Drainage and Stormwater Management Report

Environmental Assessment Study for Clark Boulevard Extension and Eastern Avenue Improvements

City of Brampton
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Contents

Tables

Figures

Appendices

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1 Introduction

The City of Brampton is undertaking a Municipal Class Environmental Assessment (EA) Study to review the improvements along Eastern Avenue and extension of Clark Boulevard. The study corridor is comprised of two sections; existing Eastern Avenue from Kennedy Road to Hansen Road and Clark Boulevard extension from Hansen Road to Rutherford Road. HDR has been retained by the City of Brampton to conduct the Clark Boulevard extension / Eastern Avenue improvement 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), Toronto and Region Conservation Authority (TRCA), Region of Peel, and the City of Brampton's Policies and Standards. The study limits are illustrated in **Figure 1-1**.

Figure 1-1. Study Area

The objective of the Drainage and Stormwater Management Report is to:

- Review available drainage information for existing conditions, including storm drainage area plans, reports and previous studies, plan-and-profile drawings and hydraulic and hydrologic models;

- Identify and evaluate existing drainage patterns and transverse culvert and bridge locations;
- Identify the existing stormwater and drainage conditions in the study area, including sensitive areas and issues;
- Establish design criteria for stormwater management to meet the requirements of the various authoritative bodies;
- Identify potential stormwater runoff quality and quantity impacts to the receiving watercourses/ storm sewer system resulting from changes to the roadway cross-section (i.e. increased pavement area); and
- Propose an appropriate drainage system, transverse culvert and bridge 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 Clark Boulevard Extension / Eastern Avenue Improvements Class Environmental Assessment Drainage and Stormwater Management Report, the following documents were obtained and reviewed:

1. Ministry of the Environment, Conservation and Parks (MECP) Stormwater Management Practices Planning and Design Manual, March 2003;
2. Ministry of Transportation (MTO) Highway Drainage Design Standards, January 2008;
3. Toronto and Region Conservation Authority (TRCA) Stormwater Management Criteria, August 2012;
4. Etobicoke Creek Hydrology Update Draft Final Report, prepared by MMM Group Limited, April 2013;
5. Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC) Low Impact Development Stormwater Management Planning and Design Guide, 2010;
6. Sustainable Technologies Evaluation Program (STEP) Low Impact Development Stormwater Management (LID SWM) Planning and Design Guide, 2020;
7. City of Brampton, Planning Design and Development Department, Engineering and Development Services Division Subdivision Design Manual, December 2008;
8. Region of Peel Public Works Stormwater Design Criteria and Procedural Manual, June 2019;
9. Region of Peel and CVC's LID Implementation Process for Regional Road Right-of-Ways (2014);
10. Channel Alignment Options for Proposed Clark Boulevard Extension Memo, prepared by Matrix Solutions Inc., April 2020;
11. Draft Fluvial Geomorphological Report, Tributary of Spring Creek, Municipal Class Environmental Study for Clark Boulevard Extension and Eastern Avenue

Improvements from Rutherford Road to Kennedy Road, prepared by GEO Morphix Ltd., December 2021;

12. Draft Clark Boulevard and Eastern Avenue Natural Environment Assessment Report, prepared by Natural Resource Solutions Inc. (NRSI), September 2019;
13. Preliminary Geotechnical/Pavement Investigation Report, Clark Avenue Extension, Rutherford Road to Kennedy Road, City of Brampton, Thurber Engineering Limited, January 2022;
14. Draft Preliminary Hydrogeological Assessment Report, Clark Avenue Extension, Rutherford Road to Kennedy Road, City of Brampton, Thurber Engineering Limited, February 2022; and
15. MECP Response to Notice of Commencement Letter, January 2019.

2 Existing Drainage Conditions

2.1 Watershed and Subwatershed

The proposed alignment is located within the watershed of Etobicoke Creek. The Toronto and Region Conservation Authority (TRCA) has jurisdiction with respect to drainage and stormwater management of the Etobicoke Creek Watershed. The proposed alignment will cross an engineered drain connected to a tributary to Spring Creek.

2.2 Land Use

The area of the proposed extension of Clark Boulevard east of the drain is currently occupied by a vacant parcel of industrial property owned by the City of Brampton at 25 Rutherford Road South. West of the drain, the area of the extension is occupied by 35 Rutherford Road South, which currently contains a manufacturing plant for pre-fabricated concrete products.

The area surrounding the project corridor mainly contains industrial properties along both sides of Eastern Avenue and the proposed Clark Boulevard extension.

2.3 Hydrogeological Conditions

Preliminary geotechnical and pavement investigations were conducted by Thurber Engineering Ltd. in August and September 2021. A borehole investigation field program was carried out between August 16 and September 23, 2021 and consisted of drilling and sampling a total of twenty five (25) boreholes. Two (2) monitoring wells on Eastern Avenue and two (2) monitoring wells at the Clark Boulevard extension were installed to measure groundwater levels.

At Eastern Avenue, the subsurface stratigraphy generally consisted of a pavement structure or topsoil overlying silty clay to clayey silt fill or native clayey silt, which was further underlain by silty sand till. At the Clark Boulevard extension area, the subsurface stratigraphy encountered generally consisted of mixed fill overlying native silty clay to clayey silt, which was further underlain by silt and sand tills.

Single monitoring well response test (SWRT) rising head tests were conducted in the installed wells on site. The resulting estimated hydraulic conductivity was 4.6×10^{-9} m/s on Eastern Avenue and 1.9×10^{-6} m/s at the Clark Boulevard extension for the saturated soils below the groundwater table. As a conservative approach, the lower hydraulic conductivity of 4.6×10^{-9} m/s was utilized for further calculation purposes. This hydraulic conductivity approximately corresponds to an infiltration rate of 11 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 3.6 mm/hr.

Measured groundwater levels in stabilized monitoring wells within the area of the proposed creek crossing during the investigation ranged between 0.54 m to 1.09 m below the ground surface (elevations ranging from 221.3 m to 217.5 m) on Eastern Avenue, and 1.52 m to 2.93 m below the ground surface (elevations ranging from 212.7 m to 213.7 m) at the Clark Boulevard extension. 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

Within the study limits, Eastern Avenue west of Kennedy Road has an urban cross-section with a storm sewer system discharging to the storm system along Kennedy Road. Eastern Avenue from east of Kennedy Road to Hansen Road has a rural cross-section with ditches and culverts conveying flow in an easterly direction towards the ditch on the northeast corner of the Eastern Avenue and Hansen Road intersection. The ditch conveys flows towards the north and ultimately outfalls to the engineered drain connected to Spring Creek Tributary.

The proposed Clark Boulevard extension alignment crosses through the existing manufacturing plant at 35 Rutherford Road. The manufacturing plant lands drain to the engineered drain via ditch inlet catchbasins that discharge directly to the drain through several concrete pipe outlets.

Within the study limits, Clark Boulevard east of Rutherford Road has an urban cross-section with a storm sewer system discharging to the trunk storm system along Rutherford Road. The trunk system outfalls to the tributary to Spring Creek.

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	130 m west of Kennedy Rd. to Kennedy Rd.	0.46	0+038	0+154	Existing Regional storm sewer system (600 mm) on Kennedy Rd.
A-2	Kennedy Rd. to Hansen Rd.	1.54	0+154	0+613	Hansen Rd. ditch system, ultimate outfall to Spring Creek Tributary
A-3	Hansen Rd. to Rutherford Rd. (Proposed Clark extension alignment)	1.30	0+613	1+047	Engineered drain, ultimate outfall to Spring Creek Tributary
A-4	200 m east of Hansen Rd. to Rutherford Rd. (Proposed channel realignment)	0.65	0+828	1+047	Engineered drain, ultimate outfall to Spring Creek Tributary
A-5	Rutherford Rd. to 100 m east of Rutherford Rd.	0.72	1+047	1+238	Existing Regional storm sewer system (2150 mm) on Rutherford Rd.

2.4.1 External Areas

Existing catchment areas and outlet locations along the corridor are identified in **Appendix A**. There are several surface drainage outlets (i.e. swales and culvert outlets) from areas outside the Right-of-Way to the existing ditch system between Kennedy Road and Hansen Road, as shown in the Drainage Area Plans in **Appendix A**.

Due to limited information regarding the extent of external drainage areas contributing to the existing ditches along Eastern Avenue west of Hansen Road, these areas were conservatively estimated. The contributing external areas are to be confirmed during detailed design to ensure that the proposed storm sewer system within the right-of-way has sufficient capacity.

Any external drainage from the existing manufacturing plant will also need to be conveyed to the engineered drain via surface ditch systems or as part of future development.

2.5 Aquatic Resources

According to the Natural Environment Assessment Report prepared by Natural Resource Solutions Inc. (NRSI, 2021), there is no regulated habitat for aquatic Species At Risk (SAR) and no SAR's were recorded within the study area. The study area does not contain fish habitat due to poor connectivity, low quality aquatic conditions, and absence of a fish community. Note that the study area is also located within the general regulation limits of the TRCA, and the proposed works will require permitting under Ontario Regulation 166/06.

2.6 Transverse Drainage Crossings

Under existing conditions, there is no transverse drainage crossing of Eastern Avenue / Clark Boulevard for the engineered drain. The watercourse crossing at Rutherford Road is outside of the study limits.

3 Proposed Drainage Condition

3.1 Roadway Drainage System

The preferred alternative design concept for Eastern Avenue / Clark Boulevard from Kennedy Road to Rutherford Road recommends a new roadway alignment between Hansen Road and Rutherford Road, widening and urbanization of the existing roadway from two to four lanes, and the addition of sidewalks on both sides of the road and dual boulevard cycle tracks on the north side of the road. The design concept also includes intersection improvements at the Kennedy Road, Hansen Road, and Rutherford Road intersections and the at-grade rail crossing east of Kennedy Road.

The proposed roadway profile will generally remain consistent with existing conditions, with the exception of the segment from approximately 100 m west of Hansen Road to 70 m west of Rutherford Road. This segment will be raised to accommodate the proposed roadway corridor and channel realignment and slopes in an easterly direction. 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.

For areas where Eastern Avenue / Clark Boulevard is higher than the existing ground (fill sections), a continuous slope to direct runoff from external drainage areas to their existing outlets will be provided. For areas where Eastern Avenue / Clark Boulevard is lower than the existing ground (cut sections), the runoff from external areas will be captured into the future storm sewer system by ditch inlet catchbasins, maintaining the existing drainage pattern. The conveyance of external flows will be further investigated as part of detailed design.

3.1.1 Minor Drainage System

The overall drainage pattern will generally be consistent with the existing conditions. To accommodate the proposed roadway widening and urbanization, the proposed roadway runoff will be collected by a series of catchbasins and will be conveyed by curb and gutter and storm sewers to the existing storm outlet locations. The storm sewer system for the ultimate roadway configuration is to be designed for a 10-year storm event as per Minimum Standard No. 1 of the City of Brampton Subdivision Design Manual, which is applicable to roadways. There are a number of existing outlets for the runoff from Eastern Avenue / Clark Boulevard 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**.

During detailed design, a hydraulic grade line analysis, considering the water surface elevations in the engineered drain as the downstream boundary condition, will be conducted for the storm sewer to demonstrate that the hydraulic grade line is at minimum 0.3 m below the footing elevation of any adjacent dwelling units under the 100-year design storm event.

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 the outfall locations. The ponding depth of water shall not exceed 15 cm above the gutter, as per the City of Brampton Subdivision Design Manual. A minimum of 2 lanes of roadway pavement must be flood-free at all times for emergency vehicles during the major storm events. However, the major overland flow shall not be permitted to flow across any arterial or major collector roads under any circumstances. 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 above criteria.

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

3.2 Hydraulic Assessment of the Engineered Drain

The proposed Clark Boulevard extension design involves a new culvert crossing and the realignment of the engineered drain, which is connected to a tributary of Spring Creek. A Channel Alignment Options Memo was prepared by Matrix Solutions Inc. in 2020 as part of the Queen's Boulevard Planning District Flood Mitigation Study to assess the flooding impact of various options for the channel realignment.

The results from the Memo indicated that the limited hydraulic capacity at the downstream Rutherford Road crossing is impacting the upstream lands and must be considered in coordination with the options for the Clark Boulevard extension. According to the Memo, flooding around Rutherford Road could potentially be mitigated by replacing the existing 1.95 m concrete pipe culvert at Rutherford Road with an 8.535 x 2.44 m Conspan arch culvert, combined with widening the channel to 5 m at the bottom and 3:1 side slopes, from downstream of the 2016 channel works to upstream of the Highway 410 crossing. Based on the HEC-RAS assessment in the Memo, these measures were found to be effective at eliminating overtopping of Rutherford Road for the 100-year and Regional storm events.

The Memo also provided the results of hydraulic assessment of three (3) channel alignment alternatives for the crossing under the proposed Clark Boulevard extension. An 8.535 x 2.44 m Conspan arch culvert was also proposed as part of this Memo for the Clark Boulevard extension crossing, based on the proximity of the crossing to Rutherford Road and the similar contributing flows.

A Fluvial Geomorphological Report for the Tributary of Spring Creek was prepared by GEO Morphix Ltd. conducted as part of this current EA study. In conjunction with the findings from the Channel Alignment Options Memo (Matrix Solutions Inc., 2020), the proposed channel realignment option involved a 90-degree bend in the channel downstream of the crossing and channel widening as per the proposed cross-section provided by GEO Morphix. Additional details on the channel realignment are provided in the Fluvial Geomorphological Report (GEO Morphix Ltd., 2021).

A preliminary hydraulic assessment is conducted with the proposed 8.535 x 2.44 m Conspan arch culvert to confirm the sizing of the proposed culvert crossing. The hydraulic assessment also includes a comparison with existing conditions without the downstream Rutherford Road improvements, to ensure that the proposed channel realignment and culvert crossing will not generate negative upstream water surface elevation impacts.

3.2.1 Assessment Criteria

The hydraulic assessment of the proposed watercourse crossing was undertaken in accordance with the Ontario Ministry of Transportation's Highway Drainage Design Standards (2008).

Design Flows

Based on the MTO Drainage Standard WC-1, the design flow for structures crossing Urban Arterial roadways with spans greater than 6.0 m is the 100-year flow.

Freeboard and Clearance

The minimum required freeboard for culverts crossing Urban Arterial roadways is specified to be a minimum of 1.0 m between the design high water level and the edge of the travelled lane for freeboard, as per MTO Drainage Standard WC-7: Culvert Crossings on a Watercourse. The minimum clearance for culverts with irregular cross sections is 0.3 m below the effective rise of the culvert.

3.2.2 Preliminary Hydraulic Model

As part of the drainage scope for the purposes of this EA study, a preliminary HEC-RAS model was developed to evaluate the impact of the proposed 36.1m length 8.535 x 2.44 m Conspan arch culvert crossing under the Clark Boulevard extension with the proposed channel realignment and widening. A more detailed analysis using a 2-dimensional hydraulic model is recommended in the detail design stage to assess the impact upstream and downstream of the crossing. Additional coordination with both the City of Brampton and the TRCA shall be carried out to finalize the detail design of the culvert and minimize the potential for flooding within the study area.

The HEC-RAS model for the Tributary to Spring Creek, which was updated by Matrix Solutions Inc. as part of the Channel Alignment Options Memo, was obtained from the City of Brampton. The model included the design peak flows as well as the proposed downstream channel widening and culvert upsizing at Rutherford Road improvements. A summary of the design storm peak flow for the culvert crossings is presented in **Table 3-1**.

Table 3-1. Design Peak Flow – Clark Boulevard Extension Crossing

Watercourse Crossing	Type	Peak Flow (m^3/s)		
		50-yr Storm	100-yr Storm	Regional Storm
Tributary to Spring Creek	Culvert	26.22	29.09	42.87

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.

Table 3-2 summarizes the hydraulic analysis results for the culvert crossing. The HEC-RAS output is provided in **Appendix B**. The results presented in **Table 3-2** indicate that the culvert meets the MTO freeboard criteria, and there is no overtopping under the Regional storm.

Table 3-2. Hydraulic Analysis Results – Clark Boulevard Extension Crossing

Scenario	Soffit Elev.[1] (m)	Road Elev. (m)	Water Surface Elev. (m)			100-yr Free-board (m)	100-yr Clearance (m)	Remarks
			50-yr	100-yr	Reg.			
Proposed Conditions	215.44	217.1	215.17	215.30	215.86	1.80	0.14	Meets MTO freeboard criteria
Proposed Conditions with Rutherford Improvements			215.05	215.11	215.86	1.99	0.33	Meets MTO freeboard and clearance criteria

[1] Elevation of equivalent rectangular culvert (effective rise of 2.12 m)

As part of the assessment, the water surface elevations at the cross-section immediately upstream of the proposed channel realignment, downstream of the realignment, and upstream and downstream of the Rutherford Road crossing were compared between existing and proposed conditions. The results for the 50-year, 100-year, and Regional storm events are summarized in **Table 3-3**, and the results for the 2-year to 25-year storm events are included in **Appendix B**. Based on the results of the assessment, the proposed crossing and channel realignment works will have no negative impact on the upstream water surface levels.

Table 3-3. Hydraulic Analysis Results – Upstream Water Surface Elevation

HEC-RAS Cross Section	Including Rutherford Improvements	50-Year			100-Year			Regional		
		Ex.	Prop.	Change	Ex.	Prop.	Change	Ex.	Prop.	Change
Upstream of Channel Realignment										
21.84	Yes	216.15	215.64	-0.51	216.21	215.69	-0.52	216.40	216.08	-0.32
	No	216.15	215.72	-0.43	216.21	215.80	-0.41	216.40	216.08	-0.32
Downstream of Channel Realignment										
21.836	Yes	214.99	214.62	-0.37	215.03	214.75	-0.28	215.17	215.13	-0.04
	No	214.99	214.98	-0.01	215.03	215.02	-0.01	215.17	215.14	-0.03
Upstream of Rutherford Road										
21.835	Yes	214.91	213.89	-1.02	214.94	213.97	-0.97	215.03	214.76	-1.24
	No	214.91	214.91	0.00	214.94	214.94	0.00	215.03	215.03	0.00
Downstream of Rutherford Road										
21.833	Yes	214.22	213.10	-1.12	214.32	213.17	-1.15	214.61	213.49	-1.12
	No	214.22	214.22	0.00	214.32	214.32	0.00	214.61	214.61	0.00

4 Stormwater Management Criteria

The stormwater management plan for the study area within the Etobicoke Creek watershed shall be developed to comply with the Toronto and Region Conservation Authority (TRCA) Stormwater Management Criteria, MECP Stormwater Management Guidelines, Etobicoke Creek Hydrology Update Draft Final Report (2013), Region of Peel Public Works Stormwater Design Criteria, and the City of Brampton Subdivision Design Manual.

4.1 Water Quality Control

Watercourses within the TRCA'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 extension/widening/improvements.

4.2 Water Quantity Control

Storm Sewer Systems

Within the project limits, the stormwater runoff from Eastern Avenue / Clark Boulevard discharges either into the existing drainage systems or outlets to the engineered drain, which is connected to a tributary of Spring Creek. 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 Region of Peel systems, which would have been designed based on a 10-year storm.

Watercourse Crossings

According to the Etobicoke Creek Hydrology Update (TRCA, 2013), for catchments in the Spring Creek Watershed, quantity control is required to existing peak flows for the 2- to 100-year design storm events and the Regional storm event. Unit flow rates are provided for the 2- to 100-year design storm events, and an additional 214 m^3/ha is required for additional storage for Regional controls. However, given the limited space within the ROW for linear infrastructure, it will be difficult to satisfy these criteria; therefore, a best efforts approach to provide sufficient storage to attenuate the post-development peak flow to the pre-development level for all design storms is recommended.

4.3 Water Balance and Erosion Control

The TRCA criteria for water balance and erosion control requires retention of 5 mm of rainfall. This criterion is applicable to increased pavement area as a result of roadway extension/widening/improvements.

4.4 Pavement Area Analysis

The existing and proposed pavement areas were measured as part of the pavement area analysis to determine the change in impervious surface under existing and proposed conditions. The measured pavement areas are detailed in **Appendix D**.

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 Clark Boulevard 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 a net 0.22 hectare decrease in pavement area within the Eastern Avenue / Clark Boulevard study corridor, due to the proposed naturalized channel realignment at the existing paved manufacturing plant.

Table 4-1. Pavement Area Analysis

Study Corridor	Existing Pavement Area (ha)	Proposed Pavement Area (ha)	Net Change in Pavement Area (ha)	Percentage Increase/ Decrease
Eastern Ave. / Clark Blvd.	3.27	3.04	-0.22	-6.7%

4.5 Stormwater Best Management Practice Options

Various Best Management Practices (BMPs) for stormwater management were reviewed and assessed for their applicability on this project. 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 in the boulevards parallel to storm sewers are proposed for catchments discharging directly to a watercourse or drainage feature for quality treatment, erosion control, and water balance. Oil-grit separator (OGS) units are proposed for the catchments that are discharging to existing storm sewer systems and are not directly treated by the bioretention facilities, as an additional quality control measure.

To provide quantity control at locations discharging to existing storm sewer systems, online storage pipes are proposed. Due to the small size and minimal increase in pavement area for the catchments that are discharging to existing storm sewer systems, additional quality control measures are not required.

4.5.1 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. Surface inlets (e.g. curb cuts) can be used to direct runoff from the roadways into the bioretention cells to reduce the overall depth of the facility.

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 3.6 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} = 437 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 0.5 m deep gravel storage layer, 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 groundwater table. According to the Hydrogeological Investigation (**Section 2.3**), the groundwater table ranges from 1.5 to 2.9 m below the ground surface where LID measures are generally proposed between Hansen Road and Rutherford Road. Due to the raise in roadway profile along the Clark Boulevard extension alignment, this should provide adequate separation between the groundwater table and the bottom of the proposed facilities. LID measures could also be implemented in areas with high groundwater to exclusively provide quality control, but the facilities should be lined if adequate separation cannot be obtained. Further investigation should be completed during the detail design stage to confirm adequate separation from the proposed facilities at each location and to 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 and A-3, where runoff discharges directly into the engineered drain, which is connected to a tributary of Spring Creek. 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 TRCA water balance and erosion control target. Pre-treatment of the runoff directed to the bioretention cells using forebay areas or catchbasin inserts (e.g. CB Shield) is recommended.

The bioretention cells are designed to provide water quality treatment for pavement areas greater than the total increase in pavement area across the study corridor. For Drainage Areas A-2 and A-3, the bioretention cells are sized to provide treatment for the entire paved area, which significantly exceeds the total increase in pavement area within the project limits.

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

Table 4-2. Summary of Proposed Bioretention Facilities

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)	Provided Quality & Erosion Control Volume (m^3)
A1	0.37	0.05	3	3	0	-	-	-
A2	1.12	0.18	10	9	305	1.12	73	268
A3	0.97	0.22	12	11	670	0.97	161	590
A4	0.00	-0.69	0	0	0	-	-	-
A5	0.59	0.01	0	0	0	-	-	-
Total	**3.04**	**-0.22**	**25**	**23**	**975**	**2.15**	**234**	**858**

[1] Based on the retention of the first 5 mm of rainfall
[2] Provided storage volume below underdrain

Through the proposed water quality treatment strategy, a total of 2.15 ha of pavement area will receive water quality control through the use of the bioretention facilities. A total of 234 m^3 and 858 m^3 of water balance and water quality/erosion control storage volumes are respectively proposed using the bioretention facilities, which exceeds the required storage volumes based on MECP and TRCA criteria. 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. Oil-grit separator (OGS) units are proposed for Drainage Areas A-1 and A-5, which discharge to existing municipal systems. No water quality treatment measures are required for Drainage Area A-4, since this catchment consists of only the naturalized realigned channel.

4.5.2 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 quantity control for catchments discharging to Region of Peel storm sewer systems (Drainage Areas A-1 and A-5), the Region 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. For Drainage Area A-1, the Region of Peel IDF curve was used to determine the required storage volumes. For Drainage Area A-5, where the runoff discharges into an existing Regional system, quantity control is not required since the increase in pavement area is negligible (1%) and no impacts to the quantity of runoff discharging to the existing receiving sewer are anticipated.

For catchments discharging Spring Creek Tributary where an increase in pavement areas is proposed (Drainage Areas A-2 and A-3), due to the linear nature of the corridor and limited space for stormwater management facilities within the right-of-way, the unitary flow rates established as part of the Etobicoke Creek Hydrology Update (2013) cannot be met. A best-efforts approach is proposed by controlling post-development peak flows for the 2-year to 100-year events to existing levels. The City of Brampton IDF curve was used to determine the required storage volumes.

The required storage volumes to achieve the quantity control targets for each catchment are summarized in **Table 4-3**. Online storage pipes are proposed for Drainage Areas A-1, A-2, and A-3, and shall be designed in combination with surface ponding to provide the required storage in the detailed design stage. Detailed calculations are provided in **Appendix C**.

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

Drainage Area ID	Drainage Area (ha)	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Req'd Storage to Control Minor Flows[2] (m^3)	Req'd Storage to Control Major Flows[2] (m^3)
A-1	0.46	0.32	0.05	8	14
A-2	1.54	0.94	0.18	24	34
A-3	1.30	0.74	0.22	30	43
A-4	1.02	0.69	-0.69	-	-
A-5	0.72	0.58	0.01	-	-
Total	5.05	3.27	-0.22	62	91

[1] Based on the capacity of the receiving storm sewer system (up to 10-year storm)
[2] Based on controlling up to 100-year storm

Through the proposed water quantity control strategy, a total of 0.46 ha of pavement area will receive quantity control through the proposed online storage pipes, which is in the total increased pavement area in Drainage Areas A-1, A-2, and A-3. A total of 62 m^3 of storage volume will need to be provided to attenuate minor peak flows and a total of 91 m^3 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.

4.5.3 Supplemental BMP Measures

Through discussions with TRCA, opportunities to implement supplemental stormwater best management practice (BMP) measures to augment the treatment proposed by the bioretention cells using a treatment train approach, including measures to mitigate water temperature impacts, are to be considered in the detail design stage.

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 Low Impact Development Stormwater Management Planning and Design Guide (STEP, 2020).

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

Exfiltration Trenches/French Drains

Exfiltration trenches and French drains 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

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.

Vegetative filter strips should be considered to provide additional water quality control in series with the bioretention cells as a treatment train system.

Plunge Pools

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.

Plunge pools should be considered at the storm outfall locations to disperse the energy of the flow.

4.6 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 detail 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 TRCA.

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.

4.7 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 bioretention systems, OGS units, and roadway storm sewer systems and discharge into either existing storm sewer systems or the engineered drain, which is connected to a tributary of Spring Creek. As per **Section 4.3**, the net roadway pavement area will decrease by 0.22 ha, including consideration of the cycle tracks and sidewalks within the boulevard areas and the naturalized realigned channel. Enhanced level water quality, water balance, and erosion control treatment will be provided for 2.15 ha of pavement area, exceeding the MECP requirement of providing treatment to the increased pavement area. The remaining pavement areas will be treated by the proposed OGS units. 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 extension/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 (m^3)	Req'd Storage to Control Minor Flows[2] (m^3)	Req'd Storage to Control Major Flows (m^3)
A-1	0.32	0.05	0.32	-	8	14
A-2	0.94	0.18	1.12	268	24	34
A-3	0.74	0.22	0.97	590	30	43
A-4[1]	0.69	-0.69	-	-	-	-
A-5	0.58	0.01	0.58	-	-	-
Total	**3.27**	**-0.22**	**3.04**	**858**	**62**	**91**

[1] Catchment consists of only naturalized realigned channel
[2] Based on capacity of receiving storm sewer system (up to 10-year storm) and controlling up to 100-year storm

5 Conclusions

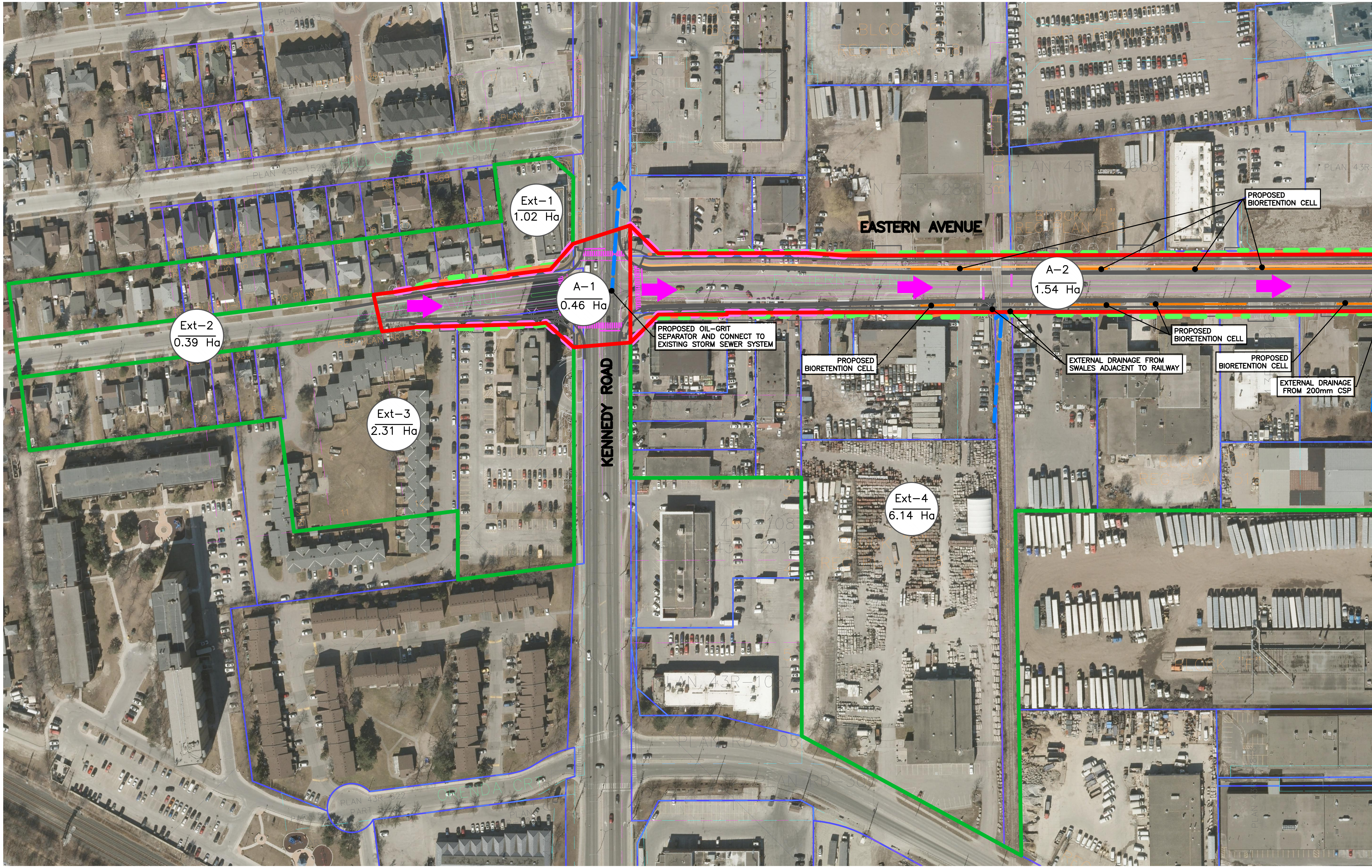
The Eastern Avenue / Clark Boulevard corridor between Kennedy Road and Rutherford Road proposed to be widened from 2 to 4 lanes with a new alignment through the existing concrete manufacturing plant, and urbanized with the addition of sidewalks on both sides of the road and dual boulevard cycle tracks on the north side of the road. The design concept also includes intersection improvements at the Kennedy Road, Hansen Road, and Rutherford Road intersections. The proposed design will 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 the TRCA, and a new 8.535 x 2.44 m Conspan arch culvert crossing with channel realignment and widening for the engineered drain, which is connect to a tributary of Spring Creek, is proposed under the Clark Boulevard extension alignment. A preliminary hydraulic assessment, including the downstream improvements at Rutherford Road, was conducted to determine the upstream impact as a result of the proposed works. The hydraulic assessment confirmed that there would be no increase in upstream flood levels and the proposed crossing meets the MTO Drainage Design freeboard criteria. A detailed hydraulic assessment should be conducted during detail design to confirm the hydraulic impacts in consideration with the proposed downstream channel improvement works.

Stormwater best management practices, including catchbasin inserts, bioretention systems, and online storage pipes, are proposed to provide stormwater quality treatment, water balance, erosion control, and quantity control of the increased runoff from the roadway right-of-way. The proposed road improvements, including consideration of the naturalized realigned channel, will result in a net decrease in pavement area of 0.22 ha. As part of the SWM strategy, a total of 2.15 ha of pavement area will receive quality treatment through the proposed bioretention cells, which exceeds the MECP requirement of providing treatment to the increased pavement area. The bioretention cells will also provide 234 m^3 of water balance storage and 858 m^3 of water quality and erosion control storage volume, which exceeds the required volumes determined by the MECP and TRCA. Oil-grit separator units are proposed for the catchments that are not treated by the bioretention facilities as an additional quality control measure. A total of 0.46 ha of pavement area, which is the increase in pavement area from Drainage Areas A-1, A-2, and A-3, 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.

Appendix A: Drainage Area Plans

METRIC



SCALES
1:2000

LEGEND

PROPOSED R.O.W.
EXISTING R.O.W.
PROPOSED WATERCOURSE CROSSING
PROPOSED CATCHMENT BOUNDARY
EXTERNAL DRAINAGE AREA TO EASTERN/CLARK BOULEVARD

OUTLET/STORM SYSTEM CONNECTION
PROPOSED CHANNEL REALIGNMENT
TEMPORARY EASEMENT
GRADING
CL EXISTING ALIGNMENT
CL PROPOSED ALIGNMENT
PROPOSED BIORETENTION CELL

A / xx Ha — CATCHMENT ID / DRAINAGE AREA (Ha)
EXISTING STORM SEWER

OVERLAND FLOW DIRECTION

HDR

EASTERN AVENUE / CLARK BOULEVARD
(KENNEDY ROAD TO RUTHERFORD ROAD)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 0+000 TO 6+100

SHEET NO.
DP–01

JULY, 2022

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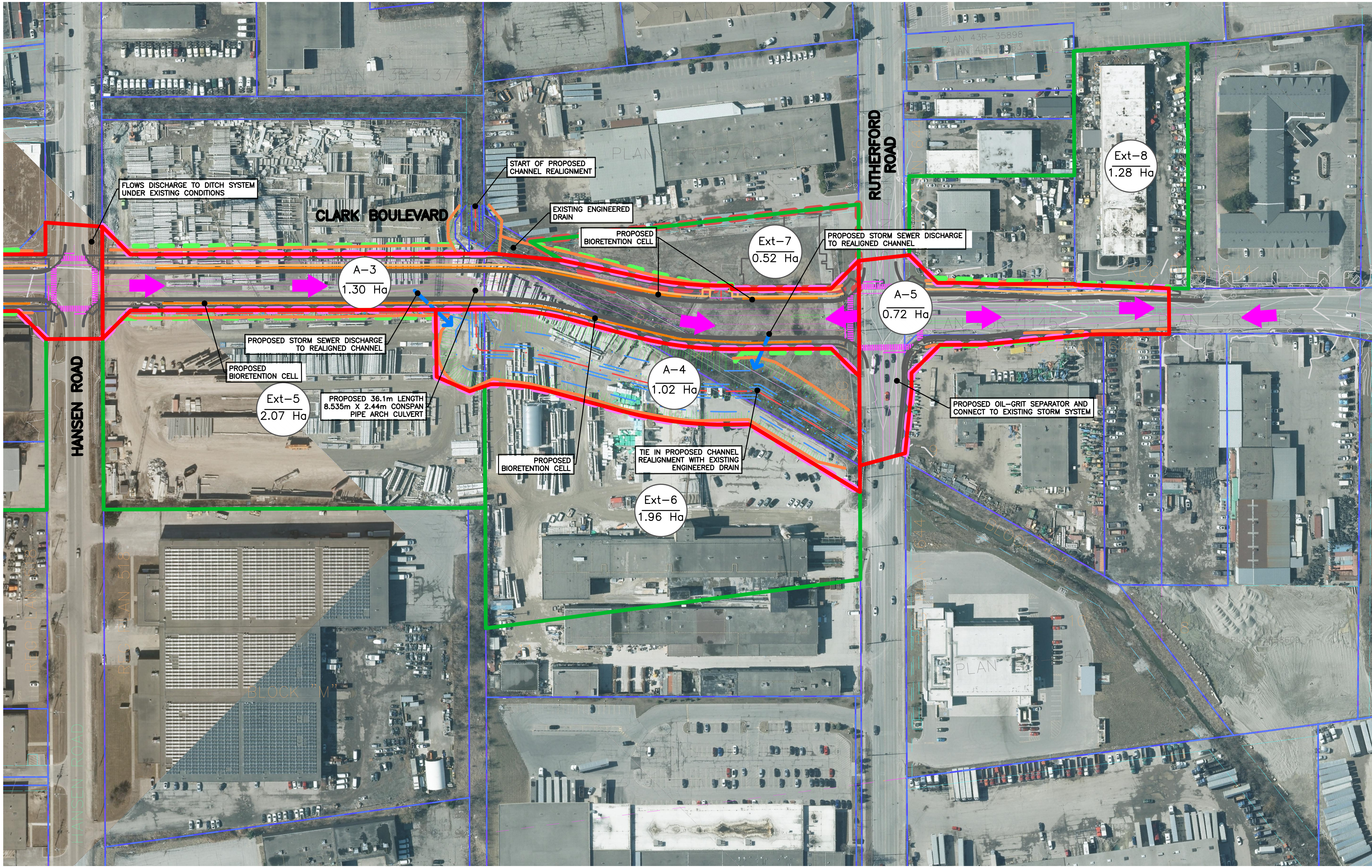
PLOTDATE: Jul 12, 2022 – 7:57am
PLOTTED BY: JLOOK

METRIC



SCALES
1:2000

LEGEND

PROPOSED R.O.W.
EXISTING R.O.W.
PROPOSED WATERCOURSE CROSSING
PROPOSED CATCHMENT BOUNDARY
EXTERNAL DRAINAGE AREA TO EASTERN/CLARK BOULEVARD
OUTLET/STORM SYSTEM CONNECTION
PROPOSED CHANNEL REALIGNMENT
TEMPORARY EASEMENT
GRADING
CL EXISTING ALIGNMENT
CL PROPOSED ALIGNMENT
PROPOSED BIORETENTION CELL
A / xx Ha — CATCHMENT ID / DRAINAGE AREA (Ha)
EXISTING STORM SEWER
OVERLAND FLOW DIRECTION

HDR

EASTERN AVENUE / CLARK BOULEVARD
(KENNEDY ROAD TO RUTHERFORD ROAD)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 6+100 TO 12+400

SHEET NO.
DP-02

JULY, 2022

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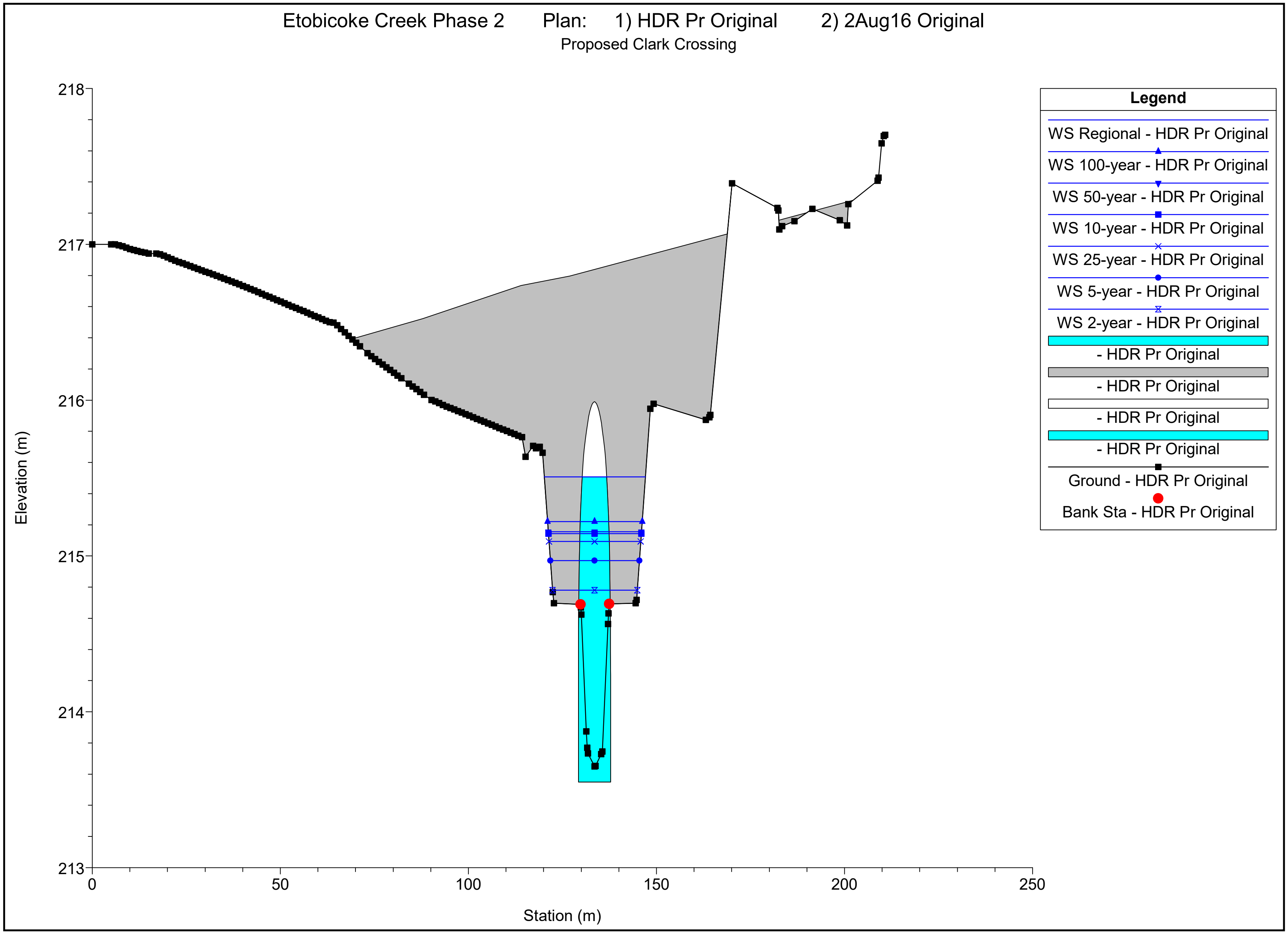
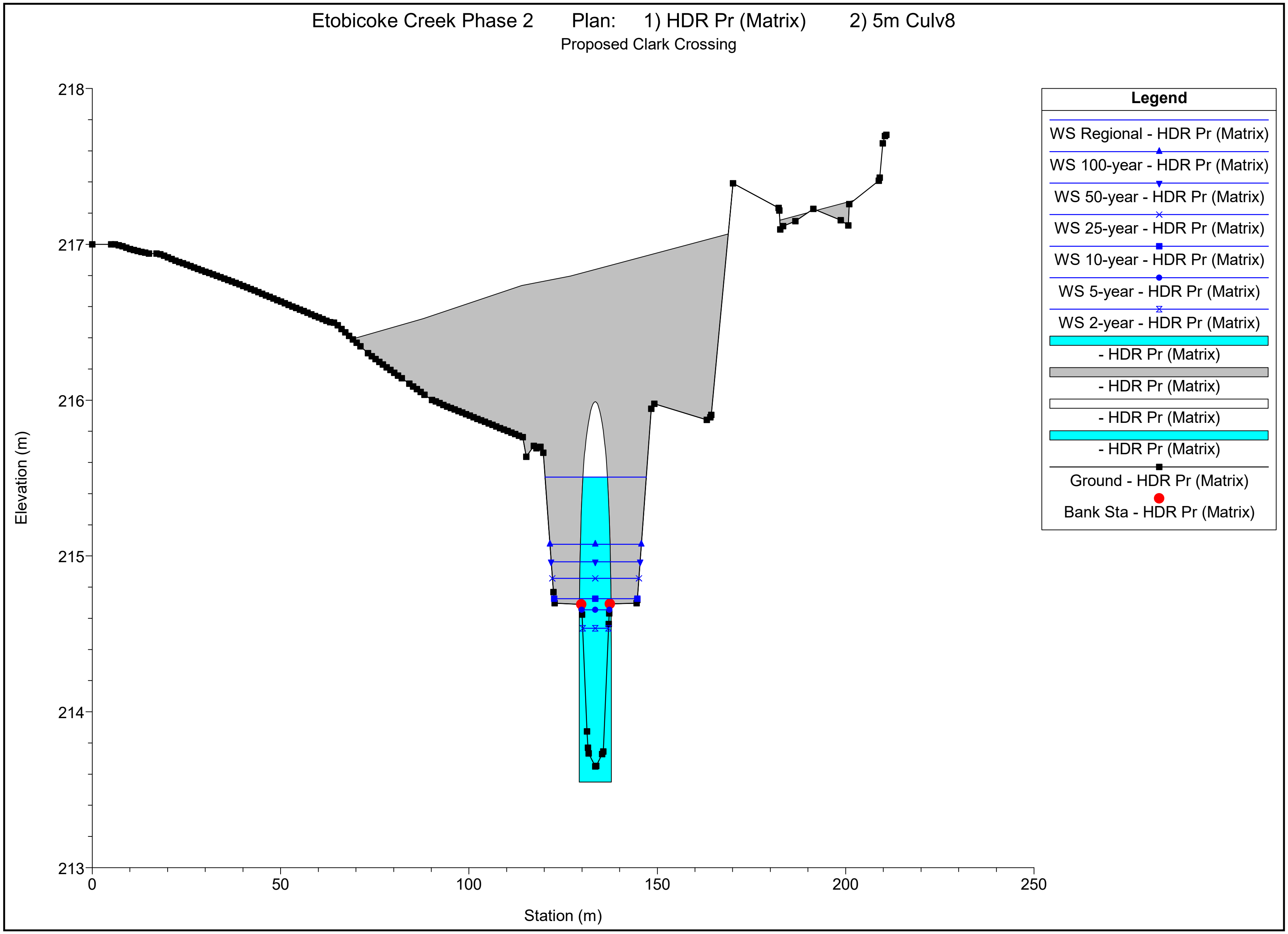
Appendix B: Hydraulic Model Output

100 York Boulevard, Suite 300, Richmond Hill, ON, CA L4B 1J8
(289) 695-4600


Etobicoke Creek Phase 2 Plan: 1) HDR Pr Original 2) 2Aug16 Original
Proposed Clark Crossing
Legend
WS Regional - HDR Pr Original
WS 100-year - HDR Pr Original
WS 50-year - HDR Pr Original
WS 10-year - HDR Pr Original
WS 25-year - HDR Pr Original
WS 5-year - HDR Pr Original
WS 2-year - HDR Pr Original
- HDR Pr Original
- HDR Pr Original
- HDR Pr Original
- HDR Pr Original
Ground - HDR Pr Original
Bank Sta - HDR Pr Original
Elevation (m)
218
217
216
215
214
213
Station (m)
0
50
100
150
200
250


Etobicoke Creek Phase 2 Plan: 1) HDR Pr (Matrix) 2) 5m Culv8
Proposed Clark Crossing
Legend
WS Regional - HDR Pr (Matrix)
WS 100-year - HDR Pr (Matrix)
WS 50-year - HDR Pr (Matrix)
WS 25-year - HDR Pr (Matrix)
WS 10-year - HDR Pr (Matrix)
WS 5-year - HDR Pr (Matrix)
WS 2-year - HDR Pr (Matrix)
- HDR Pr (Matrix)
- HDR Pr (Matrix)
- HDR Pr (Matrix)
- HDR Pr (Matrix)
Ground - HDR Pr (Matrix)
Bank Sta - HDR Pr (Matrix)
Elevation (m)
Station (m)
218
217
216
215
214
213
0
50
100
150
200
250

HEC-RAS River: EtobicokeCreek Reach: Reach2c

Note: Due to the channel realignment, the location of the sections in this segment for:
- HDR Pr Original
- HDR Pr (Matrix)
do not match the location of the sections for:
- 2Aug16 Original
- 5m Culv8

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)	
Reach2c	21.84	Regional	2Aug16 Original	42.87	213.45	216.40		216.45	0.004723	1.05	50.12	98.79	0.30
Reach2c	21.84	Regional	5m Culv8	42.87	213.45	216.40		216.45	0.004723	1.05	50.12	98.79	0.30
Reach2c	21.84	Regional	HDR Pr Original	42.87	213.45	216.08	215.49	216.26	0.019735	1.91	24.90	63.52	0.60
Reach2c	21.84	Regional	HDR Pr (Matrix)	42.87	213.45	216.08	215.49	216.26	0.019793	1.91	24.84	63.44	0.60
Reach2c	21.84	100-year	2Aug16 Original	29.09	213.45	216.21		216.25	0.005549	1.02	33.28	73.08	0.32
Reach2c	21.84	100-year	5m Culv8	29.09	213.45	216.21		216.25	0.005552	1.02	33.27	73.07	0.32
Reach2c	21.84	100-year	HDR Pr Original	29.09	213.45	215.69		215.87	0.014450	1.88	15.45	12.85	0.55
Reach2c	21.84	100-year	HDR Pr (Matrix)	29.09	213.45	215.80		215.95	0.011796	1.72	16.91	13.65	0.49
Reach2c	21.84	50-year	2Aug16 Original	26.22	213.45	216.15		216.20	0.005816	1.04	29.05	68.49	0.32
Reach2c	21.84	50-year	5m Culv8	26.22	213.45	216.15		216.20	0.005819	1.04	29.04	68.48	0.32
Reach2c	21.84	50-year	HDR Pr Original	26.22	213.45	215.64		215.80	0.012768	1.76	14.91	12.59	0.52
Reach2c	21.84	50-year	HDR Pr (Matrix)	26.22	213.45	215.72		215.86	0.011009	1.65	15.90	13.10	0.48
Reach2c	21.84	25-year	2Aug16 Original	23.38	213.45	216.08		216.13	0.006006	1.05	24.45	62.93	0.33
Reach2c	21.84	25-year	5m Culv8	23.38	213.45	216.08		216.13	0.006014	1.05	24.43	62.89	0.33
Reach2c	21.84	25-year	HDR Pr Original	23.38	213.45	215.65	215.03	215.77	0.010113	1.57	14.94	12.60	0.46
Reach2c	21.84	25-year	HDR Pr (Matrix)	23.38	213.45	215.65		215.77	0.010118	1.57	14.93	12.59	0.46
Reach2c	21.84	10-year	2Aug16 Original	19.57	213.45	215.88		215.94	0.004606	1.09	18.03	14.24	0.31
Reach2c	21.84	10-year	5m Culv8	19.57	213.45	215.85		215.91	0.004880	1.11	17.58	14.01	0.32
Reach2c	21.84	10-year	HDR Pr Original	19.57	213.45	215.43		215.56	0.011508	1.59	12.33	11.49	0.49
Reach2c	21.84	10-year	HDR Pr (Matrix)	19.57	213.45	215.53		215.64	0.009090	1.45	13.53	12.02	0.44
Reach2c	21.84	5-year	2Aug16 Original	16.61	213.45	215.72		215.77	0.004465	1.05	15.83	13.06	0.30
Reach2c	21.84	5-year	5m Culv8	16.61	213.45	215.70		215.76	0.004566	1.06	15.67	12.97	0.31
Reach2c	21.84	5-year	HDR Pr Original	16.61	213.45	215.44	214.82	215.53	0.008127	1.34	12.42	11.54	0.41
Reach2c	21.84	5-year	HDR Pr (Matrix)	16.61	213.45	215.44		215.53	0.008129	1.34	12.42	11.54	0.41
Reach2c	21.84	2-year	2Aug16 Original	12.41	213.45	215.50		215.54	0.003948	0.95	13.13	11.84	0.29
Reach2c	21.84	2-year	5m Culv8	12.41	213.45	215.48		215.53	0.004104	0.96	12.93	11.76	0.29
Reach2c	21.84	2-year	HDR Pr Original	12.41	213.45	215.30	214.66	215.37	0.006338	1.14	10.88	10.84	0.36
Reach2c	21.84	2-year	HDR Pr (Matrix)	12.41	213.45	215.30		215.37	0.006330	1.14	10.88	10.84	0.36
Reach2c	21.839	Regional	2Aug16 Original	42.87	213.16	215.93		216.08	0.015450	1.84	27.10	58.61	0.52
Reach2c	21.839	Regional	5m Culv8	42.87	213.16	215.93		216.08	0.015444	1.84	27.10	58.62	0.52
Reach2c	21.839	Regional	HDR Pr Original	42.87	213.65	215.86	215.33	216.02	0.002385	2.06	36.84	44.00	0.48
Reach2c	21.839	Regional	HDR Pr (Matrix)	42.87	213.65	215.86	215.33	216.02	0.002394	2.07	36.77	43.83	0.48
Reach2c	21.839	100-year	2Aug16 Original	29.09	213.16	215.71		215.85	0.016167	1.66	18.04	27.20	0.52
Reach2c	21.839	100-year	5m Culv8	29.09	213.16	215.71		215.85	0.016260	1.66	18.00	27.04	0.52
Reach2c	21.839	100-year	HDR Pr Original	29.09	213.65	215.30	215.11	215.52	0.004721	2.30	20.03	25.62	0.63
Reach2c	21.839	100-year	HDR Pr (Matrix)	29.09	213.65	215.11	215.11	215.47	0.008863	2.85	15.30	24.49	0.84
Reach2c	21.839	50-year	2Aug16 Original	26.22	213.16	215.66		215.78	0.015800	1.58	16.76	21.37	0.51
Reach2c	21.839	50-year	5m Culv8	26.22	213.16	215.65		215.78	0.015908	1.59	16.72	21.20	0.51
Reach2c	21.839	50-year	HDR Pr Original	26.22	213.65	215.17	215.05	215.42	0.005907	2.40	16.68	24.83	0.70
Reach2c	21.839	50-year	HDR Pr (Matrix)	26.22	213.65	215.05	215.05	215.40	0.008873	2.76	13.93	24.15	0.84
Reach2c	21.839	25-year	2Aug16 Original	23.38	213.16	215.60		215.71	0.015380	1.50	15.63	18.61	0.50
Reach2c	21.839	25-year	5m Culv8	23.38	213.16	215.60		215.71	0.015603	1.51	15.56	18.46	0.50
Reach2c	21.839	25-year	HDR Pr Original	23.38	213.65	214.99	214.99	215.32	0.009057	2.68	12.39	23.77	0.84
Reach2c	21.839	25-year	HDR Pr (Matrix)	23.38	213.65	214.99	214.99	215.32	0.009057	2.68	12.39	23.77	0.84
Reach2c	21.839	10-year	2Aug16 Original	19.57	213.16	215.51		215.61	0.012857	1.38	14.14	14.96	0.45
Reach2c	21.839	10-year	5m Culv8	19.57	213.16	215.47		215.58	0.011931	1.44	13.60	12.89	0.45
Reach2c	21.839	10-year	HDR Pr Original	19.57	213.65	215.14	214.90	215.29	0.003591	1.84	16.06	24.68	0.54
Reach2c	21.839	10-year	HDR Pr (Matrix)	19.57	213.65	214.90	214.90	215.21	0.009137	2.53	10.34	23.25	0.83
Reach2c	21.839	5-year	2Aug16 Original	16.61	213.16	215.40		215.49	0.009510	1.31	12.70	11.77	0.40
Reach2c	21.839	5-year	5m Culv8	16.61	213.16	215.37		215.46	0.009966	1.34	12.42	11.53	0.41
Reach2c	21.839	5-year	HDR Pr Original	16.61	213.65	214.82	214.82	215.11	0.009604	2.44	8.40	22.74	0.84
Reach2c	21.839	5-year	HDR Pr (Matrix)	16.61	213.65	214.82	214.82	215.11	0.009604	2.44	8.40	22.74	0.84
Reach2c	21.839	2-year	2Aug16 Original	12.41	213.16	215.23		215.30	0.007836	1.14	10.84	10.68	0.36
Reach2c	21.839	2-year	5m Culv8	12.41	213.16	215.20		215.27	0.008567	1.19	10.46	10.48	0.38
Reach2c	21.839	2-year	HDR Pr Original	12.41	213.65	214.57	214.57	214.92	0.014994	2.61	4.76	6.98	1.01
Reach2c	21.839	2-year	HDR Pr (Matrix)	12.41	213.65	214.57	214.57	214.92	0.014994	2.61	4.76	6.98	1.01
Reach2c	21.8385	Regional	HDR Pr Original	42.87	213.27	215.35		215.48	0.002374	1.96	41.21	36.39	0.47
Reach2c	21.8385	Regional	HDR Pr (Matrix)	42.87	213.27	215.35		215.47	0.002386	1.96	41.13	36.38	0.47
Reach2c	21.8385	100-year	HDR Pr Original	29.09	213.27	215.14		215.23	0.001846	1.59	33.82	35.05	0.41
Reach2c	21.8385	100-year	HDR Pr (Matrix)	29.09	213.27	214.97		215.10	0.003057	1.89	27.85	33.93	0.51
Reach2c	21.8385	50-year	HDR Pr Original	26.22	213.27	215.09		215.17	0.001737	1.51	31.98	34.71	0.39
Reach2c	21.8385	50-year	HDR Pr (Matrix)	26.22	213.27	214.86		215.00	0.003551	1.93	24.17	33.21	0.54
Reach2c	21.8385	25-year	HDR Pr Original	23.38	213.27	215.04		215.11	0.001604	1.42	30.19	34.37	0.37
Reach2c	21.8385	25-year	HDR Pr (Matrix)	23.38	213.27	214.75		214.91	0.004093	1.96	20.77	32.54	0.58
Reach2c	21.8385	10-year	HDR Pr Original	19.57	213.27	215.11		215.15	0.000913	1.10	32.70	34.84	0.28
Reach2c	21.8385	10-year	HDR Pr (Matrix)	19.57	213.27	214.63		214.79	0.004670	1.95	16.84	31.75	0.60
Reach2c	21.8385	5-year	HDR Pr Original	16.61	213.27	214.94		214.99	0.001088	1.11	26.91	33.75	0.30
Reach2c	21.8385	5-year	HDR Pr (Matrix)	16.61	213.27	214.55	214.43	214.70	0.004744	1.86	14.39	31.24	0.60
Reach2c	21.8385	2-year	HDR Pr Original	12.41	213.27	214.76		214.80	0.001144	1.04	20.84	32.56	0.30
Reach2c	21.8385	2-year	HDR Pr (Matrix)	12.41	213.27	214.42	214.24	214.56	0.005078	1.75	10.29	30.38	0.61
Reach2c	21.838	Regional	2Aug16 Original	42.87	212.86	215.64		215.68	0.002759	1.06	55.18	90.77	0.25
Reach2c	21.838	Regional	5m Culv8	42.87	212.86	215.64		215.68	0.002751	1.06	55.27	90.83	0.25
Reach2c	21.838	Regional	HDR Pr Original	42.87	213.03	215.23		215.39	0.002440	2.07	35.52	29.46	0.48
Reach2c	21.838	Regional	HDR Pr (Matrix)	42.87	213.03	215.22		215.38	0.002455	2.07	35.43	29.44	0.48
Reach2c	21.838	100-year	2Aug16 Original	29.09	212.86	215.47		215.50	0.002205	0.89	40.80	69.54	0.22
Reach2c	21.838	100-year	5m Culv8	29.09	212.86	215.46		215.49	0.002289	0.90	40.02	68.25	0.23
Reach2c	21.838	100-year	HDR Pr Original	29.09	213.03	215.07		215.17	0.001589	1.58	31.04	28.52	0.38
Reach2c	21.838	100-year	HDR Pr (Matrix)	29.09	213.03	214.84		214.99	0.002835	1.92	24.70	27.12	0.50
Reach2c	21.838	50-year	2Aug16 Original	26.22	212.86	215.42		215.45	0.002121	0.85	37.54	64.82	0.22
Reach2c	21.838	50-year	5m Culv8	26.22	212.86	215.40		215.43	0.002249	0.87	36.48	63.33	0.22
Reach2c	21.838	50-year	HDR Pr Original	26.22	213.03	215.03		215.11	0.001434	1.47	29.80	28.25	0.36
Reach2c	21.838	50-year	HDR Pr (Matrix)	26.22	213.03	214.71		214.87	0.003329	1.96	21.27	26.34	0.53
Reach2c	21.838	25-year	2Aug16 Original	23.38	212.86	215.37		215.39	0.002040	0.82	34.21	59.86	0.21
Reach2c	21.838	25-year	5m Culv8	23.38	212.86	215.33		215.36	0.002315	0.86	32.17	56.54	0.22

Note: Due to the channel realignment, the location of the sections in this segment for:
- HDR Pr Original
- HDR Pr (Matrix)
do not match the location of the sections for:
- 2Aug16 Original
- 5m Culv8

HEC-RAS River: EtobicokeCreek Reach: Reach2c (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)	
Reach2c	21.838	25-year	HDR Pr Original	23.38	213.03	214.98		215.06	0.001266	1.36	28.60	27.99	0.34
Reach2c	21.838	25-year	HDR Pr (Matrix)	23.38	213.03	214.58		214.76	0.004005	2.01	17.89	25.54	0.58
Reach2c	21.838	10-year	2Aug16 Original	19.57	212.86	215.32		215.34	0.001696	0.73	31.47	55.33	0.19
Reach2c	21.838	10-year	5m Culv8	19.57	212.86	215.17		215.21	0.002888	0.89	24.99	35.59	0.25
Reach2c	21.838	10-year	HDR Pr Original	19.57	213.03	215.08		215.12	0.000704	1.05	31.31	28.57	0.26
Reach2c	21.838	10-year	HDR Pr (Matrix)	19.57	213.03	214.40	214.27	214.60	0.005421	2.10	13.36	24.43	0.65
Reach2c	21.838	5-year	2Aug16 Original	16.61	212.86	215.20		215.23	0.001850	0.72	26.12	36.61	0.20
Reach2c	21.838	5-year	5m Culv8	16.61	212.86	215.04		215.08	0.003486	0.91	20.51	32.36	0.27
Reach2c	21.838	5-year	HDR Pr Original	16.61	213.03	214.91		214.95	0.000773	1.03	26.53	27.53	0.26
Reach2c	21.838	5-year	HDR Pr (Matrix)	16.61	213.03	214.26	214.19	214.49	0.007164	2.19	9.88	23.52	0.73
Reach2c	21.838	2-year	2Aug16 Original	12.41	212.86	215.01		215.03	0.002242	0.71	19.39	31.54	0.21
Reach2c	21.838	2-year	5m Culv8	12.41	212.86	214.82		214.86	0.004253	0.91	14.44	23.02	0.29
Reach2c	21.838	2-year	HDR Pr Original	12.41	213.03	214.73		214.76	0.000711	0.91	21.69	26.43	0.25
Reach2c	21.838	2-year	HDR Pr (Matrix)	12.41	213.03	214.07	213.94	214.31	0.009462	2.17	5.75	15.19	0.81
Reach2c	21.837	Regional	2Aug16 Original	42.87	212.83	215.39		215.44	0.003329	1.14	54.68	128.06	0.28
Reach2c	21.837	Regional	5m Culv8	42.87	212.83	215.40		215.44	0.003272	1.13	55.13	128.67	0.27
Reach2c	21.837	Regional	HDR Pr Original	42.87	212.46	215.15	214.14	215.23	0.000944	1.51	51.29	32.70	0.31
Reach2c	21.837	Regional	HDR Pr (Matrix)	42.87	212.46	215.15	214.14	215.23	0.000949	1.51	51.17	32.67	0.31
Reach2c	21.837	100-year	2Aug16 Original	29.09	212.83	215.23		215.28	0.003319	1.07	36.69	97.95	0.27
Reach2c	21.837	100-year	5m Culv8	29.09	212.83	215.18		215.24	0.004375	1.19	31.21	86.58	0.31
Reach2c	21.837	100-year	HDR Pr Original	29.09	212.46	215.03	213.91	215.07	0.000536	1.10	47.33	31.94	0.23
Reach2c	21.837	100-year	HDR Pr (Matrix)	29.09	212.46	214.77	213.91	214.84	0.000869	1.29	39.35	30.35	0.29
Reach2c	21.837	50-year	2Aug16 Original	26.22	212.83	215.18		215.23	0.003419	1.06	31.95	88.13	0.27
Reach2c	21.837	50-year	5m Culv8	26.22	212.83	215.10		215.18	0.004827	1.21	25.55	73.32	0.32
Reach2c	21.837	50-year	HDR Pr Original	26.22	212.46	214.99	213.85	215.03	0.000467	1.01	46.10	31.70	0.22
Reach2c	21.837	50-year	HDR Pr (Matrix)	26.22	212.46	214.64	213.85	214.70	0.000933	1.28	35.32	29.52	0.30
Reach2c	21.837	25-year	2Aug16 Original	23.38	212.83	215.13		215.18	0.003414	1.03	27.68	78.63	0.27
Reach2c	21.837	25-year	5m Culv8	23.38	212.83	215.02		215.09	0.005192	1.22	19.86	56.64	0.33
Reach2c	21.837	25-year	HDR Pr Original	23.38	212.46	214.95	213.80	214.99	0.000397	0.93	44.92	31.47	0.20
Reach2c	21.837	25-year	HDR Pr (Matrix)	23.38	212.46	214.50	213.80	214.56	0.001011	1.27	31.31	28.67	0.31
Reach2c	21.837	10-year	2Aug16 Original	19.57	212.83	215.15		215.19	0.002174	0.83	29.45	82.64	0.22
Reach2c	21.837	10-year	5m Culv8	19.57	212.83	214.83		214.90	0.005207	1.18	16.62	13.01	0.33
Reach2c	21.837	10-year	HDR Pr Original	19.57	212.46	215.06	213.70	215.08	0.000229	0.73	48.37	32.14	0.15
Reach2c	21.837	10-year	HDR Pr (Matrix)	19.57	212.46	214.31	213.70	214.37	0.001154	1.25	25.82	27.46	0.32
Reach2c	21.837	5-year	2Aug16 Original	16.61	212.83	215.01		215.05	0.002670	0.87	19.47	55.02	0.24
Reach2c	21.837	5-year	5m Culv8	16.61	212.83	214.68		214.74	0.005129	1.13	14.69	12.28	0.33
Reach2c	21.837	5-year	HDR Pr Original	16.61	212.46	214.89	213.62	214.91	0.000225	0.68	42.99	31.09	0.15
Reach2c	21.837	5-year	HDR Pr (Matrix)	16.61	212.46	214.15	213.62	214.21	0.001310	1.24	21.47	26.46	0.34
Reach2c	21.837	2-year	2Aug16 Original	12.41	212.83	214.83		214.85	0.002105	0.75	16.58	12.99	0.21
Reach2c	21.837	2-year	5m Culv8	12.41	212.83	214.43		214.49	0.005146	1.05	11.82	11.38	0.33
Reach2c	21.837	2-year	HDR Pr Original	12.41	212.46	214.72	213.38	214.73	0.000178	0.57	37.62	30.00	0.13
Reach2c	21.837	2-year	HDR Pr (Matrix)	12.41	212.46	213.90	213.38	213.97	0.001645	1.22	15.18	24.95	0.36
Reach2c	21.836	Regional	2Aug16 Original	42.87	211.99	215.17		215.21	0.002872	1.04	57.51	121.98	0.24
Reach2c	21.836	Regional	5m Culv8	42.87	212.00	215.18		215.22	0.002667	1.00	59.39	123.01	0.23
Reach2c	21.836	Regional	HDR Pr Original	42.87	211.94	215.14	213.63	215.17	0.000388	1.10	85.08	99.19	0.21
Reach2c	21.836	Regional	HDR Pr (Matrix)	42.87	211.94	215.13	213.63	215.17	0.000391	1.10	84.71	99.08	0.21
Reach2c	21.836	100-year	2Aug16 Original	29.09	211.99	215.03		215.06	0.002505	0.92	41.60	103.99	0.22
Reach2c	21.836	100-year	5m Culv8	29.09	212.00	214.82		214.89	0.004995	1.19	27.75	50.18	0.31
Reach2c	21.836	100-year	HDR Pr Original	29.09	211.94	215.02	213.41	215.04	0.000226	0.82	74.12	83.92	0.16
Reach2c	21.836	100-year	HDR Pr (Matrix)	29.09	211.94	214.75	213.41	214.78	0.000370	0.98	56.11	48.17	0.20
Reach2c	21.836	50-year	2Aug16 Original	26.22	211.99	214.99		215.02	0.002262	0.86	38.04	73.05	0.21
Reach2c	21.836	50-year	5m Culv8	26.22	212.00	214.69		214.77	0.006096	1.24	22.51	33.48	0.34
Reach2c	21.836	50-year	HDR Pr Original	26.22	211.94	214.98	213.35	215.00	0.000197	0.76	71.09	78.73	0.15
Reach2c	21.836	50-year	HDR Pr (Matrix)	26.22	211.94	214.62	213.35	214.65	0.000375	0.95	50.84	33.12	0.20
Reach2c	21.836	25-year	2Aug16 Original	23.38	211.99	214.95		214.98	0.002054	0.81	35.39	66.62	0.20
Reach2c	21.836	25-year	5m Culv8	23.38	212.00	214.56		214.64	0.007026	1.24	18.99	20.64	0.36
Reach2c	21.836	25-year	HDR Pr Original	23.38	211.94	214.95	213.29	214.96	0.000168	0.69	68.27	76.66	0.13
Reach2c	21.836	25-year	HDR Pr (Matrix)	23.38	211.94	214.48	213.29	214.51	0.000380	0.92	46.31	32.21	0.20
Reach2c	21.836	10-year	2Aug16 Original	19.57	211.99	215.06		215.08	0.000977	0.58	45.31	110.35	0.14
Reach2c	21.836	10-year	5m Culv8	19.57	212.00	214.36		214.44	0.007184	1.23	15.96	13.53	0.36
Reach2c	21.836	10-year	HDR Pr Original	19.57	211.94	215.06	213.20	215.07	0.000095	0.53	77.58	90.53	0.10
Reach2c	21.836	10-year	HDR Pr (Matrix)	19.57	211.94	214.28	213.20	214.31	0.000386	0.87	40.12	30.92	0.19
Reach2c	21.836	5-year	2Aug16 Original	16.61	211.99	214.89		214.91	0.001282	0.62	31.57	58.36	0.16
Reach2c	21.836	5-year	5m Culv8	16.61	212.00	214.21		214.28	0.007403	1.19	13.92	12.45	0.36
Reach2c	21.836	5-year	HDR Pr Original	16.61	211.94	214.89	213.11	214.90	0.000095	0.51	63.99	69.46	0.10
Reach2c	21.836	5-year	HDR Pr (Matrix)	16.61	211.94	214.12	213.11	214.14	0.000389	0.83	35.20	29.85	0.19
Reach2c	21.836	2-year	2Aug16 Original	12.41	211.99	214.71		214.73	0.001264	0.57	23.38	35.75	0.15
Reach2c	21.836	2-year	5m Culv8	12.41	212.00	213.97		214.03	0.007224	1.11	11.14	11.00	0.35
Reach2c	21.836	2-year	HDR Pr Original	12.41	211.94	214.71	212.87	214.72	0.000072	0.43	54.38	42.72	0.09
Reach2c	21.836	2-year	HDR Pr (Matrix)	12.41	211.94	213.87	212.87	213.90	0.000385	0.75	28.10	28.24	0.19
Reach2c	21.835	Regional	2Aug16 Original	42.87	211.99	215.03	214.77	215.14	0.004078	2.32	45.10	107.70	0.43
Reach2c	21.835	Regional	5m Culv8	42.87	211.99	214.76	214.76	215.07	0.010439	3.48	25.19	49.79	0.68
Reach2c	21.835	Regional	HDR Pr Original	42.87	211.99	215.03	214.77	215.14	0.004078	2.32	45.10	107.70	0.43
Reach2c	21.835	Regional	HDR Pr (Matrix)	42.87	211.99	214.76	214.76	215.07	0.010439	3.48	25.19	49.79	0.68
Reach2c	21.835	100-year	2Aug16 Original	29.09	211.99	214.94	214.50	215.02	0.002643	1.83	36.80	79.65	0.35
Reach2c	21.835	100-year	5m Culv8	29.09	211.99	213.97	213.97	214.59	0.025531	4.30	9.82	10.45	1.00
Reach2c	21.835	100-year	HDR Pr Original	29.09	211.99	214.94	214.50	215.02	0.002643	1.83	36.80	79.65	0.35
Reach2c	21.835	100-year	HDR Pr (Matrix)	29.09	211.99	213.97	213.97	214.59	0.025531	4.30	9.82	10.45	1.00
Reach2c	21.835	50-year	2Aug16 Original	26.22	211.99	214.91	214.50	214.98	0.002421	1.74	34.21	73.74	0.33
Reach2c	21.835	50-year	5m Culv8	26.22	211.99	213.89	213.89	214.47	0.025230	4.14	9.21	10.02	0.99
Reach2c	21.835	50-year	HDR Pr Original	26.22	211.99	214.91	214.50	214.98	0.002421	1.74	34.21	73.74	0.33
Reach2c	21.835	50-year	HDR Pr (Matrix)	26.22	211.99	213.89	213.89	214.47	0.025230	4.14	9.21	10.02	0.99
Reach2c	21.835	25-year	2Aug16 Original	23.38	211.99	214.88	214.50	214.94	0.002133	1.62	32.11	68.85	0.31
Reach2c	21.835	25-year	5m Culv8	23.38	211.99	213.80	213.80	214.34	0.024927	3.98	8.58	9.57	0.98

HEC-RAS River: EtobicokeCreek Reach: Reach2c (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)	
Reach2c	21.835	25-year	HDR Pr Original	23.38	211.99	214.88	214.50	214.94	0.002133	1.62	32.11	68.85	0.31
Reach2c	21.835	25-year	HDR Pr (Matrix)	23.38	211.99	213.80	213.80	214.34	0.024927	3.98	8.58	9.57	0.98
Reach2c	21.835	10-year	2Aug16 Original	19.57	211.99	215.04	214.28	215.06	0.000832	1.05	45.61	107.99	0.20
Reach2c	21.835	10-year	5m Culv8	19.57	211.99	213.68	213.68	214.16	0.024203	3.73	7.70	8.96	0.95
Reach2c	21.835	10-year	HDR Pr Original	19.57	211.99	215.04	214.28	215.06	0.000832	1.05	45.61	107.99	0.20
Reach2c	21.835	10-year	HDR Pr (Matrix)	19.57	211.99	213.68	213.68	214.16	0.024203	3.73	7.70	8.96	0.95
Reach2c	21.835	5-year	2Aug16 Original	16.61	211.99	214.85	214.06	214.89	0.001193	1.20	30.10	63.93	0.23
Reach2c	21.835	5-year	5m Culv8	16.61	211.99	213.57	213.57	214.01	0.023586	3.52	6.96	8.46	0.93
Reach2c	21.835	5-year	HDR Pr Original	16.61	211.99	214.85	214.06	214.89	0.001193	1.20	30.10	63.93	0.23
Reach2c	21.835	5-year	HDR Pr (Matrix)	16.61	211.99	213.57	213.57	214.01	0.023586	3.52	6.96	8.46	0.93
Reach2c	21.835	2-year	2Aug16 Original	12.41	211.99	214.67	213.71	214.71	0.001126	1.12	21.36	35.09	0.22
Reach2c	21.835	2-year	5m Culv8	12.41	211.99	213.38	213.38	213.77	0.024229	3.25	5.62	7.55	0.92
Reach2c	21.835	2-year	HDR Pr Original	12.41	211.99	214.67	213.71	214.71	0.001126	1.12	21.36	35.09	0.22
Reach2c	21.835	2-year	HDR Pr (Matrix)	12.41	211.99	213.38	213.38	213.77	0.024229	3.25	5.62	7.55	0.92
Reach2c	21.834 25			Culvert									
Reach2c	21.833	Regional	2Aug16 Original	42.87	211.80	214.61	214.14	214.71	0.002292	1.96	37.43	56.43	0.37
Reach2c	21.833	Regional	5m Culv8	42.87	211.80	213.49	213.30	214.02	0.021038	3.24	13.23	15.15	0.82
Reach2c	21.833	Regional	HDR Pr Original	42.87	211.80	214.61	214.14	214.71	0.002292	1.96	37.43	56.43	0.37
Reach2c	21.833	Regional	HDR Pr (Matrix)	42.87	211.80	213.49	213.30	214.02	0.021038	3.24	13.23	15.15	0.82
Reach2c	21.833	100-year	2Aug16 Original	29.09	211.80	214.32	214.14	214.40	0.001721	1.58	28.50	19.87	0.32
Reach2c	21.833	100-year	5m Culv8	29.09	211.80	213.17	212.98	213.56	0.020554	2.76	10.56	13.25	0.78
Reach2c	21.833	100-year	HDR Pr Original	29.09	211.80	214.32	214.14	214.40	0.001721	1.58	28.50	19.87	0.32
Reach2c	21.833	100-year	HDR Pr (Matrix)	29.09	211.80	213.17	212.98	213.56	0.020554	2.76	10.56	13.25	0.78
Reach2c	21.833	50-year	2Aug16 Original	26.22	211.80	214.22	214.14	214.29	0.001660	1.51	26.70	15.99	0.31
Reach2c	21.833	50-year	5m Culv8	26.22	211.80	213.10	212.91	213.45	0.020221	2.63	9.97	12.83	0.77
Reach2c	21.833	50-year	HDR Pr Original	26.22	211.80	214.22	214.14	214.29	0.001660	1.51	26.70	15.99	0.31
Reach2c	21.833	50-year	HDR Pr (Matrix)	26.22	211.80	213.10	212.91	213.45	0.020221	2.63	9.97	12.83	0.77
Reach2c	21.833	25-year	2Aug16 Original	23.38	211.80	214.14	214.14	214.19	0.001518	1.41	25.38	15.81	0.29
Reach2c	21.833	25-year	5m Culv8	23.38	211.80	213.03	212.84	213.34	0.019841	2.50	9.36	12.39	0.76
Reach2c	21.833	25-year	HDR Pr Original	23.38	211.80	214.14	214.14	214.19	0.001518	1.41	25.38	15.81	0.29
Reach2c	21.833	25-year	HDR Pr (Matrix)	23.38	211.80	213.03	212.84	213.34	0.019841	2.50	9.36	12.39	0.76
Reach2c	21.833	10-year	2Aug16 Original	19.57	211.80	213.97	213.97	215.06	0.017861	4.61	4.24	15.33	1.00
Reach2c	21.833	10-year	5m Culv8	19.57	211.80	212.92	212.73	213.19	0.019144	2.30	8.50	11.78	0.73
Reach2c	21.833	10-year	HDR Pr Original	19.57	211.80	213.97	213.97	215.06	0.017861	4.61	4.24	15.33	1.00
Reach2c	21.833	10-year	HDR Pr (Matrix)	19.57	211.80	212.92	212.73	213.19	0.019144	2.30	8.50	11.78	0.73
Reach2c	21.833	5-year	2Aug16 Original	16.61	211.80	213.75	213.75	214.72	0.018479	4.36	3.81	14.37	1.00
Reach2c	21.833	5-year	5m Culv8	16.61	211.80	212.84	212.65	213.07	0.018489	2.13	7.78	11.27	0.71
Reach2c	21.833	5-year	HDR Pr Original	16.61	211.80	213.75	213.75	214.72	0.018479	4.36	3.81	14.37	1.00
Reach2c	21.833	5-year	HDR Pr (Matrix)	16.61	211.80	212.84	212.65	213.07	0.018489	2.13	7.78	11.27	0.71
Reach2c	21.833	2-year	2Aug16 Original	12.41	211.80	213.41	213.41	214.20	0.019664	3.96	3.14	12.90	1.00
Reach2c	21.833	2-year	5m Culv8	12.41	211.80	212.73	212.52	212.90	0.015599	1.80	6.88	10.63	0.64
Reach2c	21.833	2-year	HDR Pr Original	12.41	211.80	213.41	213.41	214.20	0.019664	3.96	3.14	12.90	1.00
Reach2c	21.833	2-year	HDR Pr (Matrix)	12.41	211.80	212.73	212.52	212.90	0.015599	1.80	6.88	10.63	0.64

Appendix C: Stormwater Management Calculations

Project	Eastern Ave/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 02
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)	Required Bioretention Area[2] (m^2)	Required Bioretention Cell Length (m)	Bioretention Cell Width (m)	Proposed Bioretention Cell Length (m)	Provided Water Balance Storage Volume (m3)	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)												
A1	0.46	0.32	70%	11.15	0.37	81%	14.26	0.05	0.05	3	3	3	26	13	2.0	0	0	0	Existing storm sewer system (600 mm) on Kennedy Rd.
A2	1.54	0.94	61%	30.54	1.12	73%	40.34	0.18	1.12	10	9	10	561	281	2.0	305	73	268	Hansen Rd. ditch system, ultimate outfall to Spring Creek Tributary
A3	1.30	0.74	57%	23.11	0.97	74%	35.16	0.22	0.97	12	11	12	483	241	2.0	670	161	590	Engineered drain, ultimate outfall to Spring Creek Tributary
A4	1.02	0.69	67%	23.67	0.00	0%	0.00	-0.69	0.00	0	0	0	0	0	2.0	0	0	0	Engineered drain, ultimate outfall to Spring Creek Tributary
A5	0.72	0.58	80%	22.07	0.59	81%	22.53	0.01	0.01	0	0	0	4	2	2.0	0	0	0	Existing storm sewer system (2150 mm) on Rutherford Rd.
Total		**3.27**		**110.54**	**3.04**		112.29	**-0.22**	**2.15**	**25**	**23**	**25**	**1074**	**537**		**975**	**234**	**858**	

[1] From Table 3.2 of MOE SWM Planning and Design Manual (2003)
[2] 5% of the contributing pavement area
[3] Based on TRCA target of 5 mm retention

MOE Table 3.2

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

Bioretention Cell Dimensions

Hydraulic Conductivity =	4.60E-07 cm/s
Infiltration Rate, i =	11 mm/hr
Safety Factor =	3
Infilt. With Safety Factor	3.6 mm/hr
d_p =	100 mm
t_s =	48 hr
V_r =	0.4
$d_{r\ max}$ =	437 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

Stormwater Management Calculations

Project	Eastern Ave/Clark Boulevard Class EA, City of Brampton				
Date	12-Jul-22	No.	--	Page	
By	J. Look	Checked	S. Sadek		

TABLE 03

QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	Existing			Proposed			Increased Paved Area (ha)	10-Year			100-Year			Etobicoke Creek Hydrology Update (2013) Unitary Flow Rate Storage Req's			Remarks
	Drainage Area (ha)	Paved Area (ha)	Runoff Coefficient	Drainage Area (ha)	Paved Area (ha)	Runoff Coefficient		Existing Flow (m3/s)	Uncontrolled Proposed Flow (m3/s)	Req'd Storage Vol. (m^3)	Existing Flow (m3/s)	Uncontrolled Proposed Flow (m3/s)	Req'd Storage Vol. (m^3)	Req'd Storage Vol. (m^3) based on 10-Year *(0.053 m3/s/ha)*	Req'd Storage Vol. (m^3) based on 100-Year *(0.07894 m3/s/ha)*	Req'd Storage Vol. (m^3) based on Regional *(Add. 214 m3/ha)*	
A1	0.46	0.32	0.70	0.46	0.37	0.78	0.05	0.12	0.13	8	0.22	0.24	14	-	-	-	Stm sewer along Kennedy Rd.
A2	1.54	0.94	0.65	1.54	1.12	0.72	0.18	0.34	0.38	24	0.49	0.54	34	183	261	330	Discharges to Spring Creek, part of Etobicoke Creek watershed
A3	1.30	0.74	0.62	1.30	0.97	0.73	0.22	0.27	0.32	30	0.39	0.46	43	157	224	278	Discharges to Spring Creek, part of Etobicoke Creek watershed
A4	1.02	0.69	0.69	1.02	0.00	0.25	-0.69	0.24	0.09	0	0.34	0.12	0	19	26	219	Discharges to Spring Creek, part of Etobicoke Creek watershed, no increase in pavement area, no quantity control req'd
A5	0.72	0.58	0.77	0.72	0.59	0.78	0.01	0.21	0.21	1	0.38	0.38	2	-	-	-	Stm sewer on Rutherford Rd., increase < 10%, no quantity control req'd
Total	5.05	3.27		5.05	3.04		-0.22			61.18			90.98				

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 04
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A1**	
Existing Drainage Area	0.46	ha
Existing Pavement Area	0.32	ha
Existing Runoff Coefficient	0.70	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	0.46	ha
Proposed Pavement Area	0.37	ha
Proposed Runoff Coefficient	0.78	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

Existing and Proposed - Region of Peel Rainfall Parameters (Receiving System)

Return Period	IDF Parameters (Region of Peel) $i = C_f \times A / (Tc + B)^C$ A	B	C	C_f	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	1070	7.85	0.8759	1	85.72	76.47
5-yr	1593	11	0.8789	1	109.68	97.85
10-yr	**2221**	**12**	**0.9080**	**1**	**134.16**	**119.69**
25-yr	3158	15	0.9335	1.1	172.12	153.56
50-yr	3886	16	0.9495	1.2	211.43	188.63
100-yr	**4688**	**17**	**0.9624**	**1.25**	**245.67**	**219.17**

Peak Flow Control Requirement

Discharging to regional storm sewer on Kennedy Road

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)
10	134.16	132.37	79.42	71.82	7.60
15	111.40	109.91	98.92	107.72	0.00
20	95.47	94.19	113.03	143.63	0.00
25	83.68	82.56	123.84	179.54	0.00
30	74.58	73.58	132.45	215.45	0.00
40	61.44	60.61	145.47	287.26	0.00
50	52.37	51.67	155.00	359.08	0.00
60	45.72	45.11	162.38	430.89	0.00
70	40.63	40.08	168.35	502.71	0.00
80	36.60	36.11	173.31	574.52	0.00
90	33.32	32.88	177.53	646.34	0.00
100	30.61	30.20	181.20	718.15	0.00
120	26.37	26.01	187.31	861.78	0.00
360	10.29	10.15	219.33	2585.35	0.00
720	5.57	5.49	237.25	5170.71	0.00
1440	2.99	2.95	254.77	10341.42	0.00
Required Storage Volume:			**7.60**	**m^3**	

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)
10	245.67	242.38	145.43	131.50	13.93
15	208.61	205.82	185.24	197.26	0.00
20	181.41	178.98	214.78	263.01	0.00
25	160.58	158.43	237.64	328.76	0.00
30	144.10	142.17	255.91	394.51	0.00
40	119.69	118.08	283.40	526.02	0.00
50	102.44	101.07	303.22	657.52	0.00
60	89.61	88.41	318.27	789.03	0.00
70	79.67	78.61	330.14	920.53	0.00
80	71.75	70.79	339.80	1052.04	0.00
90	65.29	64.41	347.83	1183.54	0.00
100	59.91	59.11	354.63	1315.05	0.00
120	51.47	50.78	365.59	1578.06	0.00
360	19.43	19.17	414.03	4734.18	0.00
720	10.19	10.06	434.39	9468.35	0.00
1440	5.29	5.22	450.87	18936.70	0.00
Required Storage Volume:			**13.93**	**m^3**	

Required Storage Summary			
Uncontrolled Discharge Flow Rate	**0.13**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.12**	m^3/s	10 Year Existing Flow
Required Storage Volume	**7.60**	m^3	
Uncontrolled Discharge Flow Rate	**0.24**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.22**	m^3/s	100 Year Existing Flow
Required Storage Volume	**13.93**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton		
Date	12-Jul-22	No. --	Page
By	J. Look	Checked S. Sadek	

Stormwater Management Calculations

TABLE 05
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A2**	
Existing Drainage Area	1.54	ha
Existing Pavement Area	0.94	ha
Existing Runoff Coefficient	0.65	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.54	ha
Proposed Pavement Area	1.12	ha
Proposed Runoff Coefficient	0.72	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A (T)^B$ A	B	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	22.1	-0.714	79.43	220.36
5-yr	29.9	-0.701	104.99	291.27
10-yr	**35.1**	**-0.695**	**121.93**	**338.26**
25-yr	41.6	-0.691	143.48	398.04
50-yr	46.5	-0.688	159.52	442.54
100-yr	**51.3**	**-0.686**	**175.36**	**486.48**

Peak Flow Control Requirement
Discharging to Engineered Drain, which is a tributary of Spring Creek

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)
10	121.93	378.01	226.80	202.96	23.85
15	91.99	285.18	256.66	304.44	0.00
20	75.32	233.50	280.20	405.92	0.00
25	64.50	199.96	299.93	507.40	0.00
30	56.82	176.16	317.08	608.88	0.00
40	46.53	144.23	346.16	811.83	0.00
50	39.84	123.51	370.54	1014.79	0.00
60	35.10	108.81	391.73	1217.75	0.00
70	31.53	97.76	410.59	1420.71	0.00
80	28.74	89.10	427.66	1623.67	0.00
90	26.48	82.09	443.30	1826.63	0.00
100	24.61	76.30	457.78	2029.59	0.00
120	21.68	67.22	483.95	2435.50	0.00
360	10.10	31.32	676.59	7306.51	0.00
720	6.24	19.35	835.87	14613.02	0.00
1440	3.86	11.95	1032.65	29226.04	0.00
Required Storage Volume:			**23.85**	**m^3**	

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)
10	175.36	543.64	326.18	291.89	34.29
15	132.78	411.63	370.47	437.83	0.00
20	109.00	337.91	405.49	583.77	0.00
25	93.53	289.95	434.92	729.72	0.00
30	82.53	255.86	460.55	875.66	0.00
40	67.75	210.04	504.09	1167.55	0.00
50	58.13	180.22	540.67	1459.43	0.00
60	51.30	159.04	572.53	1751.32	0.00
70	46.15	143.08	600.92	2043.21	0.00
80	42.11	130.55	626.66	2335.09	0.00
90	38.84	120.42	650.27	2626.98	0.00
100	36.14	112.02	672.14	2918.87	0.00
120	31.89	98.85	711.74	3502.64	0.00
360	15.01	46.52	1004.94	10507.92	0.00
720	9.33	28.92	1249.29	21015.85	0.00
1440	5.80	17.98	1553.05	42031.69	0.00
Required Storage Volume:			**34.29**	**m^3**	

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.38**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.34**	m^3/s	10 Year Existing Flow
Required Storage Volume	**23.85**	m^3	
Uncontrolled Discharge Flow Rate	**0.54**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.49**	m^3/s	100 Year Existing Flow
Required Storage Volume	**34.29**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 06
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A2**	
Existing Drainage Area	1.54	ha
Existing Pavement Area	0.94	ha
Existing Runoff Coefficient	0.65	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.54	ha
Proposed Pavement Area	1.12	ha
Proposed Runoff Coefficient	0.72	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A(T)^B$ A	B	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	22.1	-0.714	79.43	220.36
5-yr	29.9	-0.701	104.99	291.27
10-yr	**35.1**	**-0.695**	**121.93**	**338.26**
25-yr	41.6	-0.691	143.48	398.04
50-yr	46.5	-0.688	159.52	442.54
100-yr	**51.3**	**-0.686**	**175.36**	**486.48**

Etobicoke Watershed Quantity Control Strategy - Unit Flow Rates

Basin 6 - Spring Creek
Catchments 93 and 99

Return Period	Unit Flow Rates (m3/s/ha)
2-yr	0.03300
5-yr	0.04485
10-yr	**0.05300**
25-yr	0.06337
50-yr	0.07113
100-yr	**0.07894**

Peak Flow Control Requirement

Discharging to Engineered Drain, which is a tributary of Spring Creek

Storage Volume Calculation - 10 Year Post to 10 Year Unit Flows

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)
10	121.93	378.01	226.80	49.07	177.73
15	91.99	285.18	256.66	73.61	183.05
20	75.32	233.50	280.20	98.15	182.05
25	64.50	199.96	299.93	122.68	177.25
30	56.82	176.16	317.08	147.22	169.86
40	46.53	144.23	346.16	196.30	149.87
50	39.84	123.51	370.54	245.37	125.17
60	35.10	108.81	391.73	294.44	97.29
70	31.53	97.76	410.59	343.52	67.07
80	28.74	89.10	427.66	392.59	35.07
90	26.48	82.09	443.30	441.66	1.63
100	24.61	76.30	457.78	490.74	0.00
120	21.68	67.22	483.95	588.89	0.00
360	10.10	31.32	676.59	1766.66	0.00
720	6.24	19.35	835.87	3533.31	0.00
1440	3.86	11.95	1032.65	7066.62	0.00
Required Storage Volume:			**183.05**	**m^3**	

Storage Volume Calculation - 100 Year Post to 100 Year Unit Flows

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)
10	175.36	543.64	326.18	73.09	253.09
15	132.78	411.63	370.47	109.64	260.83
20	109.00	337.91	405.49	146.18	259.31
25	93.53	289.95	434.92	182.73	252.19
30	82.53	255.86	460.55	219.28	241.27
40	67.75	210.04	504.09	292.37	211.72
50	58.13	180.22	540.67	365.46	175.21
60	51.30	159.04	572.53	438.55	133.98
70	46.15	143.08	600.92	511.64	89.28
80	42.11	130.55	626.66	584.74	41.92
90	38.84	120.42	650.27	657.83	0.00
100	36.14	112.02	672.14	730.92	0.00
120	31.89	98.85	711.74	877.11	0.00
360	15.01	46.52	1004.94	2631.32	0.00
720	9.33	28.92	1249.29	5262.63	0.00
1440	5.80	17.98	1553.05	10525.27	0.00
Required Storage Volume:			**260.83**	**m^3**	

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.38**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.08**	m^3/s	10 Year Unit Flow Flows
Required Storage Volume	**183.05**	m^3	
Uncontrolled Discharge Flow Rate	**0.54**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.12**	m^3/s	100 Year Unit Flows
Required Storage Volume	**260.83**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton		
Date	12-Jul-22	No.	--
By	J. Look	Checked	S. Sadek

Page

Stormwater Management Calculations

TABLE 07
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A3**	
Existing Drainage Area	1.30	ha
Existing Pavement Area	0.74	ha
Existing Runoff Coefficient	0.62	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.30	ha
Proposed Pavement Area	0.97	ha
Proposed Runoff Coefficient	0.73	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A (T)^B$		Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
	A	B		
2-yr	22.1	-0.714	79.43	178.05
5-yr	29.9	-0.701	104.99	235.35
10-yr	**35.1**	**-0.695**	**121.93**	273.32
25-yr	41.6	-0.691	143.48	321.63
50-yr	46.5	-0.688	159.52	357.58
100-yr	**51.3**	**-0.686**	**175.36**	393.08

Peak Flow Control Requirement

Discharging to Engineered Drain, which is a tributary of Spring Creek

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)
10	121.93	322.87	193.72	163.99	29.73
15	91.99	243.58	219.22	245.99	0.00
20	75.32	199.44	239.33	327.99	0.00
25	64.50	170.79	256.18	409.99	0.00
30	56.82	150.46	270.83	491.98	0.00
40	46.53	123.20	295.67	655.98	0.00
50	39.84	105.50	316.50	819.97	0.00
60	35.10	92.94	334.59	983.97	0.00
70	31.53	83.50	350.70	1147.96	0.00
80	28.74	76.10	365.28	1311.95	0.00
90	26.48	70.12	378.64	1475.95	0.00
100	24.61	65.17	391.00	1639.94	0.00
120	21.68	57.41	413.36	1967.93	0.00
360	10.10	26.75	577.90	5903.79	0.00
720	6.24	16.53	713.95	11807.58	0.00
1440	3.86	10.21	882.03	23615.16	0.00

Required Storage Volume: 29.73 m^3

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)
10	175.36	464.34	278.60	235.85	42.76
15	132.78	351.59	316.43	353.77	0.00
20	109.00	288.62	346.35	471.70	0.00
25	93.53	247.66	371.49	589.62	0.00
30	82.53	218.54	393.37	707.55	0.00
40	67.75	179.40	430.56	943.40	0.00
50	58.13	153.94	461.81	1179.25	0.00
60	51.30	135.84	489.02	1415.10	0.00
70	46.15	122.21	513.27	1650.95	0.00
80	42.11	111.51	535.25	1886.80	0.00
90	38.84	102.86	555.42	2122.65	0.00
100	36.14	95.68	574.10	2358.50	0.00
120	31.89	84.43	607.93	2830.20	0.00
360	15.01	39.74	858.36	8490.59	0.00
720	9.33	24.70	1067.07	16981.18	0.00
1440	5.80	15.35	1326.52	33962.35	0.00

Required Storage Volume: 42.76 m^3

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.32**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.27**	m^3/s	10 Year Existing Flow
Required Storage Volume	**29.73**	m^3	
Uncontrolled Discharge Flow Rate	**0.46**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.39**	m^3/s	100 Year Existing Flow
Required Storage Volume	**42.76**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 08
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A3**	
Existing Drainage Area	1.30	ha
Existing Pavement Area	0.74	ha
Existing Runoff Coefficient	0.62	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.30	ha
Proposed Pavement Area	0.97	ha
Proposed Runoff Coefficient	0.73	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A (T)^B$ A	B	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	22.1	-0.714	79.43	178.05
5-yr	29.9	-0.701	104.99	235.35
10-yr	**35.1**	**-0.695**	**121.93**	**273.32**
25-yr	41.6	-0.691	143.48	321.63
50-yr	46.5	-0.688	159.52	357.58
100-yr	**51.3**	**-0.686**	**175.36**	**393.08**

Etobicoke Watershed Quantity Control Strategy - Unit Flow Rates

Basin 6 - Spring Creek
Catchments 93 and 99

Return Period	Unit Flow Rates (m3/s/ha)
2-yr	0.03300
5-yr	0.04485
10-yr	**0.05300**
25-yr	0.06337
50-yr	0.07113
100-yr	**0.07894**

Peak Flow Control Requirement

Discharging to Engineered Drain, which is a tributary of Spring Creek

Storage Volume Calculation - 10 Year Post to 10 Year Unit Flows

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)
10	121.93	322.87	193.72	41.34	152.38
15	91.99	243.58	219.22	62.01	157.21
20	75.32	199.44	239.33	82.68	156.65
25	64.50	170.79	256.18	103.35	152.83
30	56.82	150.46	270.83	124.02	146.81
40	46.53	123.20	295.67	165.36	130.31
50	39.84	105.50	316.50	206.70	109.80
60	35.10	92.94	334.59	248.04	86.55
70	31.53	83.50	350.70	289.38	61.32
80	28.74	76.10	365.28	330.72	34.56
90	26.48	70.12	378.64	372.06	6.58
100	24.61	65.17	391.00	413.40	0.00
120	21.68	57.41	413.36	496.08	0.00
360	10.10	26.75	577.90	1488.24	0.00
720	6.24	16.53	713.95	2976.48	0.00
1440	3.86	10.21	882.03	5952.96	0.00
Required Storage Volume:			**157.21**	m^3	

Storage Volume Calculation - 100 Year Post to 100 Year Unit Flows

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)
10	175.36	464.34	278.60	61.57	217.03
15	132.78	351.59	316.43	92.36	224.07
20	109.00	288.62	346.35	123.15	223.20
25	93.53	247.66	371.49	153.93	217.55
30	82.53	218.54	393.37	184.72	208.65
40	67.75	179.40	430.56	246.29	184.27
50	58.13	153.94	461.81	307.87	153.95
60	51.30	135.84	489.02	369.44	119.58
70	46.15	122.21	513.27	431.01	82.26
80	42.11	111.51	535.25	492.59	42.67
90	38.84	102.86	555.42	554.16	1.26
100	36.14	95.68	574.10	615.73	0.00
120	31.89	84.43	607.93	738.88	0.00
360	15.01	39.74	858.36	2216.64	0.00
720	9.33	24.70	1067.07	4433.27	0.00
1440	5.80	15.35	1326.52	8866.54	0.00
Required Storage Volume:			**224.07**	m^3	

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.32**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.07**	m^3/s	10 Year Unit Flows
Required Storage Volume	**157.21**	m^3	
Uncontrolled Discharge Flow Rate	**0.46**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.10**	m^3/s	100 Year Unit Flows
Required Storage Volume	**224.07**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton		
Date	12-Jul-22	No.	--
By	J. Look	Checked	S. Sadek

Page

Stormwater Management Calculations

TABLE 09
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A4**	
Existing Drainage Area	1.02	ha
Existing Pavement Area	0.69	ha
Existing Runoff Coefficient	0.69	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.02	ha
Proposed Pavement Area	0.00	ha
Proposed Runoff Coefficient	0.25	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A (T)^B$ A	B	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	22.1	-0.714	79.43	155.41
5-yr	29.9	-0.701	104.99	205.42
10-yr	**35.1**	**-0.695**	**121.93**	**238.56**
25-yr	41.6	-0.691	143.48	280.72
50-yr	46.5	-0.688	159.52	312.11
100-yr	**51.3**	**-0.686**	**175.36**	**343.09**

Peak Flow Control Requirement

Discharging to Engineered Drain, which is a tributary of Spring Creek

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)
10	121.93	86.71	52.03	143.14	0.00
15	91.99	65.42	58.87	214.71	0.00
20	75.32	53.56	64.27	286.28	0.00
25	64.50	45.87	68.80	357.85	0.00
30	56.82	40.41	72.73	429.41	0.00
40	46.53	33.09	79.40	572.55	0.00
50	39.84	28.33	85.00	715.69	0.00
60	35.10	24.96	89.86	858.83	0.00
70	31.53	22.42	94.18	1001.97	0.00
80	28.74	20.44	98.10	1145.10	0.00
90	26.48	18.83	101.69	1288.24	0.00
100	24.61	17.50	105.01	1431.38	0.00
120	21.68	15.42	111.01	1717.66	0.00
360	10.10	7.19	155.20	5152.97	0.00
720	6.24	4.44	191.74	10305.94	0.00
1440	3.86	2.74	236.88	20611.88	0.00

Required Storage Volume: **0.00** m^3

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)
10	175.36	124.70	74.82	205.86	0.00
15	132.78	94.42	84.98	308.78	0.00
20	109.00	77.51	93.01	411.71	0.00
25	93.53	66.51	99.77	514.64	0.00
30	82.53	58.69	105.64	617.57	0.00
40	67.75	48.18	115.63	823.42	0.00
50	58.13	41.34	124.02	1029.28	0.00
60	51.30	36.48	131.33	1235.13	0.00
70	46.15	32.82	137.84	1440.99	0.00
80	42.11	29.95	143.75	1646.84	0.00
90	38.84	27.62	149.16	1852.70	0.00
100	36.14	25.70	154.18	2058.55	0.00
120	31.89	22.68	163.26	2470.26	0.00
360	15.01	10.67	230.52	7410.79	0.00
720	9.33	6.63	286.57	14821.58	0.00
1440	5.80	4.12	356.25	29643.17	0.00

Required Storage Volume: **0.00** m^3

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.09**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.24**	m^3/s	10 Year Existing Flow
Required Storage Volume	**0.00**	m^3	
Uncontrolled Discharge Flow Rate	**0.12**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.34**	m^3/s	100 Year Existing Flow
Required Storage Volume	**0.00**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 10
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A4**	
Existing Drainage Area	1.02	ha
Existing Pavement Area	0.69	ha
Existing Runoff Coefficient	0.69	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	1.02	ha
Proposed Pavement Area	0.00	ha
Proposed Runoff Coefficient	0.25	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

City of Brampton - Rainfall Parameters

Return Period	IDF Parameters $i = A (T)^B$ A	B	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	22.1	-0.714	79.43	155.41
5-yr	29.9	-0.701	104.99	205.42
10-yr	**35.1**	**-0.695**	**121.93**	**238.56**
25-yr	41.6	-0.691	143.48	280.72
50-yr	46.5	-0.688	159.52	312.11
100-yr	**51.3**	**-0.686**	**175.36**	**343.09**

Etobicoke Watershed Quantity Control Strategy - Unit Flow Rates

Basin 6 - Spring Creek
Catchments 93 and 99

Return Period	Unit Flow Rates (m3/s/ha)
2-yr	0.03300
5-yr	0.04485
10-yr	**0.05300**
25-yr	0.06337
50-yr	0.07113
100-yr	**0.07894**

Peak Flow Control Requirement

Discharging to Engineered Drain, which is a tributary of Spring Creek

Storage Volume Calculation - 10 Year Post to 10 Year Unit Flows

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)
10	121.93	86.71	52.03	32.54	19.49
15	91.99	65.42	58.87	48.81	10.07
20	75.32	53.56	64.27	65.08	0.00
25	64.50	45.87	68.80	81.34	0.00
30	56.82	40.41	72.73	97.61	0.00
40	46.53	33.09	79.40	130.15	0.00
50	39.84	28.33	85.00	162.69	0.00
60	35.10	24.96	89.86	195.23	0.00
70	31.53	22.42	94.18	227.76	0.00
80	28.74	20.44	98.10	260.30	0.00
90	26.48	18.83	101.69	292.84	0.00
100	24.61	17.50	105.01	325.38	0.00
120	21.68	15.42	111.01	390.45	0.00
360	10.10	7.19	155.20	1171.36	0.00
720	6.24	4.44	191.74	2342.72	0.00
1440	3.86	2.74	236.88	4685.44	0.00
Required Storage Volume:			**19.49**	**m^3**	

Storage Volume Calculation - 100 Year Post to 100 Year Unit Flows

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)
10	175.36	124.70	74.82	48.46	26.36
15	132.78	94.42	84.98	72.69	12.29
20	109.00	77.51	93.01	96.93	0.00
25	93.53	66.51	99.77	121.16	0.00
30	82.53	58.69	105.64	145.39	0.00
40	67.75	48.18	115.63	193.85	0.00
50	58.13	41.34	124.02	242.31	0.00
60	51.30	36.48	131.33	290.78	0.00
70	46.15	32.82	137.84	339.24	0.00
80	42.11	29.95	143.75	387.70	0.00
90	38.84	27.62	149.16	436.17	0.00
100	36.14	25.70	154.18	484.63	0.00
120	31.89	22.68	163.26	581.55	0.00
360	15.01	10.67	230.52	1744.66	0.00
720	9.33	6.63	286.57	3489.32	0.00
1440	5.80	4.12	356.25	6978.65	0.00
Required Storage Volume:			**26.36**	**m^3**	

Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.09**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.05**	m^3/s	10 Year Unit Flows
Required Storage Volume	**19.49**	m^3	
Uncontrolled Discharge Flow Rate	**0.12**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.08**	m^3/s	100 Year Unit Flows
Required Storage Volume	**26.36**	m^3	

Project	Eastern Avenue/Clark Boulevard Class EA, City of Brampton			
Date	12-Jul-22	No.	--	Page
By	J. Look	Checked	S. Sadek	

Stormwater Management Calculations

TABLE 11
DRAINAGE AREA QUANTITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	**A5**	
Existing Drainage Area	0.72	ha
Existing Pavement Area	0.58	ha
Existing Runoff Coefficient	0.77	*Assume pavement C = 0.9, landscaped C = 0.25*
Proposed Drainage Area	0.72	ha
Proposed Pavement Area	0.59	ha
Proposed Runoff Coefficient	0.78	*Assume pavement C = 0.9, landscaped C = 0.25*
Time of Concentration	10	minute

Existing and Proposed - Region of Peel Rainfall Parameters (Receiving System)

Return Period	IDF Parameters (Region of Peel) $i = C_f \times A / (Tc + B)^C$ A	B	C	C_f	Rainfall Intensity (mm/hr)	Allowable Release Rate (L/s)
2-yr	1070	7.85	0.8759	1	85.72	132.61
5-yr	1593	11	0.8789	1	109.68	169.67
10-yr	**2221**	**12**	**0.9080**	**1**	**134.16**	**207.55**
25-yr	3158	15	0.9335	1.1	172.12	266.27
50-yr	3886	16	0.9495	1.2	211.43	327.09
100-yr	**4688**	**17**	**0.9624**	**1.25**	**245.67**	**380.06**

Peak Flow Control Requirement

Discharging to regional storm sewer on Rutherford Road

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)
10	134.16	209.33	125.60	124.53	1.07
15	111.40	173.81	156.43	186.80	0.00
20	95.47	148.96	178.75	249.06	0.00
25	83.68	130.56	195.85	311.33	0.00
30	74.58	116.37	209.47	373.59	0.00
40	61.44	95.86	230.05	498.12	0.00
50	52.37	81.71	245.12	622.65	0.00
60	45.72	71.33	256.80	747.18	0.00
70	40.63	63.39	266.23	871.71	0.00
80	36.60	57.10	274.08	996.24	0.00
90	33.32	51.99	280.76	1120.77	0.00
100	30.61	47.76	286.56	1245.30	0.00
120	26.37	41.14	296.21	1494.36	0.00
360	10.29	16.06	346.86	4483.09	0.00
720	5.57	8.69	375.20	8966.18	0.00
1440	2.99	4.66	402.90	17932.37	0.00
Required Storage Volume:			**1.07**	m^3	

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)
10	245.67	383.32	229.99	228.03	1.96
15	208.61	325.49	292.95	342.05	0.00
20	181.41	283.05	339.66	456.07	0.00
25	160.58	250.54	375.82	570.08	0.00
30	144.10	224.84	404.71	684.10	0.00
40	119.69	186.74	448.19	912.14	0.00
50	102.44	159.84	479.52	1140.17	0.00
60	89.61	139.81	503.32	1368.20	0.00
70	79.67	124.31	522.10	1596.24	0.00
80	71.75	111.95	537.37	1824.27	0.00
90	65.29	101.86	550.07	2052.31	0.00
100	59.91	93.47	560.83	2280.34	0.00
120	51.47	80.30	578.17	2736.41	0.00
360	19.43	30.31	654.76	8209.22	0.00
720	10.19	15.90	686.96	16418.44	0.00
1440	5.29	8.25	713.02	32836.89	0.00
Required Storage Volume:			**1.96**	m^3	

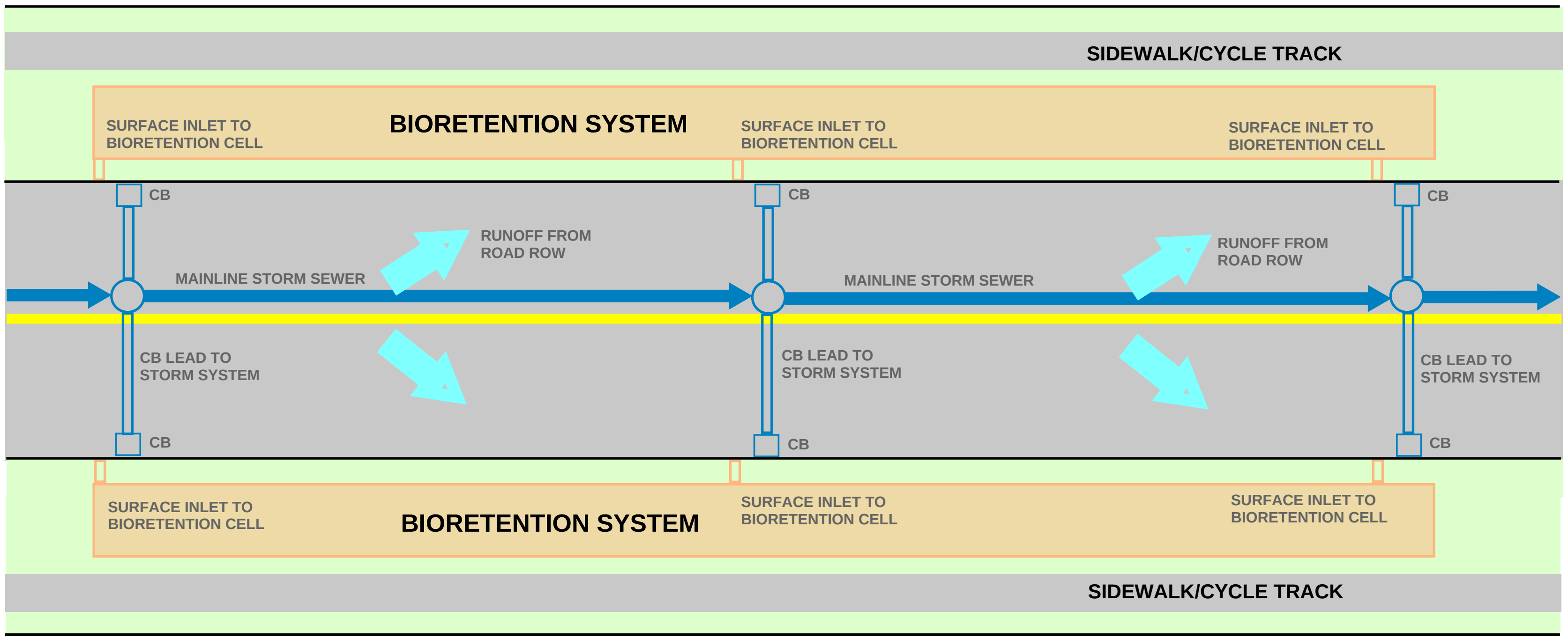
Required Storage Summary

Uncontrolled Discharge Flow Rate	**0.21**	m^3/s	10 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.21**	m^3/s	10 Year Existing Flow
Required Storage Volume	**1.07**	m^3	
Uncontrolled Discharge Flow Rate	**0.38**	m^3/s	100 Year Proposed Conditions
Controlled Discharge Flow Rate	**0.38**	m^3/s	100 Year Existing Flow
Required Storage Volume	**1.96**	m^3	

Appendix D: Bio-retention 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

NOTE: BIORETENTION SYSTEM CAN POTENTIALLY INCLUDE VEGETATIVE PLANTINGS OR STREETCAPING TREES, DESIGN TO BE DETERMINED