2015	17.50	186.00	187.60		187.60	0.000037	0.17	221.13	222.21	0.05
Reach-1	215	(Ex) - 5Y	HDR Pr Mar 2021	17.50	186.00	187.60		187.60	0.000037	0.17	221.13	222.21	0.05
Reach-1	215	(Ex) - 10Y	Ex-Oct 2015	31.27	186.00	188.06		188.06	0.000036	0.20	327.56	243.19	0.05
Reach-1	215	(Ex) - 10Y	HDR Pr Mar 2021	31.27	186.00	188.06		188.06	0.000036	0.20	327.56	243.19	0.05
Reach-1	215	(Ex) - 25Y	Ex-Oct 2015	42.17	186.00	188.64		188.64	0.000021	0.19	471.24	249.88	0.04
Reach-1	215	(Ex) - 25Y	HDR Pr Mar 2021	42.17	186.00	188.64		188.64	0.000021	0.19	471.24	249.88	0.04
Reach-1	215	(Ex) - 50Y	Ex-Oct 2015	53.27	186.00	189.34		189.34	0.000012	0.17	650.14	259.48	0.03
Reach-1	215	(Ex) - 50Y	HDR Pr Mar 2021	53.27	186.00	189.34		189.34	0.000012	0.17	650.14	259.48	0.03
Reach-1	215	(Ex) - 100Y	Ex-Oct 2015	65.78	186.00	189.45		189.45	0.000016	0.20	678.43	261.45	0.03
Reach-1	215	(Ex) - 100Y	HDR Pr Mar 2021	65.78	186.00	189.45		189.45	0.000016	0.20	678.43	261.45	0.03
Reach-1	215	(Ex) - Regional	Ex-Oct 2015	200.73	186.00	189.88		189.89	0.000140	0.63	831.35	419.37	0.10
Reach-1	215	(Ex) - Regional	HDR Pr Mar 2021	200.73	186.00	189.88		189.88	0.000125	0.60	823.50	375.07	0.10
Reach-1	214	(Ex) - 2Y	Ex-Oct 2015	7.53	186.00	187.39		187.39	0.000009	0.07	214.78	251.79	0.02
Reach-1	214	(Ex) - 2Y	HDR Pr Mar 2021	7.53	186.00	187.39		187.39	0.000009	0.07	214.78	251.79	0.02
Reach-1	214	(Ex) - 5Y	Ex-Oct 2015	17.50	186.00	187.60		187.60	0.000023	0.13	268.04	257.49	0.04
Reach-1	214	(Ex) - 5Y	HDR Pr Mar 2021	17.50	186.00	187.60		187.60	0.000023	0.13	268.04	257.49	0.04
Reach-1	214	(Ex) - 10Y	Ex-Oct 2015	31.27	186.00	188.05		188.05	0.000023	0.16	387.31	266.30	0.04
Reach-1	214	(Ex) - 10Y	HDR Pr Mar 2021	31.27	186.00	188.05		188.05	0.000023	0.16	387.31	266.30	0.04
Reach-1	214	(Ex) - 25Y	Ex-Oct 2015	42.17	186.00	188.64		188.64	0.000015	0.15	548.15	285.92	0.03
Reach-1	214	(Ex) - 25Y	HDR Pr Mar 2021	42.17	186.00	188.64		188.64	0.000015	0.15	548.15	285.92	0.03
Reach-1	214	(Ex) - 50Y	Ex-Oct 2015	53.27	186.00	189.34		189.34	0.000009	0.14	758.36	314.23	0.03
Reach-1	214	(Ex) - 50Y	HDR Pr Mar 2021	53.27	186.00	189.34		189.34	0.000009	0.14	758.09	312.34	0.03

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	214	(Ex) - 100Y	Ex-Oct 2015	65.78	186.00	189.45		189.45	0.000012	0.17	793.04	329.96	0.03
Reach-1	214	(Ex) - 100Y	HDR Pr Mar 2021	65.78	186.00	189.45		189.45	0.000012	0.17	792.54	327.63	0.03
Reach-1	214	(Ex) - Regional	Ex-Oct 2015	200.73	186.00	189.87		189.87	0.000085	0.48	960.78	420.37	0.08
Reach-1	214	(Ex) - Regional	HDR Pr Mar 2021	200.73	186.00	189.87		189.87	0.000080	0.47	951.79	388.69	0.08
Reach-1	213	(Ex) - 2Y	Ex-Oct 2015	7.53	186.00	187.39		187.39	0.000004	0.05	275.57	262.74	0.02
Reach-1	213	(Ex) - 2Y	HDR Pr Mar 2021	7.53	186.00	187.39		187.39	0.000004	0.05	275.57	262.74	0.02
Reach-1	213	(Ex) - 5Y	Ex-Oct 2015	17.50	186.00	187.60		187.60	0.000013	0.10	330.16	264.69	0.03
Reach-1	213	(Ex) - 5Y	HDR Pr Mar 2021	17.50	186.00	187.60		187.60	0.000013	0.10	330.16	264.69	0.03
Reach-1	213	(Ex) - 10Y	Ex-Oct 2015	31.27	186.00	188.05		188.05	0.000015	0.13	451.64	268.83	0.03
Reach-1	213	(Ex) - 10Y	HDR Pr Mar 2021	31.27	186.00	188.05		188.05	0.000015	0.13	451.64	268.83	0.03
Reach-1	213	(Ex) - 25Y	Ex-Oct 2015	42.17	186.00	188.63		188.63	0.000010	0.13	609.90	273.83	0.03
Reach-1	213	(Ex) - 25Y	HDR Pr Mar 2021	42.17	186.00	188.63		188.63	0.000010	0.13	609.90	273.83	0.03
Reach-1	213	(Ex) - 50Y	Ex-Oct 2015	53.27	186.00	189.34		189.34	0.000009	0.14	821.35	387.39	0.03
Reach-1	213	(Ex) - 50Y	HDR Pr Mar 2021	53.27	186.00	189.34		189.34	0.000009	0.14	821.31	385.36	0.03
Reach-1	213	(Ex) - 100Y	Ex-Oct 2015	65.78	186.00	189.45		189.45	0.000012	0.17	863.59	395.53	0.03
Reach-1	213	(Ex) - 100Y	HDR Pr Mar 2021	65.78	186.00	189.45		189.45	0.000012	0.17	863.03	388.00	0.03
Reach-1	213	(Ex) - Regional	Ex-Oct 2015	200.73	186.00	189.86		189.87	0.000074	0.45	1039.27	452.77	0.08
Reach-1	213	(Ex) - Regional	HDR Pr Mar 2021	200.73	186.00	189.86		189.86	0.000067	0.43	1027.20	419.15	0.07
Reach-1	212	(Ex) - 2Y	Ex-Oct 2015	7.53	186.00	187.39		187.39	0.000006	0.06	242.59	255.49	0.02
Reach-1	212	(Ex) - 2Y	HDR Pr Mar 2021	7.53	186.00	187.39		187.39	0.000006	0.06	242.59	255.49	0.02
Reach-1	212	(Ex) - 5Y	Ex-Oct 2015	17.50	186.00	187.59		187.59	0.000017	0.12	295.52	257.66	0.03
Reach-1	212	(Ex) - 5Y	HDR Pr Mar 2021	17.50	186.00	187.59		187.59	0.000017	0.12	295.52	257.66	0.03
Reach-1	212	(Ex) - 10Y	Ex-Oct 2015	31.27	186.00	188.05		188.05	0.000019	0.15	413.54	260.94	0.03
Reach-1	212	(Ex) - 10Y	HDR Pr Mar 2021	31.27	186.00	188.05		188.05	0.000019	0.15	413.54	260.94	0.03
Reach-1	212	(Ex) - 25Y	Ex-Oct 2015	42.17	186.00	188.63		188.63	0.000012	0.14	567.15	265.32	0.03
Reach-1	212	(Ex) - 25Y	HDR Pr Mar 2021	42.17	186.00	188.63		188.63	0.000012	0.14	567.15	265.32	0.03
Reach-1	212	(Ex) - 50Y	Ex-Oct 2015	53.27	186.00	189.34		189.34	0.000008	0.13	756.55	271.75	0.02
Reach-1	212	(Ex) - 50Y	HDR Pr Mar 2021	53.27	186.00	189.34		189.34	0.000008	0.13	756.55	271.75	0.02
Reach-1	212	(Ex) - 100Y	Ex-Oct 2015	65.78	186.00	189.45		189.45	0.000011	0.16	785.92	274.02	0.03
Reach-1	212	(Ex) - 100Y	HDR Pr Mar 2021	65.78	186.00	189.45		189.45	0.000011	0.16	785.92	274.02	0.03
Reach-1	212	(Ex) - Regional	Ex-Oct 2015	200.73	186.00	189.86		189.86	0.000065	0.43	899.83	282.65	0.07
Reach-1	212	(Ex) - Regional	HDR Pr Mar 2021	200.73	186.00	189.86		189.86	0.000065	0.43	899.82	282.65	0.07
Reach-1	211	(Ex) - 2Y	Ex-Oct 2015	7.53	185.99	187.39		187.39	0.000006	0.06	252.96	256.39	0.02
Reach-1	211	(Ex) - 2Y	HDR Pr Mar 2021	7.53	185.99	187.39		187.39	0.000006	0.06	252.96	256.39	0.02
Reach-1	211	(Ex) - 5Y	Ex-Oct 2015	17.50	185.99	187.59		187.59	0.000016	0.11	305.72	257.76	0.03
Reach-1	211	(Ex) - 5Y	HDR Pr Mar 2021	17.50	185.99	187.59		187.59	0.000016	0.11	305.72	257.76	0.03
Reach-1	211	(Ex) - 10Y	Ex-Oct 2015	31.27	185.99	188.05		188.05	0.000018	0.14	423.69	260.80	0.03
Reach-1	211	(Ex) - 10Y	HDR Pr Mar 2021	31.27	185.99	188.05		188.05	0.000018	0.14	423.69	260.80	0.03
Reach-1	211	(Ex) - 25Y	Ex-Oct 2015	42.17	185.99	188.63		188.63	0.000012	0.14	577.24	264.85	0.03
Reach-1	211	(Ex) - 25Y	HDR Pr Mar 2021	42.17	185.99	188.63		188.63	0.000012	0.14	577.24	264.85	0.03
Reach-1	211	(Ex) - 50Y	Ex-Oct 2015	53.27	185.99	189.34		189.34	0.000008	0.13	767.20	273.49	0.02
Reach-1	211	(Ex) - 50Y	HDR Pr Mar 2021	53.27	185.99	189.34		189.34	0.000008	0.13	767.20	273.49	0.02
Reach-1	211	(Ex) - 100Y	Ex-Oct 2015	65.78	185.99	189.45		189.45	0.000010	0.16	796.65	275.00	0.03
Reach-1	211	(Ex) - 100Y	HDR Pr Mar 2021	65.78	185.99	189.45		189.45	0.000010	0.16	796.65	275.00	0.03
Reach-1	211	(Ex) - Regional	Ex-Oct 2015	200.73	185.99	189.85		189.85	0.000063	0.42	909.21	281.85	0.07
Reach-1	211	(Ex) - Regional	HDR Pr Mar 2021	200.73	185.99	189.85		189.85	0.000064	0.42	909.21	281.85	0.07
Reach-1	210	(Ex) - 2Y	Ex-Oct 2015	7.53	185.90	187.39		187.39	0.000039	0.16	88.24	85.54	0.05
Reach-1	210	(Ex) - 2Y	HDR Pr Mar 2021	7.53	185.90	187.39		187.39	0.000039	0.16	88.24	85.54	0.05
Reach-1	210	(Ex) - 5Y	Ex-Oct 2015	17.50	185.90	187.59		187.59	0.000121	0.32	105.59	87.45	0.08
Reach-1	210	(Ex) - 5Y	HDR Pr Mar 2021	17.50	185.90	187.59		187.59	0.000121	0.32	105.59	87.45	0.08
Reach-1	210	(Ex) - 10Y	Ex-Oct 2015	31.27	185.90	188.04		188.04	0.000141	0.41	146.22	92.06	0.09
Reach-1	210	(Ex) - 10Y	HDR Pr Mar 2021	31.27	185.90	188.04		188.04	0.000141	0.41	146.22	92.06	0.09
Reach-1	210	(Ex) - 25Y	Ex-Oct 2015	42.17	185.90	188.63		188.63	0.000118	0.44	221.09	161.87	0.09
Reach-1	210	(Ex) - 25Y	HDR Pr Mar 2021	42.17	185.90	188.63		188.63	0.000118	0.44	221.09	161.87	0.09
Reach-1	210	(Ex) - 50Y	Ex-Oct 2015	53.27	185.90	189.33		189.34	0.000055	0.36	374.99	237.76	0.06
Reach-1	210	(Ex) - 50Y	HDR Pr Mar 2021	53.27	185.90	189.33		189.34	0.000055	0.36	374.99	237.76	0.06
Reach-1	210	(Ex) - 100Y	Ex-Oct 2015	65.78	185.90	189.44		189.44	0.000070	0.41	400.47	244.24	0.07
Reach-1	210	(Ex) - 100Y	HDR Pr Mar 2021	65.78	185.90	189.44		189.44	0.000070	0.41	400.47	244.24	0.07
Reach-1	210	(Ex) - Regional	Ex-Oct 2015	200.73	185.90	189.82		189.83	0.000384	1.04	501.51	281.05	0.17
Reach-1	210	(Ex) - Regional	HDR Pr Mar 2021	200.73	185.90	189.82		189.83	0.000384	1.04	501.51	281.05	0.17
Reach-1	209	(Ex) - 2Y	Ex-Oct 2015	7.73	185.80	187.38		187.38	0.000040	0.17	89.33	85.75	0.05
Reach-1	209	(Ex) - 2Y	HDR Pr Mar 2021	7.73	185.80	187.38		187.38	0.000040	0.17	89.33	85.75	0.05
Reach-1	209	(Ex) - 5Y	Ex-Oct 2015	17.80	185.80	187.58		187.58	0.000122	0.32	106.24	87.35	0.08
Reach-1	209	(Ex) - 5Y	HDR Pr Mar 2021	17.80	185.80	187.58		187.58	0.000122	0.32	106.24	87.35	0.08
Reach-1	209	(Ex) - 10Y	Ex-Oct 2015	31.76	185.80	188.03		188.03	0.000143	0.41	146.62	91.64	0.09
Reach-1	209	(Ex) - 10Y	HDR Pr Mar 2021	31.76	185.80	188.03		188.03	0.000143	0.41	146.62	91.64	0.09
Reach-1	209	(Ex) - 25Y	Ex-Oct 2015	42.70	185.80	188.62		188.62	0.000137	0.48	207.85	156.06	0.10
Reach-1	209	(Ex) - 25Y	HDR Pr Mar 2021	42.70	185.80	188.62		188.62	0.000137	0.48	207.85	156.06	0.10
Reach-1	209	(Ex) - 50Y	Ex-Oct 2015	54.07	185.80	189.33		189.33	0.000067	0.40	339.02	214.15	0.07
Reach-1	209	(Ex) - 50Y	HDR Pr Mar 2021	54.07	185.80	189.33		189.33	0.000067	0.40	339.02	214.15	0.07
Reach-1	209	(Ex) - 100Y	Ex-Oct 2015	66.78	185.80	189.44		189.44	0.000087	0.46	361.91	221.19	0.08
Reach-1	209	(Ex) - 100Y	HDR Pr Mar 2021	66.78	185.80	189.44		189.44	0.000087	0.46	361.91	221.19	0.08
Reach-1	209	(Ex) - Regional	Ex-Oct 2015	205.61	185.80	189.79		189.81	0.000479	1.16	442.31	232.91	0.19
Reach-1	209	(Ex) - Regional	HDR Pr Mar 2021	205.61	185.80	189.79		189.81	0.000479	1.16	442.31	232.91	0.19
Reach-1	208	(Ex) - 2Y	Ex-Oct 2015	7.73	185.71	187.38		187.38	0.000041	0.17	87.36	83.48	0.05
Reach-1	208	(Ex) - 2Y	HDR Pr Mar 2021	7.73	185.71	187.38		187.38	0.000041	0.17	87.36	83.48	0.05
Reach-1	208	(Ex) - 5Y	Ex-Oct 2015	17.80	185.71	187.57		187.57	0.000128	0.33	103.34	84.88	0.09
Reach-1	208	(Ex) - 5Y	HDR Pr Mar 2021	17.80	185.71	187.57		187.57	0.000128	0.33	103.34	84.88	0.09
Reach-1	208	(Ex) - 10Y	Ex-Oct 2015	31.76	185.71	188.02		188.02	0.000150	0.43	142.33	88.21	0.10
Reach-1	208	(Ex) - 10Y	HDR Pr Mar 2021	31.76	185.71	188.02		188.02	0.000150	0.43	142.33	88.21	0.10
Reach-1	208	(Ex) - 25Y	Ex-Oct 2015	42.70	185.71	188.61		188.61	0.000102	0.42	196.79	129.92	0.08

HEC-RAS River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	208	(Ex) - 25Y	HDR Pr Mar 2021	42.70	185.71	188.61		188.61	0.000102	0.42	196.79	129.92	0.08
Reach-1	208	(Ex) - 50Y	Ex-Oct 2015	54.07	185.71	189.33		189.33	0.000076	0.42	357.13	315.76	0.07
Reach-1	208	(Ex) - 50Y	HDR Pr Mar 2021	54.07	185.71	189.33		189.33	0.000076	0.42	357.13	315.76	0.07
Reach-1	208	(Ex) - 100Y	Ex-Oct 2015	66.78	185.71	189.43		189.43	0.000095	0.48	390.82	332.66	0.08
Reach-1	208	(Ex) - 100Y	HDR Pr Mar 2021	66.78	185.71	189.43		189.43	0.000095	0.48	390.82	332.66	0.08
Reach-1	208	(Ex) - Regional	Ex-Oct 2015	205.61	185.71	189.76		189.78	0.000480	1.16	506.37	361.66	0.19
Reach-1	208	(Ex) - Regional	HDR Pr Mar 2021	205.61	185.71	189.76		189.78	0.000480	1.16	506.57	363.20	0.19

Hydraulic Analysis Results for Alternative Scenarios
at C-3 Crossing

HY-8 Culvert Analysis Report

Crossing Discharge Data
Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: Test - C-3 Reg 1A 191.15

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.13	Zero	0.00	0.00	0.00	1
191.43	Regional	97.42	95.36	2.12	5
191.15	Overtopping	24.61	24.61	0.00	Overtopping

Rating Curve Plot for Crossing: Test - C-3 Reg 1A 191.15

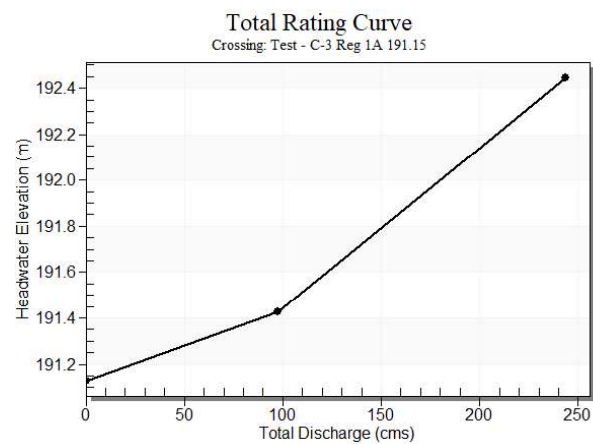
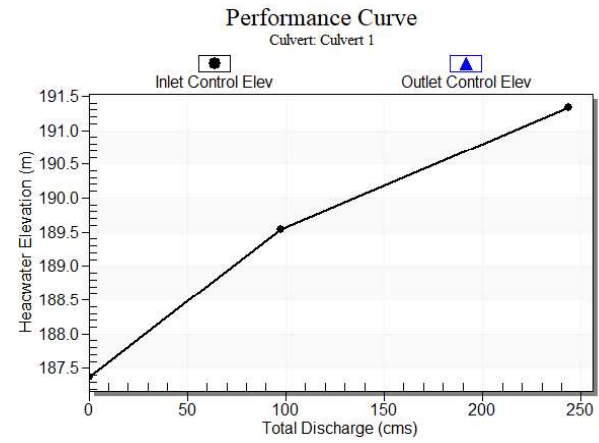


Table 2 - Culvert Summary Table: Culvert 1

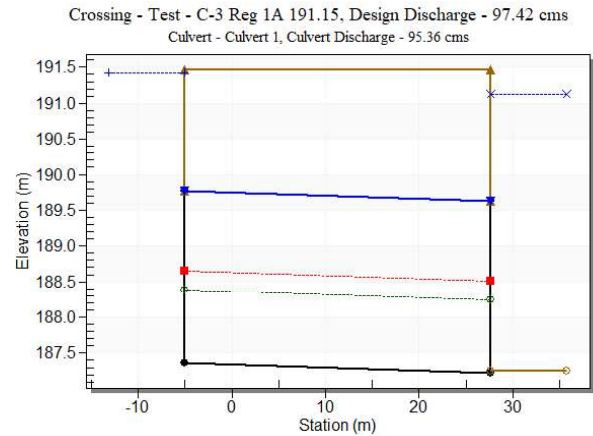
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	191.13	0.001	3.760	4-FF	0.000	0.001	2.400	3.880	0.000	0.000
Region	97.42	95.36	191.43	2.162	4.056	4-FF	1.014	1.281	2.400	3.880	1.892	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Test - C-3 Reg 1A 191.15)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Test - C-3 Reg 1A 191.15

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Test - C-3 Reg 1A 191.15

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 4 - Summary of Culvert Flows at Crossing: Test - C-3 Reg 1B 191.15

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.13	Zero	0.00	0.00	0.00	1
191.30	Regional	97.42	96.77	0.75	9
191.15	Overtopping	32.80	32.80	0.00	Overtopping

Rating Curve Plot for Crossing: Test - C-3 Reg 1B 191.15

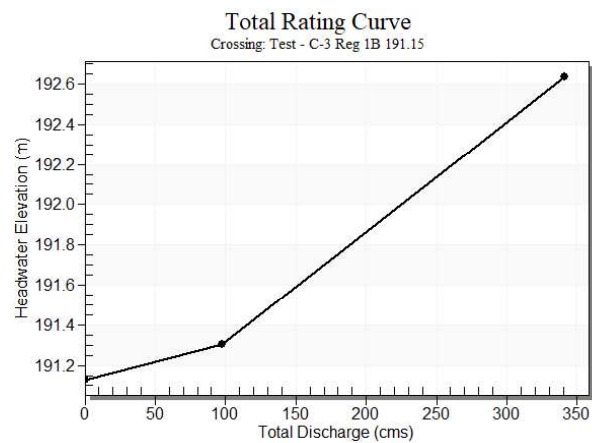
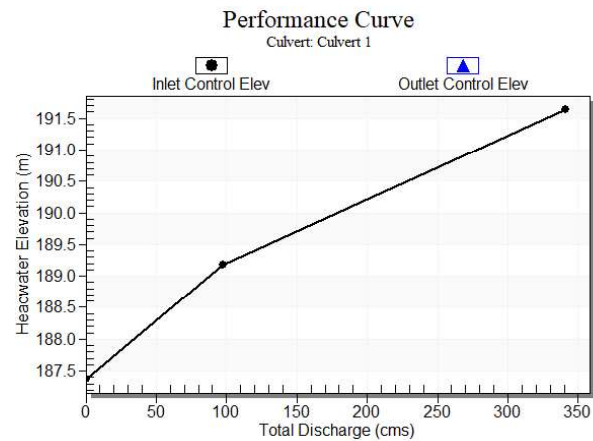


Table 5 - Culvert Summary Table: Culvert 1

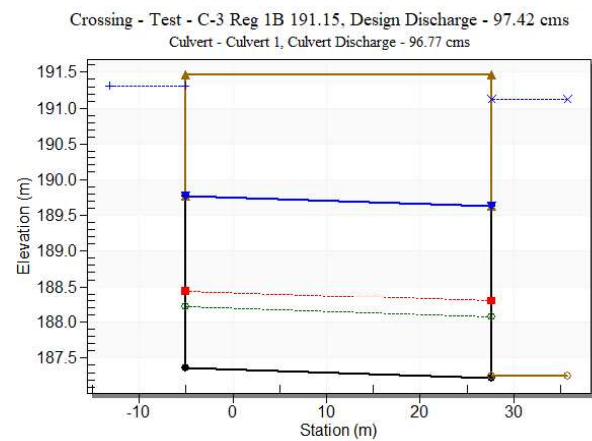
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	191.13	0.001	3.760	4-FF	0.000	0.001	2.400	3.880	0.000	0.000
Region	97.42	96.77	191.30	1.804	3.932	4-FF	0.848	1.068	2.400	3.880	1.440	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 4

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Test - C-3 Reg 1B 191.15)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Test - C-3 Reg 1B 191.15

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Test - C-3 Reg 1B 191.15

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 7 - Summary of Culvert Flows at Crossing: Test - C-3 Reg 2

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.13	Zero	0.00	0.07	0.00	2
191.28	Regional	97.42	89.04	8.51	9
190.73	Overtopping	-2935507232038 .00	-2935507232038 .00	0.00	Overtopping

Rating Curve Plot for Crossing: Test - C-3 Reg 2

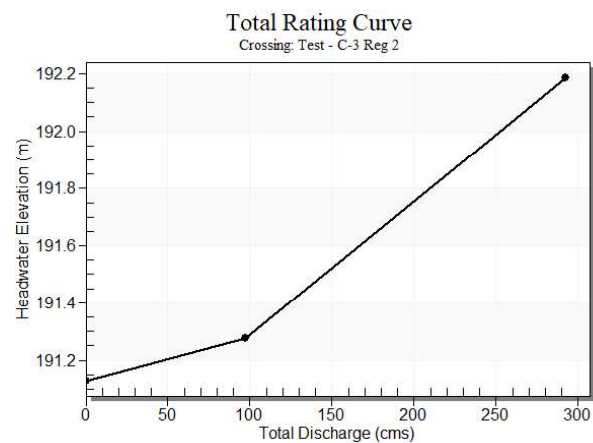
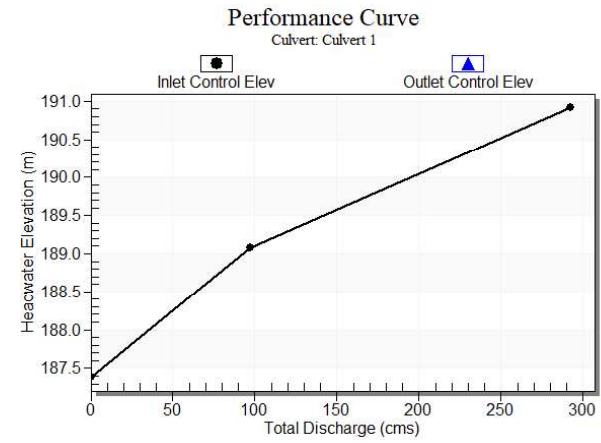


Table 8 - Culvert Summary Table: Culvert 1

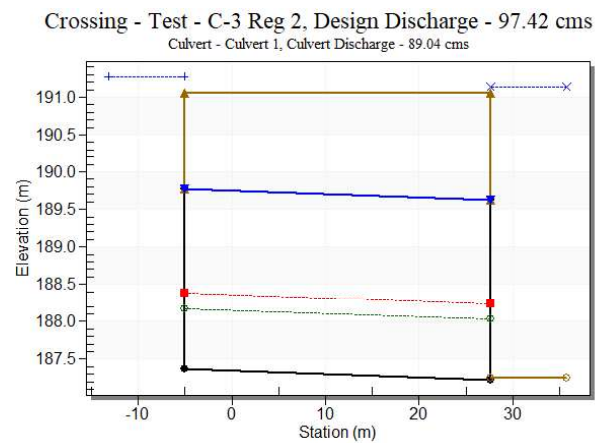
Dischar e Name	Total Dischar e (cms)	Culvert Dischar e (cms)	Headwa r Elevatio (m)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.07	191.13	0.014	3.760	4-FF	0.003	0.008	2.400	3.880	0.001	0.000
Region	97.42	89.04	191.28	1.709	3.905	4-FF	0.803	1.010	2.400	3.880	1.325	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 4

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: Test - C-3 Reg 2)

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Test - C-3 Reg 2

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Test - C-3 Reg 2

Roadway Profile Shape: Irregular Roadway Shape (coordinates)
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 10 - Summary of Culvert Flows at Crossing: Test - C-3 Reg 3A 191.45

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
191.13	Zero	0.00	0.00	0.00	1
191.44	Regional	97.42	97.42	0.00	1
191.45	Overtopping	99.07	99.07	0.00	Overtopping

Rating Curve Plot for Crossing: Test - C-3 Reg 3A 191.45

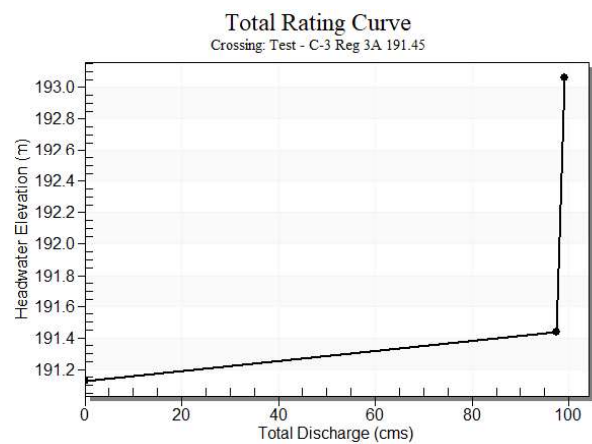
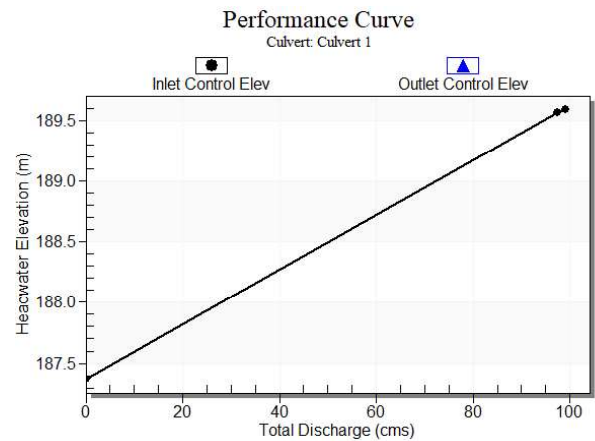


Table 11 - Culvert Summary Table: Culvert 1

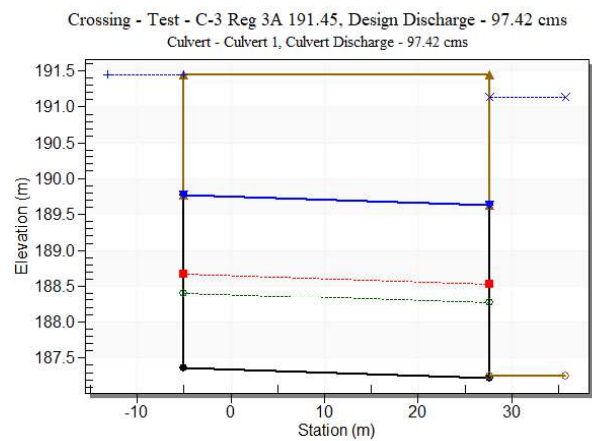
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	191.13	0.001	3.760	4-FF	0.000	0.001	2.400	3.880	0.000	0.000
Region	97.42	97.42	191.44	2.194	4.069	4-FF	1.029	1.299	2.400	3.880	1.933	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: Test - C-3 Reg 3A 19

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Test - C-3 Reg 3A 191.45

Tailwater Channel Option: Enter Constant Tailwater Elevation
Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Test - C-3 Reg 3A 191.45

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 64.00 m
Crest Elevation: 191.45 m
Roadway Surface: Paved
Roadway Top Width: 32.60 m

Crossing Discharge Data
Discharge Selection Method: User Defined

Table 13 - Summary of Culvert Flows at Crossing: Test - C-3 Reg 3B 191.35

Headwater Elevation (m)	Discharge Name	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cm)	Iterations
191.13	Zero	0.00	0.00	0.00	1
191.30	Regional	97.42	97.42	0.00	1
191.35	Overtopping	109.50	109.50	0.00	Overtopping

Rating Curve Plot for Crossing: Test - C-3 Reg 3B 191.35

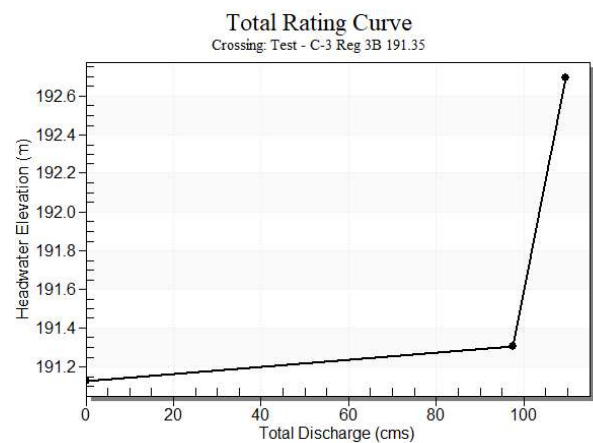
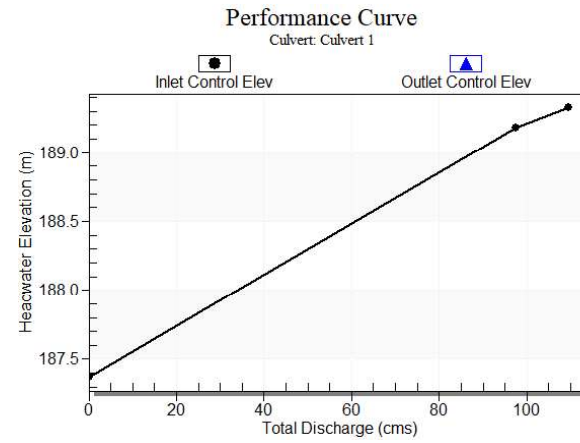


Table 14 - Culvert Summary Table: Culvert 1

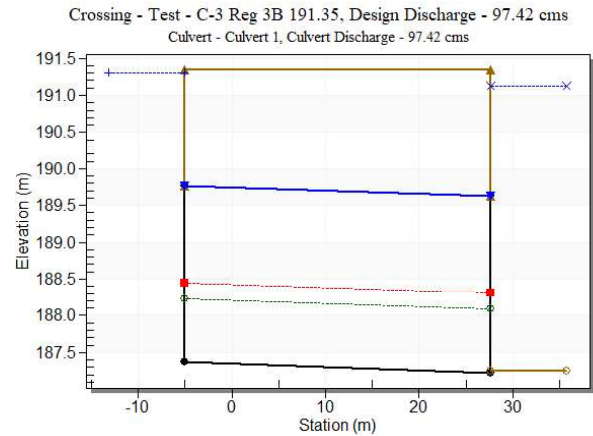
Discharge Name	Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
Zero	0.00	0.00	191.13	0.001	3.760	4-FF	0.000	0.001	2.400	3.880	0.000	0.000
Region	97.42	97.42	191.30	1.812	3.934	4-FF	0.852	1.072	2.400	3.880	1.450	0.000

Straight Culvert
Inlet Elevation (invert): 187.37 m, Outlet Elevation (invert): 187.23 m
Culvert Length: 32.60 m, Culvert Slope: 0.0043

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: -5.00 m
Inlet Elevation: 187.37 m
Outlet Station: 27.60 m
Outlet Elevation: 187.23 m
Number of Barrels: 4

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box
Barrel Span: 7000.00 mm
Barrel Rise: 2400.00 mm
Barrel Material: Concrete
Embedment: 0.00 mm
Barrel Manning's n: 0.0130
Culvert Type: Straight
Inlet Configuration: Square Edge (90°) Headwall
Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: Test - C-3 Reg 3B 19

Flow (cms)	Water Surface Elev (m)	Depth (m)
0.00	191.13	3.88
97.42	191.13	3.88

Tailwater Channel Data - Test - C-3 Reg 3B 191.35

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 191.13 m

Roadway Data for Crossing: Test - C-3 Reg 3B 191.35

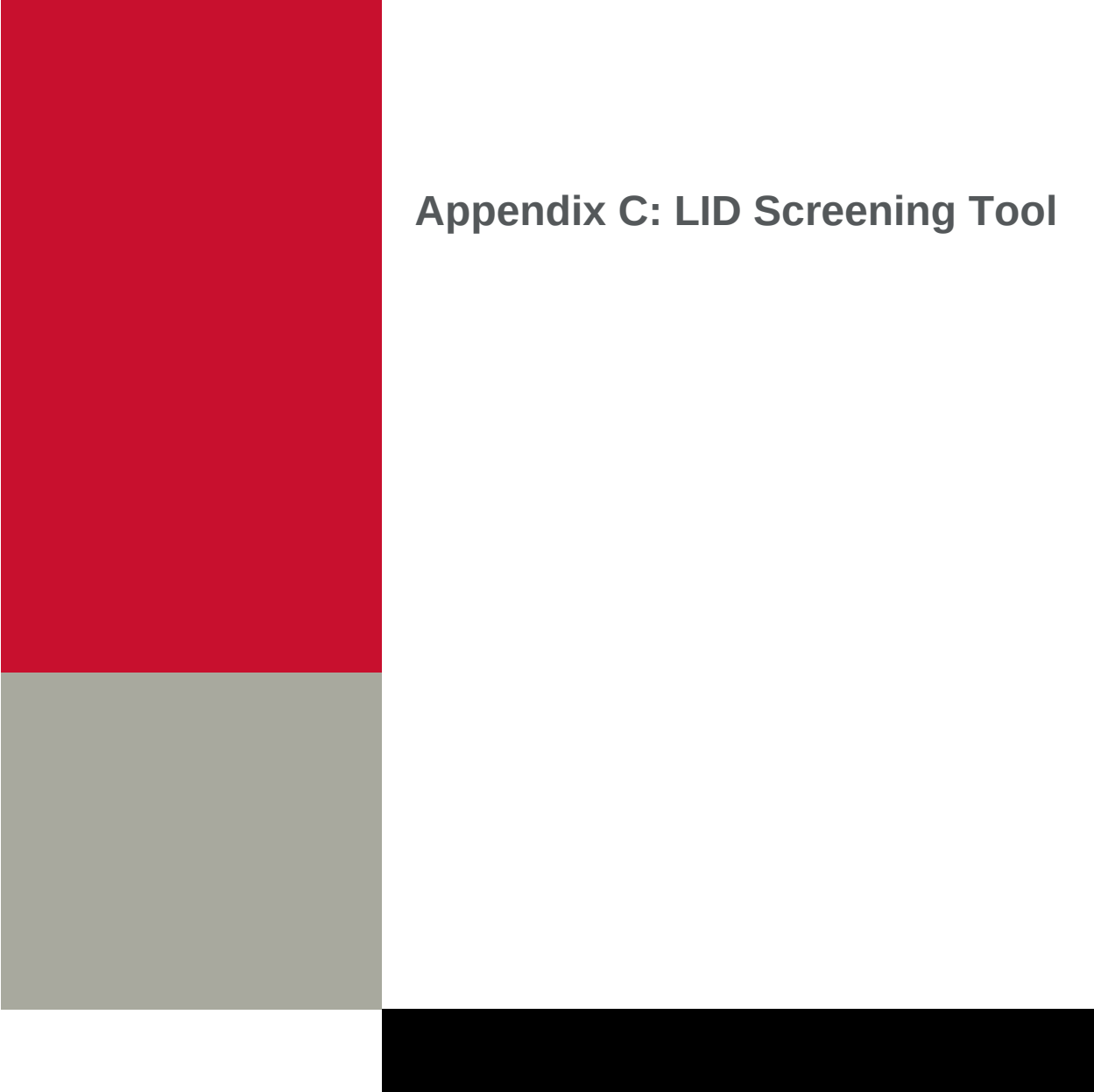
Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 64.00 m

Crest Elevation: 191.35 m

Roadway Surface: Paved

Roadway Top Width: 32.60 m



Appendix C: LID Screening Tool

LID Options Feasibility Screening (Stage 1)

Options (Urban Reconstruction of Major Arterial Rd)	Suitable Outlet/ Overflow	Elevation Constraints	Available Area	Source of Stormwater	Groundwater/ Bedrock	Conflict with Utilities ¹	Road Structure	Sight-lines and Safety	Drainage Function	Aquatic Environment	Cost	OVERALL
Median Bioretention	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	Not feasible
Boulevard Bioretention ²	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible (moderate)	Feasible
Bioswale	Not feasible	Not feasible	Not feasible	Not feasible	Feasible	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	Not feasible
Perforated Pipe / Soakaway (median)	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not Feasible	Feasible	Not Feasible (very high)	Not feasible
Perforated Pipe / Soakaway (boulevard)	Feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible (moderate)	Not feasible
Permeable Pavement (median)	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	Feasible ⁴
Permeable Pavement (sidewalk)	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Not feasible (very high)	Not feasible
Prefabricated Modules ³	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible (moderate)	Feasible

Note 1: Utility conflicts are present (relocations required)

Note 2: Considers subsurface inlet and integration with streetscaping

Note 3: Can be integrated with other options

Note 4: Proposed a measure to reduce impervious area

Table 9 – Recommended Feasibility Screening Criteria

Criteria	Description
Suitable Outlet/ Overflow	Ability of the proposed LID option to discharge to a suitable outlet or overflow (stormsewer or watercourse) based on capacity, elevations and additional structure requirements.
Elevation/ Grading Constraints	Ability of the proposed LID option to be integrated with the constructed/ proposed grades without the need for significant roadway alteration. Includes all surface and sub-surface infrastructure.
Available Area	Ability of the proposed LID option to be constructed with the available area.
Source of Stormwater	Ability of the proposed LID option to accept stormwater at surface or below grade given the constructed/ proposed roadway designs (top of pavement).
Groundwater	Ability for the invert of the proposed infiltration based LID option to be located a minimum of 0.5-1m above the seasonally high groundwater elevation based on the borehole logs and groundwater monitoring well (piezometer).
Bedrock	Ability for the invert of the proposed infiltration based LID option to be located a minimum of 0.5-1m above the local bedrock elevations.
Conflicts with Utilities	Ability of the proposed LID option to integrate within the constructed/ proposed roadway designs without conflicts to existing or proposed utilities. Note: at the feasibility screening stage, the criteria are limited to conflicts which cannot be mitigated in design and would require relocations or present an unacceptable risk. Includes impacts to existing or proposed sanitary sewers, water mains, electrical lines including signalization and surface walkways/pathways.
Road Structure	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising the road structure including sub-base soils, aggregate base and roadway surface. Long-term design-life must also not be compromised. Note: Criteria includes reduction in load bearing capacity, reduced cross-sectional stiffness due to saturation effects or reductions in layer thicknesses.
Sight-lines and Safety	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising vehicle sight-lines or user safety. Safety criteria include the ability of the LID system to meet H20 loading for areas within 1.0m of the roadway edge, LID location within the roadway and height/location of proposed vegetation.
Drainage Function	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising the drainage system design or capacity. Criteria includes impacts related to transferring drainage from adjacent but previously separate drainage areas, reduced pipe/outlet capacity, risk of ponding on the roadway surface and storm sewer surcharging.
Aquatic Environment	Ability of the proposed LID option to comply with Federal, Provincial and Agency policy relating to sensitive, endangered or threatened aquatic species within local waterways or downstream of proposed or existing outlets locations as well as in-stream water quality and or discharge requirements.
Cost Effectiveness*	Relative cost of the proposed LID options. Criteria includes the screening of the options which present an unacceptably high construction costs based on the requirement for structural reinforcements, excessive infrastructure and or excavation or a high degree of disturbance to the built environment including the constructed roadway surface.

* Estimated costs are a high level, 'Class C' cost estimate

LID Implementation Process for Regional Road Right-of-ways (Region of Peel, 2014)

Table 4.3.9: LID options for the major arterial road

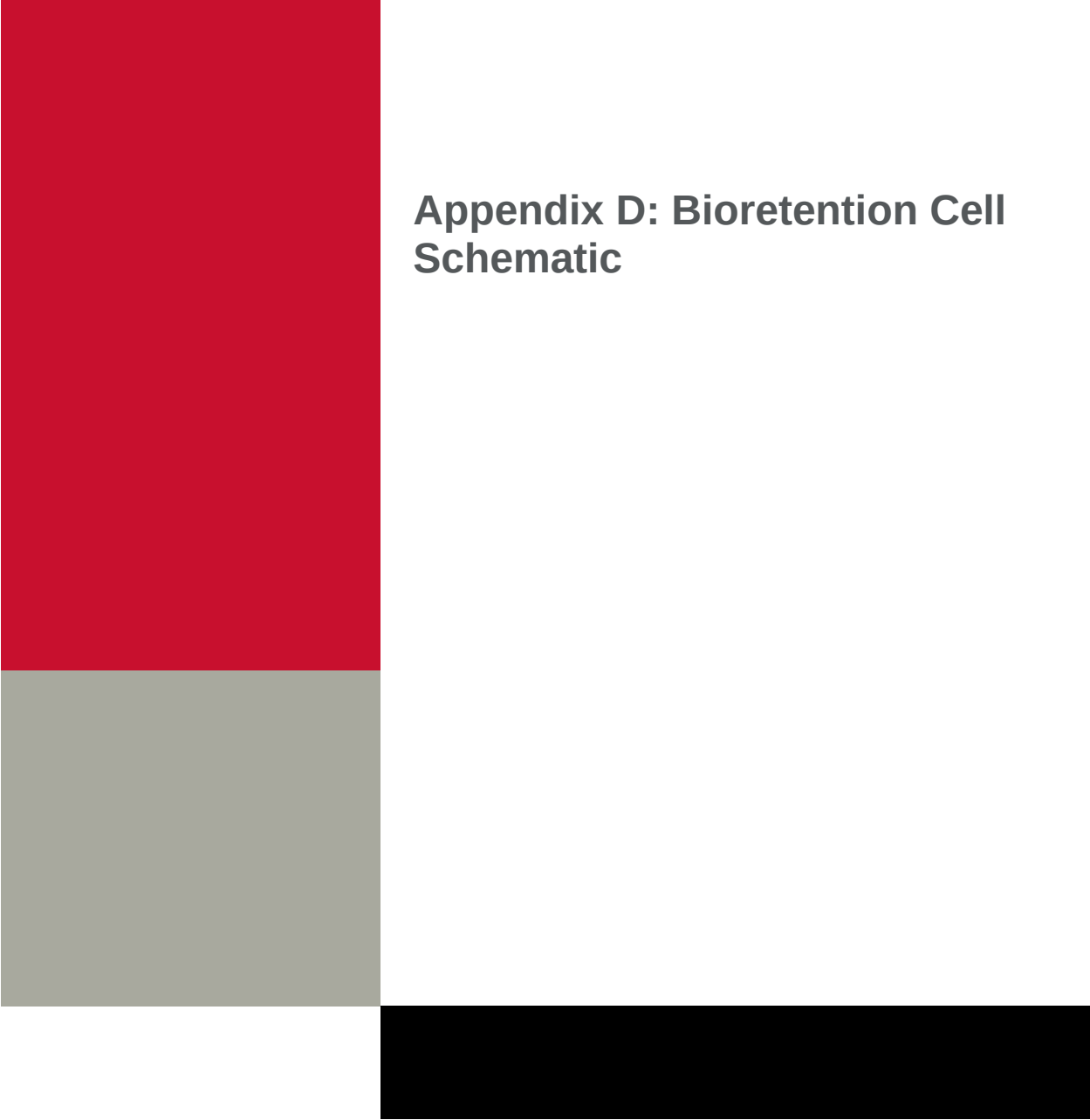
ROW Construction Type	Bioretention Planter	Curb Extension	Boulevard Bioretention	Bioswale	Enhanced Grass Swales	Perforated Pipe	Permeable Pavement (sidewalk)	Prefabricated Modules
Rural Resurfacing	○	○	●	●	●	○	○	○
Rural Reconstruction	○	○	●	●	●	○	○	○
Rural to Urban Reconstruction	○	○	●	●	○	●	●	●
Urban Resurfacing	○	○	●	●	○	○	○	●
Urban Reconstruction	●	○	●	●	○	●	●	●
Urban Reduction	●	○	●	●	○	●	○	●

○ Unlikely Option ● Possible Option ● Common Option



Figure 4.3.29

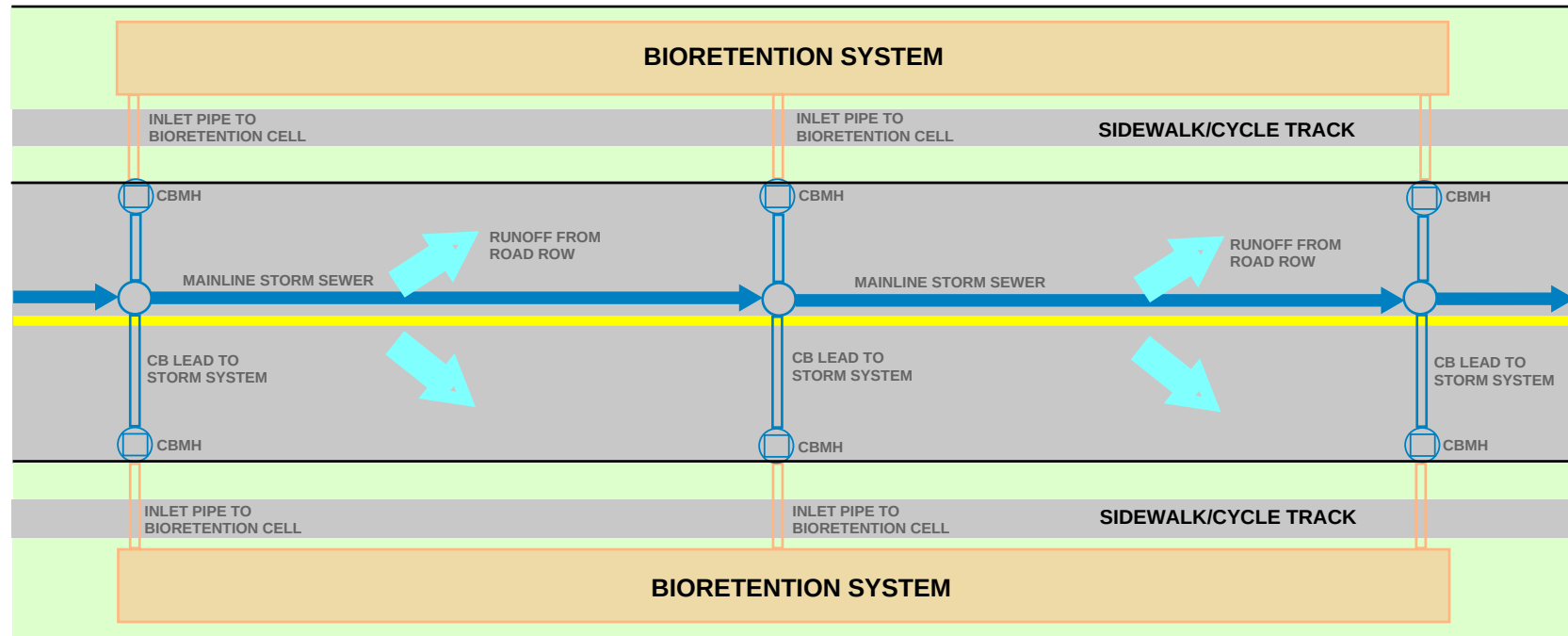
LID Implementation Process for Regional Road Right-of-ways (Region of Peel, 2014)



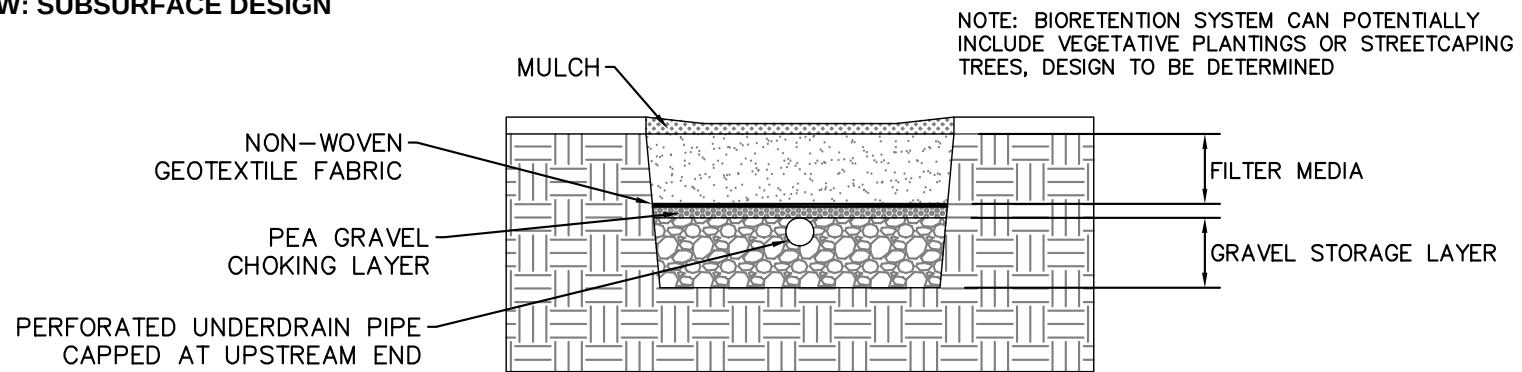
Appendix D: Bioretention Cell Schematic

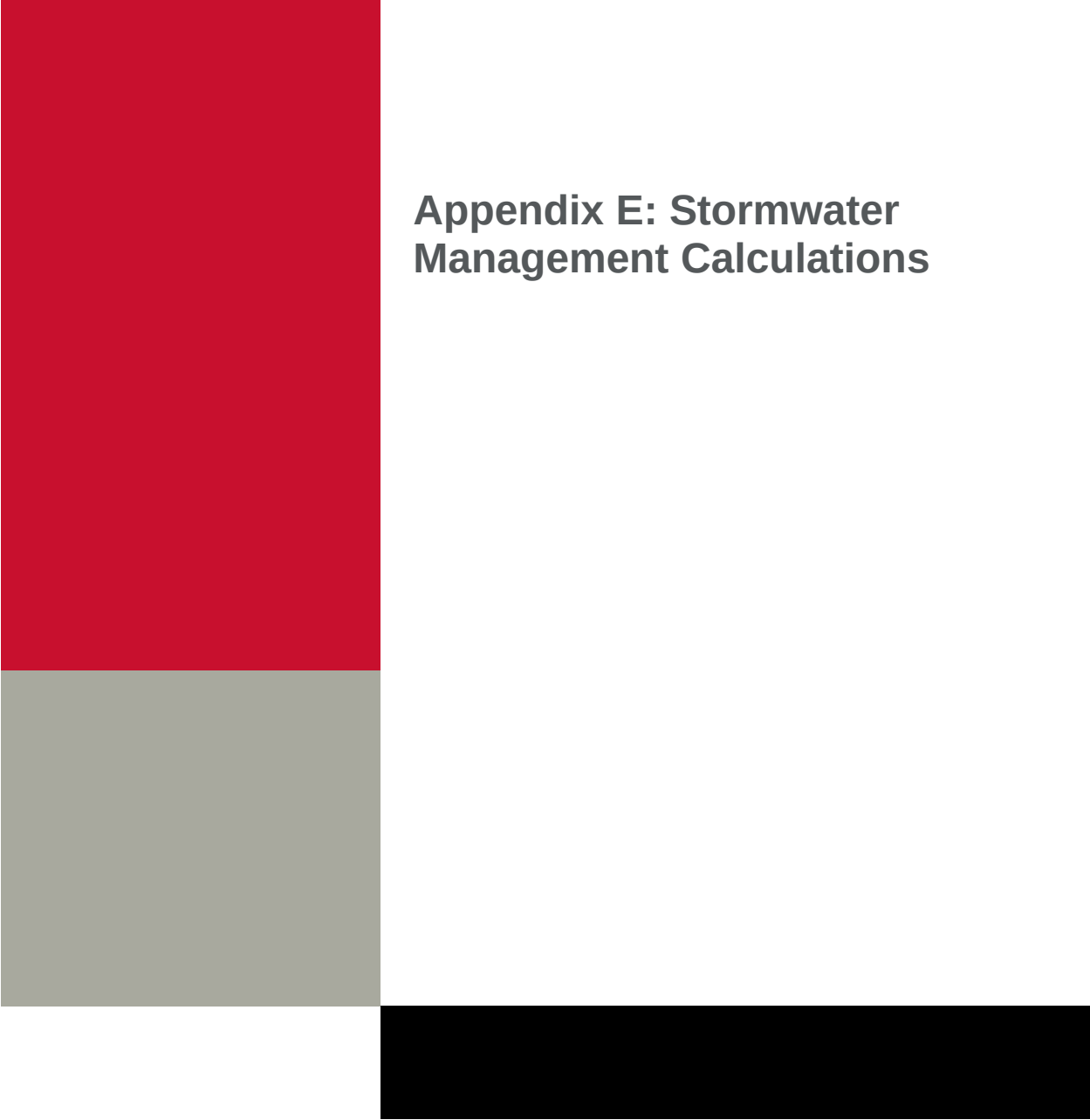
SCHEMATIC OF LINEAR LID BIORETENTION CELL FEATURE - FIGURE NOT TO SCALE

PLAN VIEW: ROAD RIGHT-OF-WAY LID IMPLEMENTATION



SECTION VIEW: SUBSURFACE DESIGN





Appendix E: Stormwater Management Calculations

Stormwater Management Calculations

TABLE 01 QUALITY CONTROL REQUIREMENT CALCULATION																				
Drainage Area ID	Drainage Area (ha)	Existing			Proposed			Increased Paved Area (ha)	Contributing Pavement Area (ha)	Required Treatment Volume ¹ (m ³)	Water Balance Storage ³ (m ³)	Total Required Storage (m ³)	Bioretention Area ² (m ²)	Required Bioretention Cell Length (m)	Bioretention Cell Width (m)	Proposed Bioretention Cell Length (m)	Provided Water Balance Storage Volume (m ³)	Required Erosion Control Storage Volume ⁶ (m ³)	Provided Water Quality and Erosion Control Storage Volume (m ³)	Discharge Location
		Paved Area (ha)	% Impervious	Req. Volume (m ³)	Paved Area (ha)	% Impervious	Req. Volume (m ³)													
A2	4.61	2.00	43%	54.04	3.53	77%	130.91	1.53	1.53	77	77	77	767	383	2.0	481	115	422	423	Crossing C-1 (Pond B) ⁴
A3	1.50	0.66	44%	18.13	1.15	76%	42.55	0.48	0.48	24	24	24	242	121	2.0	156	37	133	137	Crossing C-2 (Pond A) ⁴
A4	0.87	0.41	48%	11.77	0.72	83%	28.14	0.31	0.72	28	36	36	361	180	2.0	203	49	84	179	Drainage Feature D
A5	7.14	2.83	40%	73.71	5.07	71%	179.58	2.23	5.07	180	253	253	2534	1267	2.0	1287	309	614	1133	Crossing C-3 (NLT-1)
Total	14.12	5.91	42%		10.47	74%		4.56	7.81	309	390	391	3904	1952		2127	510	1254	1872	

¹ From Table 3.2 of MOE SWM Planning and Design Manual (2003)

² 1/20 of the contributing pavement area

³ Based on CH runoff volume reduction requirements of 5 mm retention

⁴ Treatment provided for the increased paved area due to presence of existing SWM ponds

⁵ Based on silty clay soil texture (Rawls, W.J. et al., (1983). J. Hyd. Engr., 109:1316.) obtained from Thurber borehole investigation (Dec 2020)

⁶ Based on Ninth Line Lands Scoped Subwatershed Study unitary storage volumes for erosion control (Wood, 2020)

MOE Table 3.2

Impervious Level (%)	W.Q. Storage Volume (m ³ /ha)
35%	25
55%	30
70%	35
85%	40

Bioretention Cell Dimensions

Hydraulic Conductivity =	1.42E-05 cm/s
Infiltration Rate, i =	31 mm/hr
Safety Factor =	3
Infilt. with Safety Factor =	10.3 mm/hr
d _o =	100 mm
t _s =	48 hr
V _r =	0.4
d _{r max} =	1237 mm
d _r =	0.3 m
Perforated Pipe	0.20 m
d _{filter} = d _{f minimum}	0.50 m
d _{pea gravel} =	0.1 m
d _{total} =	1.10 m

LID SWM GUIDE Table C1

Kfs cm/s	T min/cm	1/T mm/hr
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Cumulative Unitary Storage Volumes (Erosion Control)

(MSH Phase 3 report, Wood 2020)

Watershed	Vol. (m ³ /imp ha)
Sixteen Mile Creek	275
Sawmill Creek	275



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 03
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A1
Existing Drainage Area	3.46 ha
Existing Pavement Area	1.58 ha
Existing Runoff Coefficient	0.55 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	3.46 ha
Proposed Pavement Area	2.57 ha
Proposed Runoff Coefficient	0.73 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters $i = A / (T_c + B)^C$				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C_f		
2-yr	610	4.6	0.78	1	59.89	317.25
5-yr	820	4.6	0.78	1	80.51	426.47
10-yr	1010	4.6	0.78	1	99.17	525.28
25-yr	1160	4.6	0.78	1.1	125.28	663.62
50-yr	1300	4.7	0.78	1.2	152.56	808.11
100-yr	1450	4.9	0.78	1.25	175.86	931.54

Peak Flow Control Requirement

Discharging to municipal storm sewer on Ninth Line

Storage Volume Calculation - 10 Year Post to 10 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	704.55	634.10	472.75	161.35
20	83.06	590.13	708.15	630.34	77.81
25	71.90	510.82	766.23	787.92	0.00
30	63.66	452.27	814.08	945.51	0.00
40	52.22	371.02	890.44	1260.67	0.00
50	44.60	316.86	950.57	1575.84	0.00
60	39.11	277.90	1000.45	1891.01	0.00
70	34.96	248.39	1043.25	2206.18	0.00
80	31.69	225.18	1080.85	2521.35	0.00
90	29.05	206.39	1114.48	2836.52	0.00
100	26.86	190.83	1144.96	3151.68	0.00
120	23.43	166.48	1198.68	3782.02	0.00
360	10.14	72.05	1556.36	11346.06	0.00
720	5.94	42.17	1821.72	22692.13	0.00
1440	3.47	24.62	2127.08	45384.25	0.00

Required Storage Volume: **161.35**

Storage Volume Calculation - 100 Year Post to 100 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	1249.47	1124.52	838.39	286.13
20	147.65	1049.05	1258.86	1117.85	141.01
25	128.01	909.51	1364.26	1397.31	0.00
30	113.47	806.17	1451.10	1676.78	0.00
40	93.22	662.34	1589.60	2235.70	0.00
50	79.69	566.19	1698.58	2794.63	0.00
60	69.94	496.91	1788.88	3353.55	0.00
70	62.54	444.36	1866.31	3912.48	0.00
80	56.72	402.98	1934.30	4471.40	0.00
90	52.00	369.46	1995.06	5030.33	0.00
100	48.09	341.68	2050.11	5589.25	0.00
120	41.97	298.20	2147.06	6707.10	0.00
360	18.19	129.22	2791.18	20121.31	0.00
720	10.65	75.65	3268.11	40242.61	0.00
1440	6.22	44.17	3816.54	80485.23	0.00

Required Storage Volume: **286.13**

Required Storage Summary

Uncontrolled Discharge Flow Rate	0.705 m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.525 m ³ /s	10 Year Existing Flow
Required Pipe Storage	161.35 m ³	
Uncontrolled Discharge Flow Rate	1.249 m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.932 m ³ /s	100 Year Existing Flow
Required Pipe Storage	286.13 m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 04

DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A2
Existing Drainage Area	4.61 ha
Existing Pavement Area	2.00 ha
Existing Runoff Coefficient	0.53 Assume pavement C = 0.9, landscaped C = 0.25
Proposed Drainage Area	4.61 ha
Proposed Pavement Area	3.53 ha
Proposed Runoff Coefficient	0.75 Assume pavement C = 0.9, landscaped C = 0.25
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	410.87
5-yr	820	4.6	0.78	1	80.51	552.32
10-yr	1010	4.6	0.78	1	99.17	680.29
25-yr	1160	4.6	0.78	1.1	125.28	859.46
50-yr	1300	4.7	0.78	1.2	152.56	1046.58
100-yr	1450	4.9	0.78	1.25	175.86	1206.44

Peak Flow Control Requirement

Discharging to Headwater Drainage Feature B (SWM Pond B)

Storage Volume Calculation - 10 Year Post to 10 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	957.01	861.30	612.26	249.04
20	83.06	801.58	961.89	816.35	145.54
25	71.90	693.85	1040.78	1020.44	20.34
30	63.66	614.32	1105.78	1224.52	0.00
40	52.22	503.96	1209.50	1632.70	0.00
50	44.60	430.39	1291.17	2040.87	0.00
60	39.11	377.48	1358.92	2449.05	0.00
70	34.96	337.39	1417.06	2857.22	0.00
80	31.69	305.86	1468.14	3265.40	0.00
90	29.05	280.34	1513.81	3673.57	0.00
100	26.86	259.20	1555.22	4081.74	0.00
120	23.43	226.14	1628.18	4898.09	0.00
360	10.14	97.87	2114.03	14694.28	0.00
720	5.94	57.28	2474.46	29388.56	0.00
1440	3.47	33.44	2889.25	58777.13	0.00
Required Storage Volume:			249.04		

Storage Volume Calculation - 100 Year Post to 100 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	1697.17	1527.45	1085.80	441.66
20	147.65	1424.94	1709.92	1447.73	262.20
25	128.01	1235.40	1853.10	1809.66	43.44
30	113.47	1095.03	1971.06	2171.59	0.00
40	93.22	899.66	2159.18	2895.46	0.00
50	79.69	769.07	2307.20	3619.32	0.00
60	69.94	674.96	2429.87	4343.18	0.00
70	62.54	603.58	2535.04	5067.05	0.00
80	56.72	547.37	2627.39	5790.91	0.00
90	52.00	501.84	2709.92	6514.77	0.00
100	48.09	464.12	2784.69	7238.64	0.00
120	41.97	405.05	2916.38	8686.37	0.00
360	18.19	175.52	3791.31	26059.10	0.00
720	10.65	102.76	4439.13	52118.19	0.00
1440	6.22	60.00	5184.07	104236.38	0.00
Required Storage Volume:			441.66		

Required Storage Summary			
Uncontrolled Discharge Flow Rate	0.957	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.680	m ³ /s	10 Year Existing Flow
Required Pipe Storage	249.04	m ³	
Uncontrolled Discharge Flow Rate	1.697	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	1.206	m ³ /s	100 Year Existing Flow
Required Pipe Storage	441.66	m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 05
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A3
Existing Drainage Area	1.50 ha
Existing Pavement Area	0.66 ha
Existing Runoff Coefficient	0.54 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	1.50 ha
Proposed Pavement Area	1.15 ha
Proposed Runoff Coefficient	0.75 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters $i = A / (T_c + B)^C$				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C_f		
2-yr	610	4.6	0.78	1	59.89	135.23
5-yr	820	4.6	0.78	1	80.51	181.78
10-yr	1010	4.6	0.78	1	99.17	223.90
25-yr	1160	4.6	0.78	1.1	125.28	282.86
50-yr	1300	4.7	0.78	1.2	152.56	344.45
100-yr	1450	4.9	0.78	1.25	175.86	397.06

Peak Flow Control Requirement

Discharging to Headwater Drainage Feature C (SWM Pond A)

Storage Volume Calculation - 10 Year Post to 10 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	311.39	280.26	201.51	78.75
20	83.06	260.82	312.98	268.68	44.31
25	71.90	225.77	338.65	335.85	2.81
30	63.66	199.89	359.80	403.01	0.00
40	52.22	163.98	393.55	537.35	0.00
50	44.60	140.04	420.13	671.69	0.00
60	39.11	122.83	442.17	806.03	0.00
70	34.96	109.78	461.09	940.37	0.00
80	31.69	99.52	477.71	1074.71	0.00
90	29.05	91.22	492.57	1209.04	0.00
100	26.86	84.34	506.04	1343.38	0.00
120	23.43	73.58	529.78	1612.06	0.00
360	10.14	31.85	687.87	4836.18	0.00
720	5.94	18.64	805.15	9672.36	0.00
1440	3.47	10.88	940.12	19344.72	0.00

Required Storage Volume: **78.75**

Storage Volume Calculation - 100 Year Post to 100 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	552.23	497.01	357.36	139.65
20	147.65	463.65	556.38	476.48	79.91
25	128.01	401.98	602.97	595.59	7.37
30	113.47	356.31	641.35	714.71	0.00
40	93.22	292.74	702.57	952.95	0.00
50	79.69	250.24	750.73	1191.19	0.00
60	69.94	219.62	790.64	1429.43	0.00
70	62.54	196.40	824.86	1667.67	0.00
80	56.72	178.11	854.91	1905.90	0.00
90	52.00	163.29	881.77	2144.14	0.00
100	48.09	151.02	906.10	2382.38	0.00
120	41.97	131.80	948.95	2858.85	0.00
360	18.19	57.11	1233.63	8576.56	0.00
720	10.65	33.44	1444.42	17153.13	0.00
1440	6.22	19.52	1686.82	34306.26	0.00

Required Storage Volume: **139.65**

Required Storage Summary

Uncontrolled Discharge Flow Rate	0.311	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.224	m ³ /s	10 Year Existing Flow
Required Pipe Storage	78.75	m ³	
Uncontrolled Discharge Flow Rate	0.552	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.397	m ³ /s	100 Year Existing Flow
Required Pipe Storage	139.65	m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 06
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A4
Existing Drainage Area	0.87 ha
Existing Pavement Area	0.41 ha
Existing Runoff Coefficient	0.56 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	0.87 ha
Proposed Pavement Area	0.72 ha
Proposed Runoff Coefficient	0.79 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	81.68
5-yr	820	4.6	0.78	1	80.51	109.79
10-yr	1010	4.6	0.78	1	99.17	135.23
25-yr	1160	4.6	0.78	1.1	125.28	170.85
50-yr	1300	4.7	0.78	1.2	152.56	208.05
100-yr	1450	4.9	0.78	1.25	175.86	239.83

Peak Flow Control Requirement

Discharging to Headwater Drainage Feature D

Storage Volume Calculation - 10 Year Post to 10 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	190.57	171.51	121.71	49.80
20	83.06	159.62	191.54	162.28	29.26
25	71.90	138.17	207.25	202.85	4.40
30	63.66	122.33	220.19	243.42	0.00
40	52.22	100.35	240.85	324.56	0.00
50	44.60	85.70	257.11	405.70	0.00
60	39.11	75.17	270.60	486.84	0.00
70	34.96	67.19	282.18	567.98	0.00
80	31.69	60.91	292.35	649.12	0.00
90	29.05	55.82	301.45	730.26	0.00
100	26.86	51.62	309.69	811.40	0.00
120	23.43	45.03	324.22	973.68	0.00
360	10.14	19.49	420.97	2921.04	0.00
720	5.94	11.41	492.74	5842.09	0.00
1440	3.47	6.66	575.34	11684.17	0.00

Required Storage Volume: **49.80**

Storage Volume Calculation - 100 Year Post to 100 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	337.96	304.16	215.84	88.32
20	147.65	283.75	340.50	287.79	52.71
25	128.01	246.01	369.01	359.74	9.27
30	113.47	218.05	392.50	431.69	0.00
40	93.22	179.15	429.96	575.58	0.00
50	79.69	153.14	459.43	719.48	0.00
60	69.94	134.41	483.86	863.37	0.00
70	62.54	120.19	504.80	1007.27	0.00
80	56.72	109.00	523.19	1151.16	0.00
90	52.00	99.93	539.63	1295.06	0.00
100	48.09	92.42	554.52	1438.95	0.00
120	41.97	80.66	580.74	1726.74	0.00
360	18.19	34.95	754.97	5180.23	0.00
720	10.65	20.46	883.97	10360.46	0.00
1440	6.22	11.95	1032.31	20720.92	0.00

Required Storage Volume: **88.32**

Required Storage Summary

Uncontrolled Discharge Flow Rate	0.191 m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.135 m ³ /s	10 Year Existing Flow
Required Pipe Storage	49.80 m ³	
Uncontrolled Discharge Flow Rate	0.338 m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.240 m ³ /s	100 Year Existing Flow
Required Pipe Storage	88.32 m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 07
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A5
Existing Drainage Area	7.14 ha
Existing Pavement Area	2.83 ha
Existing Runoff Coefficient	0.51 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	7.14 ha
Proposed Pavement Area	5.07 ha
Proposed Runoff Coefficient	0.71 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	608.37
5-yr	820	4.6	0.78	1	80.51	817.81
10-yr	1010	4.6	0.78	1	99.17	1007.30
25-yr	1160	4.6	0.78	1.1	125.28	1272.59
50-yr	1300	4.7	0.78	1.2	152.56	1549.67
100-yr	1450	4.9	0.78	1.25	175.86	1786.37

Peak Flow Control Requirement

Discharging to NLT-1 (Osprey Marsh crossing)

Storage Volume Calculation - 10 Year Post to 10 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	1410.45	1269.40	906.57	362.83
20	83.06	1181.37	1417.65	1208.76	208.88
25	71.90	1022.61	1533.91	1510.96	22.95
30	63.66	905.39	1629.71	1813.15	0.00
40	52.22	742.74	1782.57	2417.53	0.00
50	44.60	634.32	1902.95	3021.91	0.00
60	39.11	556.33	2002.80	3626.29	0.00
70	34.96	497.26	2088.47	4230.68	0.00
80	31.69	450.78	2163.76	4835.06	0.00
90	29.05	413.16	2231.08	5439.44	0.00
100	26.86	382.02	2292.10	6043.82	0.00
120	23.43	333.28	2399.63	7252.59	0.00
360	10.14	144.24	3115.68	21757.77	0.00
720	5.94	84.42	3646.89	43515.54	0.00
1440	3.47	49.28	4258.21	87031.08	0.00

Required Storage Volume: **362.83**

Storage Volume Calculation - 100 Year Post to 100 Year Pre

Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	2501.31	2251.18	1607.73	643.44
20	147.65	2100.09	2520.10	2143.64	376.46
25	128.01	1820.75	2731.12	2679.56	51.56
30	113.47	1613.87	2904.97	3215.47	0.00
40	93.22	1325.93	3182.23	4287.29	0.00
50	79.69	1133.46	3400.38	5359.11	0.00
60	69.94	994.77	3581.17	6430.93	0.00
70	62.54	889.56	3736.17	7502.76	0.00
80	56.72	806.72	3872.27	8574.58	0.00
90	52.00	739.61	3993.92	9646.40	0.00
100	48.09	684.02	4104.11	10718.22	0.00
120	41.97	596.97	4298.20	12861.87	0.00
360	18.19	258.69	5587.67	38585.61	0.00
720	10.65	151.45	6542.44	77171.21	0.00
1440	6.22	88.43	7640.35	154342.43	0.00

Required Storage Volume: **643.44**

Required Storage Summary

Uncontrolled Discharge Flow Rate	1.410	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	1.007	m ³ /s	10 Year Existing Flow
Required Pipe Storage	362.83	m ³	
Uncontrolled Discharge Flow Rate	2.501	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	1.786	m ³ /s	100 Year Existing Flow
Required Pipe Storage	643.44	m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 08

DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A6
Existing Drainage Area	1.61 ha
Existing Pavement Area	0.56 ha
Existing Runoff Coefficient	0.48 Assume pavement C = 0.9, landscaped C = 0.25
Proposed Drainage Area	1.61 ha
Proposed Pavement Area	1.18 ha
Proposed Runoff Coefficient	0.73 Assume pavement C = 0.9, landscaped C = 0.25
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	129.06
5-yr	820	4.6	0.78	1	80.51	173.49
10-yr	1010	4.6	0.78	1	99.17	213.69
25-yr	1160	4.6	0.78	1.1	125.28	269.97
50-yr	1300	4.7	0.78	1.2	152.56	328.75
100-yr	1450	4.9	0.78	1.25	175.86	378.96

Peak Flow Control Requirement

Discharging to municipal storm sewer on Doug Leavens Boulevard

Storage Volume Calculation - 10 Year Post to 10 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	324.88	292.40	192.32	100.08
20	83.06	272.12	326.54	256.43	70.12
25	71.90	235.55	353.32	320.54	32.79
30	63.66	208.55	375.39	384.64	0.00
40	52.22	171.08	410.60	512.86	0.00
50	44.60	146.11	438.33	641.07	0.00
60	39.11	128.15	461.33	769.28	0.00
70	34.96	114.54	481.06	897.50	0.00
80	31.69	103.83	498.40	1025.71	0.00
90	29.05	95.17	513.91	1153.93	0.00
100	26.86	87.99	527.97	1282.14	0.00
120	23.43	76.77	552.74	1538.57	0.00
360	10.14	33.23	717.67	4615.71	0.00
720	5.94	19.45	840.03	9231.42	0.00
1440	3.47	11.35	980.84	18462.84	0.00
Required Storage Volume:			100.08		

Storage Volume Calculation - 100 Year Post to 100 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	576.16	518.54	341.07	177.48
20	147.65	483.74	580.49	454.75	125.73
25	128.01	419.39	629.09	568.44	60.65
30	113.47	371.74	669.14	682.13	0.00
40	93.22	305.42	733.00	909.51	0.00
50	79.69	261.08	783.25	1136.89	0.00
60	69.94	229.14	824.89	1364.26	0.00
70	62.54	204.90	860.60	1591.64	0.00
80	56.72	185.82	891.95	1819.02	0.00
90	52.00	170.36	919.97	2046.39	0.00
100	48.09	157.56	945.35	2273.77	0.00
120	41.97	137.51	990.06	2728.53	0.00
360	18.19	59.59	1287.08	8185.58	0.00
720	10.65	34.88	1507.00	16371.16	0.00
1440	6.22	20.37	1759.89	32742.32	0.00
Required Storage Volume:			177.48		

Required Storage Summary			
Uncontrolled Discharge Flow Rate	0.325	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.214	m ³ /s	10 Year Existing Flow
Required Pipe Storage	100.08	m ³	
Uncontrolled Discharge Flow Rate	0.576	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.379	m ³ /s	100 Year Existing Flow
Required Pipe Storage	177.48	m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 09
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A7
Existing Drainage Area	0.53 ha
Existing Pavement Area	0.25 ha
Existing Runoff Coefficient	0.55 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	0.53 ha
Proposed Pavement Area	0.42 ha
Proposed Runoff Coefficient	0.76 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	49.21
5-yr	820	4.6	0.78	1	80.51	66.15
10-yr	1010	4.6	0.78	1	99.17	81.47
25-yr	1160	4.6	0.78	1.1	125.28	102.93
50-yr	1300	4.7	0.78	1.2	152.56	125.34
100-yr	1450	4.9	0.78	1.25	175.86	144.49

Peak Flow Control Requirement

Discharging to municipal storm sewer on Worthview Place

Storage Volume Calculation - 10 Year Post to 10 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	113.01	101.70	73.33	28.38
20	83.06	94.65	113.58	97.77	15.81
25	71.90	81.93	122.90	122.21	0.68
30	63.66	72.54	130.57	146.65	0.00
40	52.22	59.51	142.82	195.54	0.00
50	44.60	50.82	152.46	244.42	0.00
60	39.11	44.57	160.46	293.31	0.00
70	34.96	39.84	167.33	342.19	0.00
80	31.69	36.12	173.36	391.08	0.00
90	29.05	33.10	178.75	439.96	0.00
100	26.86	30.61	183.64	488.85	0.00
120	23.43	26.70	192.26	586.62	0.00
360	10.14	11.56	249.63	1759.86	0.00
720	5.94	6.76	292.19	3519.72	0.00
1440	3.47	3.95	341.17	7039.44	0.00
Required Storage Volume:			28.38		

Storage Volume Calculation - 100 Year Post to 100 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	200.41	180.36	130.04	50.32
20	147.65	168.26	201.91	173.39	28.52
25	128.01	145.88	218.82	216.73	2.08
30	113.47	129.30	232.75	260.08	0.00
40	93.22	106.23	254.96	346.77	0.00
50	79.69	90.81	272.44	433.47	0.00
60	69.94	79.70	286.92	520.16	0.00
70	62.54	71.27	299.34	606.85	0.00
80	56.72	64.63	310.25	693.55	0.00
90	52.00	59.26	319.99	780.24	0.00
100	48.09	54.80	328.82	866.93	0.00
120	41.97	47.83	344.37	1040.32	0.00
360	18.19	20.73	447.69	3120.97	0.00
720	10.65	12.13	524.18	6241.93	0.00
1440	6.22	7.09	612.15	12483.86	0.00
Required Storage Volume:			50.32		

Required Storage Summary			
Uncontrolled Discharge Flow Rate	0.113	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.081	m ³ /s	10 Year Existing Flow
Required Pipe Storage	28.38	m ³	
Uncontrolled Discharge Flow Rate	0.200	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.144	m ³ /s	100 Year Existing Flow
Required Pipe Storage	50.32	m ³	



Project	Ninth Line Class EA, City of Mississauga			
Date	12-Apr-21	No.	--	Page
By	J. Look	Checked	S. Khorshid	

Stormwater Management Calculations

TABLE 10
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	A8
Existing Drainage Area	2.53 ha
Existing Pavement Area	0.87 ha
Existing Runoff Coefficient	0.47 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Proposed Drainage Area	2.53 ha
Proposed Pavement Area	1.72 ha
Proposed Runoff Coefficient	0.69 <i>Assume pavement C = 0.9, landscaped C = 0.25</i>
Time of Concentration	15 minute

City of Mississauga Rainfall Parameters

Return Period	IDF Parameters				Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B	C	C _f		
2-yr	610	4.6	0.78	1	59.89	201.20
5-yr	820	4.6	0.78	1	80.51	270.46
10-yr	1010	4.6	0.78	1	99.17	333.13
25-yr	1160	4.6	0.78	1.1	125.28	420.87
50-yr	1300	4.7	0.78	1.2	152.56	512.50
100-yr	1450	4.9	0.78	1.25	175.86	590.78

Peak Flow Control Requirement

Discharging to municipal storm sewer on Beacham Street

Storage Volume Calculation - 10 Year Post to 10 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	99.17	485.40	436.86	299.82	137.05
20	83.06	406.57	487.88	399.76	88.12
25	71.90	351.93	527.89	499.70	28.20
30	63.66	311.59	560.86	599.64	0.00
40	52.22	255.61	613.47	799.52	0.00
50	44.60	218.30	654.90	999.39	0.00
60	39.11	191.46	689.26	1199.27	0.00
70	34.96	171.13	718.75	1399.15	0.00
80	31.69	155.14	744.66	1599.03	0.00
90	29.05	142.19	767.82	1798.91	0.00
100	26.86	131.47	788.82	1998.79	0.00
120	23.43	114.70	825.83	2398.55	0.00
360	10.14	49.64	1072.26	7195.64	0.00
720	5.94	29.05	1255.08	14391.29	0.00
1440	3.47	16.96	1465.46	28782.57	0.00
Required Storage Volume:			137.05		

Storage Volume Calculation - 100 Year Post to 100 Year Pre					
Time (minutes)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Storm Runoff Volume (m ³)	Ex. Discharge Flow Vol. (m ³)	Required Storage Volume (m ³)
15	175.86	860.82	774.74	531.70	243.04
20	147.65	722.74	867.29	708.94	158.35
25	128.01	626.61	939.91	886.17	53.74
30	113.47	555.41	999.74	1063.41	0.00
40	93.22	456.32	1095.16	1417.88	0.00
50	79.69	390.08	1170.24	1772.34	0.00
60	69.94	342.35	1232.46	2126.81	0.00
70	62.54	306.14	1285.80	2481.28	0.00
80	56.72	277.63	1332.64	2835.75	0.00
90	52.00	254.54	1374.50	3190.22	0.00
100	48.09	235.40	1412.43	3544.69	0.00
120	41.97	205.45	1479.22	4253.63	0.00
360	18.19	89.03	1922.99	12760.88	0.00
720	10.65	52.12	2251.58	25521.76	0.00
1440	6.22	30.43	2629.42	51043.52	0.00
Required Storage Volume:			243.04		

Required Storage Summary			
Uncontrolled Discharge Flow Rate	0.485	m ³ /s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	0.333	m ³ /s	10 Year Existing Flow
Required Pipe Storage	137.05	m ³	
Uncontrolled Discharge Flow Rate	0.861	m ³ /s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	0.591	m ³ /s	100 Year Existing Flow
Required Pipe Storage	243.04	m ³	