Regional Road 25, from Steeles Avenue to 5 Sideroad

Stormwater Management Report

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Prepared for:

Halton Region

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1.0 INTRODUCTION

The Regional Municipality of Halton (the Region) is undertaking a Schedule 'C' Municipal Class Environmental Assessment (MCEA) to identify a preferred alternative that would address the need for road improvements to meet capacity needs on Regional Road 25 (Regional Road 25) from Steeles Avenue to 5 Side Road (to 2031). Road improvements include widening of the road from four to six lanes, improvements at intersections, and the addition of multi-use pathways and on-road bike lanes in both directions.

In support of the MCEA Study, Stantec conducted a stormwater management and drainage analysis. The results of the analysis are summarized in this report, including a description of the existing Stormwater Management (SWM) and drainage conditions within the study area, identification of potential impacts of the project, and recommendations for mitigation.

The study area includes Regional Road 25 from Steeles Avenue to 5 Side Road and adjacent lands within 120 m of the Right-of-Way (ROW) on both sides (**Figures 1 to 3**).

1.1 OBJECTIVES

The purpose of this Stormwater Management Report was to:

- Summarize the existing SWM features and drainage patterns within the study area;
- Evaluate the condition and performance of the existing SWM and drainage features;
- Identify constraints associated with the proposed road improvements; and
- Provide recommendations to mitigate the potential impacts.

2.0 EXISTING CONDITIONS

2.1 SURFACE DRAINAGE AND WATERSHED CHARACTERISTICS

The study area, Regional Road 25 between Steeles Avenue and 5 Side Road, contains tributaries and channels of Sixteen Mile Creek that ultimately drain to Lake Ontario and falls under the authority of Conservation Halton (CH). CH regulates the erosion hazards, flooding hazards, and associated allowance within 15m of the greatest hazard (100-year storm, Regional storm surface water elevation or erosion hazard) associated with Sixteen Mile Creek. The study area includes portions of the Tributaries N2-B and N1-A which form part of the west branch of the Sixteen Mile Creek. Tributary N2-B has a total drainage area of 501.6 ha, located to the west of Regional Road 25 and north of Highway 401. Tributary N1-A has a total drainage area of 59.4 ha, located to the west of Reg. Rd. 25 and north of Steeles Avenue.

The existing land use on both sides of Regional Road 25 is mainly developed, with commercial and industrial areas. There are two SWM ponds which are located within the Tributary N2-B subwatershed and provide quantity and quality control near the study area. SWM Pond S34 is located near the southwest intersection of Regional Road 25 and James Snow Parkway. High Point Pond (S36) is located at the northeast intersection of Highway 401 and Regional Road 25.

SWM Pond S34 is located within the land owned by Escarpment Business Community West (EBCW), north of Highway 401 and west of Regional Road 25. The SWM facility was designed as a multi-celled wet pond to provide Enhanced (80% Total Suspended Solids (TSS) Removal) water quality treatment, extended detention for erosion control and flood control up to the 100-year storm event. The SWM facility directs flows southerly to Tributary N1-A and easterly to Tributary N2-B under all rainfall events, and in accordance with the approved rating curve to maintain healthy streams and downstream fish habitat as required by the Town of Milton and CH. Analyses completed by CH and Ministry of Transportation (MTO) confirm that any downstream impacts regarding depth of flow over Highway 401 or downstream flood elevations related to Tributary N2-B are not significant.

The north portion of Regional Road 25, between Highway 401 and 5 Side Road has an urban section. Runoff from the road is collected via a system of curbs, gutters, catchbasins and storm sewer. The storm sewer system drains into Tributary N2-B which crosses Regional Road 25 from west to east and discharges into the existing High Point Pond (S36). Quality control for this portion of the road is provided via a treatment train which includes an Oil/Grit Separator (STC 9000) providing 70% TSS removal efficiency and SWM Pond S36 which provides 60% TSS removal. The combined TSS removal for the existing road is 88% (1.0 x 70% + 0.3 x 60%).

The south portion of the road, between Steeles Avenue and Highway 401 has an urban section. Runoff from the road is collected via a system of curbs, gutters, and catchbasins, and directly discharges to Tributary N1-A.

As per the Halton Region *Environmentally Sensitive Areas Consolidation Report* (2005), no Environmentally Sensitive Areas (ESAs) were specifically identified within the study area. However, the

Regional Road 25 study area is located within the Sixteen Mile Creek watershed, which is an identified floodplain.

2.1.1 Watercourse Crossings and Bridges

The existing roadway within the study area includes five (5) crossings over tributaries to Sixteen Mile Creek and one crossing east of Regional Road 25, along the CNR. Locations and details of these crossings are listed below and illustrated in **Figures 1 to 6**:

- **Culvert C1:** Located about 80m north of Steeles Avenue, it consists of a 2130 x 1220 mm concrete box culvert. This culvert conveys the flow of an unidentified branch of Tributary N1-A across Regional Road 25 in a west-east direction. The culvert receives runoff from a 59 ha drainage area, which is occupied by industrial and commercial developments. The peak flows from the Subcatchment are controlled to pre-development levels via three existing Stormwater Management (SWM) facilities. A Visual OTTHYMO (VO5) model was used to calculate the 100-year peak flow into the culvert. No HEC-RAS model was received for this tributary; accordingly, a new HEC-RAS model was developed to evaluate the culvert. The analysis confirmed that the culvert has sufficient capacity to convey the 100-year and Regional peak flows.

- **Culvert C2:** Located under Regional Road 25 and the parking lot for a car dealership, approximately 150m south of Chisholm Drive and identified as Culvert C21 and Culvert C22. C21 is a rectangular reinforced concrete culvert (6000mm x 2000mm) and C22 is a Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culvert (3800mm x 2500mm) which adjoins to C21 at the upstream end. The culvert was built in 1980. This culvert conveys the flow of Tributary N1-A across Regional Road 25 in a west-east direction. The concrete portion of the culvert is in good condition and requires minor patch repairs. The SPCSPA invert is buckled and corroded. The creek infiltrates under the SPCSPA and reappears to enter the downstream concrete portion of the culvert. The SPCSPA cut-off wall is exposed and the inlet creek bed is below the invert. Rehabilitation work is scheduled and includes repair of deteriorated concrete; replacement of the inlet SPCSPA with a precast concrete structure; inlet retaining walls; safety improvements; and, creek rehabilitation. A HEC-RAS2.1 model was received for this tributary from CH.

- **Culvert C3:** Located near the intersection of Regional Road 25 and Chisholm Drive. The 3000 x 2400mm concrete box culvert conveys the flow of Tributary N1-A across Chisholm Drive.

- **Culvert C4:** Located north of Highway 401, approximately 70m north of the westbound off-ramp, consists of a reinforced concrete box culvert (RCBC) (2997mm x 2182mm x 59.91m). This conveys the flow of Tributary N2-B across Regional Road 25 in a west-east direction.

- **CNR Bridge BR01:** The CNR crosses over Regional Road 25 via a 15m span bridge, which is located about 300m north of Steeles Avenue.

- **CNR Culvert BR02:** This is a 2500mm diameter culvert, located about 60m east of Regional Road 25 and north of Steeles Avenue and conveys the flow of Tributary N1-A across the CNR tracks.

Table 1 : Summary of Existing Culverts

Culvert ID	Location	Span Size (mm)	Length (m)	Type (material)
C1	just north of Steeles (south of the railway)	2100 x 1200	57	concrete box
C21	Across RRD25	6000 x 2000	62	concrete box
C22	Upstream End of C21	3800x2500	10	CSP
C3	culvert that crosses Chisholm,	3000 x 2400	23	concrete box
C4	crosses RR25 just north of Highway 401	2997 x 2182	60	concrete box
BR02	200m east of RRD25	2500	35	concrete pipe

Stantec completed an updated hydraulic assessment for the existing culverts. The assessment was based on the (CH provided) HEC-2/HEC-RAS models to simulate the anticipated impacts that the proposed roadway improvements will have on the tributaries to Sixteen Mile Creek, and the associated upstream/downstream flood conveyance infrastructure. Particular attention was given to potential grading implications along the east and west sides of Regional Road 25 (from Chisholm Drive to Market Drive), which lies immediately adjacent to the tributary. The following hydraulic models were received, reviewed and updated where necessary:

- Model 16JSP (HEC-RAS): this model includes analysis of the proposed creek design by Parish Geomorphic (upstream of Regional Road 25). Client is MGM Consulting Inc representing Snoek Property. The model represents Tributary N2-B from 75m west of Regional Road 25 to 5 Side Road. The model includes the 2-year to 100-year and Regional flow events. This model was not used in this study.

- Model RR25 Channel (HEC-RAS): this model includes analysis of Tributary N2-B from 250m west of Regional Road 25 to the existing Milton Pond (S36) located to the east of Regional Road 25. The model includes Culvert C4 with the 2 to 100-year and Regional flow events.

- Model 0126mag (HEC-RAS 2.1): The model represents Tributary N1-A from Chisholm Drive to Peru Road. The model includes the 2-year to 100-year and Regional flow events. This model was not used in this study.

- Model FOAK11 (HEC2): The model represents Tributary N1-A from Chisholm Drive to Steeles Avenue. The model was created as part of Oakville Creek Floodline Mapping EO83147 and includes the following water courses:
    - River 1, Reach1: represents Tributary N2-B from Highway 401 to CNR tracks;

- River 1, Reach2: represents Tributary N2-B from CNR tracks to Millside Drive; and
- River 2: represents Tributary N1-A from Chisholm Drive to confluence with Tributary N2-B near CNR tracks.

The peak flows for this model were imported from Table 4.5 and the Hydrologic Reference Plan of the Highway 401 FSEMS Report, which was received from CH.

Table 1 below provides a summary of the relevant HEC-RAS models and the related Crossings/Culverts.

Model FOAK11 results show that the CNR culvert BR02, located east of Regional Road 25 and north of Steeles Avenue, has sufficient capacity to convey the 100-year storm event. The results also show that, during the Regional storm event, a large area upstream of the CNR culvert will be flooded, including Regional Road 25 and Chisholm Drive as shown within **Figure 9 (Appendix A)**. Background hydraulic modeling details and flooded area are included in **Appendix A**.

Table 2 : HEC-RAS Models and Crossings

HEC-RAS Model	Version	Culverts	Tributary
FOAK11	5.3	Culverts C2, C3 and CN BR02	N1-A
RR25 Channel	5.3	Culvert C4	N2-B
Culvert C1	5.3	Culvert C1	N1-A

2.1.2 High Point Pond (S36)

The downstream portion of the existing storm sewer servicing the area north of Highway 401 runs parallel to Tributary N2-B and discharges into High Point Pond (S-36). Recent stream reconstruction work was done on Tributary N2-B between Regional Road 25. The work changed the concrete-lined trapezoidal channel downstream of Culvert C4 into a natural channel, possessing reliable geomorphic indicators with which to establish appropriate channel dimensions through the reach. The natural channel was designed to incorporate stabilization methods that use natural materials and rely on vegetation growth for long term stability. The channel has a meandering pattern with riffles and pools, woody debris structures, J-hook structures, cross-vanes, and constructed riffles. Additional coordination with MTO, the Ministry of Natural Resources and Forestry (MNRF), and Department of Fisheries and Oceans (DFO) may be required during detail design.

A HEC-RAS model was received from CH for Tributary N2-B from High Point Drive to Pond S36 (model RR25 Channel). The flows used in the hydraulic model were taken from the Phillips (January 2003) report. The model includes Culvert C4, the natural channel, and the access road culvert. The model confirms that Culvert C4 has sufficient capacity to convey peak flows from all storm events up to, and including, the Regional Storm.

Functional Stormwater and Environmental Management Strategy – Highway 401 Industrial/Business Park Secondary Plan Area (FSEMS) provides the operational characteristics of the High Point Pond (S36) with a maximum storage of 97,400 m^3, which accommodates a total drainage area of 691 ha, including a development area of 251 ha, at an imperviousness of 68%. Figure 3 of the FSEMS (included in **Appendix A**) identifies the Proposed Land Use Plan in which Regional Road 25 is contained, and indicates the surrounding industrial, employment and business park developments. These developable lands, totaling 250 ha, are identified in Tables 6.4 and 6.5 (including 12.7 ha and 6.5 ha roads respectively). The existing Regional Road 25 has an imperviousness ROW of approximately 58.4%, compared to the 68% imperviousness assumed by the SWM facility design. Therefore, the pond currently provides the stormwater quantity control requirements for the existing Regional Road 25, and still has additional capacity to control runoff from 68% impervious ROW.

3.0 PROPOSED CONDITIONS

3.1 STORMWATER MANAGEMENT CRITERIA:

- Water Quantity Control: It is required to restrict the proposed road peak releases for the new impervious area to the pre-development peak flows for all storm events, up to and including the 100-year storm;
- Water Quality Control: Water quality treatment is required for the proposed Regional Road 25. The treatment should satisfy the Ministry of Environment, Culture and Parks (MECP) Enhanced quality control criteria of providing a minimum 80% TSS removal efficiency; and,
- Potential opportunities to implement infiltration measures/low impact developments (LIDs) should be identified and implemented wherever feasible and appropriate.

3.1.1 Quantity Control:

As noted above, Pond S36 has been constructed with sufficient quantity control capacity to treat the widened Regional Road 25 north of Highway 401. Any increased quantity of flow will be accommodated as required in this pond. The existing Regional Road 25 has an imperviousness right-of-way of approximately 58.4%, compared to the 68% imperviousness assumed by the SWM facility design. Therefore, the pond provides the stormwater quantity control requirements for the existing Regional Road 25, and still has additional capacity to control runoff from the proposed 67.6% impervious ROW (See **Table 2** and **Table 3** below). The Town of Milton, owner of Pond S36, should be contacted during the detailed design stage to verify the design conditions of the pond.

The runoff from Regional Road 25 south of the Highway 401 interchange and north of Steeles Avenue will be controlled to pre-development levels. Upsized pipes (“super-pipes”) will be utilized to provide the necessary storage volume. Details and a summary table of the proposed super-pipes, orifices and stage-storage-discharge tables will be required at the detailed design stage. **Figures 7A-E** and **Figures 8A-E** illustrate the existing and proposed storm drainage areas respectively.

Table 3 : Existing Impervious area to Pond 36

FROM MH	TO MH	AREA (ha)	Imp %	Imp x Area
DICB76	CBMH77	2.51	29%	0.72
CBMH77	CBMH78	0.437	100%	0.44
CBMH78	CBMH75	0.153	100%	0.28
CBMH75	CBMH72	0.87	65%	0.70
CBMH72	CBMH70	0.34	65%	0.27
CBMH70	CBMH67	0.37	65%	0.29
CBMH67	CBMH63	0.32	65%	0.25
CBMH63	CBMH61	0.27	65%	0.21
CBMH61	CBMH59	0.27	65%	0.21
CBMH59	MHS56	0.24	71%	0.19
MHS56	MHS48	0.63	71%	0.50
MHS48	MHS39	0.74	57%	0.60
MHS39	MHS33	0.62	65%	0.49
MHS33	MHS28	0.49	65%	0.39
MHS28	MHS21	1.03	65%	0.81
MHS21	MHS13	0.83	65%	0.59
MHS13	MHS6	0.71	65%	0.51
MHS6	STC9000	0		
Totals		**10.83**	**58.4%**	**6.33**

Table 4 : Proposed Impervious area to Pond 36

FROM MH	TO MH	AREA (ha)	Imp %	Imp x Area
DICB76	CBMH77	2.51	29%	0.72
CBMH77	CBMH78	0.437	100%	0.44
CBMH78	CBMH75	0.284	100%	0.28
CBMH75	CBMH72	0.896	79%	0.70
CBMH72	CBMH70	0.34	79%	0.27
CBMH70	CBMH67	0.37	79%	0.29
CBMH67	CBMH63	0.32	79%	0.25
CBMH63	CBMH61	0.27	79%	0.21
CBMH61	CBMH59	0.27	79%	0.21
CBMH59	MHS56	0.24	79%	0.19
MHS56	MHS48	0.63	79%	0.50
MHS48	MHS39	0.76	79%	0.60
MHS39	MHS33	0.62	79%	0.49
MHS33	MHS28	0.49	79%	0.39
MHS28	MHS21	1.03	79%	0.81
MHS21	MHS13	0.83	71%	0.59
MHS13	MHS6	0.71	71%	0.51
MHS6	STC9000	0		
Totals		**11.007**	**67.6%**	**7.44**

3.1.1.1 Potential LID Opportunities

Low Impact Development (LID) is a SWM strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff as close to its source as possible. LID comprises a set of design strategies that minimize runoff by utilizing small scale structural practices that mimic natural or predevelopment hydrology through the processes of infiltration, evapotranspiration, harvesting, filtration and detention of stormwater. To protect the health of the Sixteen Mile Creek watershed, the updated water management strategy calls for an immediate shift to more proactive and innovative stormwater management systems that include LID practices.

Studies show that implementing LID practices can have multiple positive environmental effects which help to mitigate potential negative impacts of climate change on groundwater levels, risk of flooding and stream channel erosion. Therefore, evaluation of the available SWM measures for the subject site will include different types of the source treatment LID options as described below.

Suitable source treatment for roads includes the following:

- Permeable pavement;
- Engineered soil cells;
- Underground polypropylene chambers (such as StormTech®);
- Catchbasin shields (CB Shields®); and
- Oil-Grit Separators (OGS).

Permeable pavement is generally not appropriate for this type of urban road due to concerns regarding maintenance requirements to prevent clogging of the permeable pathways through the pavement, and due to potential groundwater contamination.

Engineered soil cells, such as Silva Cells® or GreenBlue Urban®, are modular support systems that provide a sturdy and permeable ground level decking that transfers surface loads to a compacted subbase 0.4 – 1.1 m below grade without compacting the near-surface soil layers. Because the near-surface layers remain uncompacted, void ratios remain high making the near surface layers useful for stormwater detention and infiltration. Engineered soil cells also provide suitable soil conditions for large tree growth. Engineered soil cells may be used to provide water balance and erosion and sediment control for the proposed road.

Underground polypropylene chambers (such as StormTech®) are recommended and will be confirmed during detail design. These can provide a cost-effective subsurface detention/retention system which provides a large storage volume per square metre. CB Shields® and Oil-Grit Separators (OGS) are proposed as part of a treatment train for the portion of the road south of Highway 401.

3.1.2 Quality Control:

The existing quality control measures for the widened Regional Road 25 north of Highway 401 consist of a treatment train, which includes a Stormceptor STC9000 and Pond S36. The Stormceptor unit was analyzed using the vendor sizing tool, and it was confirmed that the unit has sufficient capacity to treat the widened road. A report from the sizing tool results is provided in **Appendix B**. Therefore, it is concluded that the combined measures have sufficient capacity to treat the additional impervious area, and no additional quality control is required for this portion of Regional Road 25.

Quality control for the widened Regional Road 25 south of Highway 401 interchange and north of Steeles Avenue will be provided via treatment trains which include Catchbasin Shield units and three proposed Oil-Grit Separator (OGS) units. OGS sizing was determined using the Storm Water Management Model (PCSWMM) for Stormceptor software. Detailed report outputs are included in **Appendix B**. Other alternative or supplemental measures may be used to achieve the required 80% TSS removal, such as Jellyfish Filters and LID measures**.** These options will be further developed during detailed design.

3.1.3 Minor and Major System Drainage:

The existing storm sewer system was analyzed to ensure that the system is designed in accordance with Halton Region and Town of Milton standards. The existing storm sewers were designed to convey the 5-year storm event flows as required by the Engineering and Parks Standards, Town of Milton, August 2014. A similar approach was adopted for the design of the proposed storm sewers, which were sized to convey the peak flows generated during the 5-year storm event, calculated using the Town of Milton IDF curves. The minor system will maintain the existing two outlets, namely SWM facility S36 north of Highway 401, and the downstream side of Culvert C1, north of Steeles Avenue, in addition to a third outlet at the upstream end of Culvert C2. The existing storm sewer system north of Highway 401 was recently constructed, therefore it will not be replaced. A parallel storm sewer system will be provided along the west side of the road to convey the additional flow generated by the proposed widened road. Existing and proposed storm sewer design sheets are provided in **Appendix C**.

An overland flow route is provided via Regional Road 25 to convey major system flows in excess of the minor system up to the 100-year and Regional storm event. Overland flow will be directed to the proposed SWM facilities S36 for the north side of Highway 401, and to the Tributary of Sixteen Mile Creek for the south side of the Highway 401. Calculations were conducted at two critical sections to confirm that the road has capacity to convey the maximum overland flow generated by storm events including the 100-year and Regional Storm. Calculations confirmed that the major system flow will not exceed the width of the road allowance, and in no case will the two centre lanes of the ROW be inundated by flooding under the 100-year and the Regional Storm events, in accordance with Halton Region requirements for Regional roads. The models also confirmed that the maximum runoff is generated by the 100-year storm event. Therefore, major flow calculations were based on the 100-year storm event.

The existing outlets downstream of Crossing C1 (via roadside ditches) will be replaced with two new source point outlets to a branch of Tributary N2-B. A Permit from CH under Ontario Regulation 162/06 will be required prior to construction of the outlets.

A Visual OTTHYMO (VO2) hydrologic model was developed to estimate localized runoff from the roadway and external areas under existing conditions, using the locally appropriate storm duration, distribution, and return period(s). Modeling outputs are provided in **Appendix D**.

3.1.4 Culvert Analysis:

Culvert C1: Preliminary calculations show that Culvert C1 has sufficient capacity to convey the 100-year flow across Regional Road 25. The existing culvert has also sufficient length and no extension will be required to accommodate the widened road.

Culvert C2: This culvert will be extended by 16.0 m on the east side of the road to accommodate the road widening at this location. Tributary NW-2-G3, downstream of the culvert, will be affected by the widening and will therefore be realigned to the east for a total length of 130 m. Natural channel design for the realigned section will be provided in the detailed design. Structural rehabilitation works will also be required for Culvert C2. The detailed design will review the need for repair of deteriorated concrete; replacement of the inlet SPCSPA with a precast 6000 x 2000 concrete structure (similar to the main culvert); inlet retaining walls; safety improvements; and, creek rehabilitation.

Culvert C3: This culvert will be extended by 3.0 m, and 6.0 m on the north and south sides of Chisholm Drive respectively, to accommodate the road widening at this location.

Culvert C4: The 60 m long concrete culvert C4, which conveys flows from Tributary N2-B underneath Regional Road 25, is under the jurisdiction of the MTO. Since there is no intention to discharge minor system flows at the upstream side of Regional Road 25, and the roadway profile will not be altered in the vicinity of the existing culvert crossing, there is no need for any hydraulic capacity upgrades and/or improvements to the existing culvert C4 at this time.

Refer to **Appendix D** for culvert capacity calculations.

3.1.5 Analysis of CNR Crossing at Regional Road 25:

The CNR crosses over Regional Road 25 via a 15 m span bridge (BR01), which is located about 300m north of Steeles Avenue. An analysis was conducted to confirm that the bridge has sufficient capacity to convey the Regional Road 25 overland flow during the 100-year and Regional Storm events. The maximum flow was calculated, using VO4 software, as 0.56 m^3/s during the 100-year storm event. FlowMaster software was used to evaluate the conveyance capacity. The model results confirmed that the bridge has sufficient capacity to convey the peak flow, with a maximum depth of 0.05 m. Model results are included in **Appendix D**.

3.1.6 CNR Culvert Flood Impact Analysis:

The HEC2 model FOAK11 received from CH includes Tributary N1-A which crosses Reg. Rd. 25 and the CN track via culverts C2 and BR02, respectively. The model was converted to HEC-RAS model to study the proposed conditions, and to mitigate the existing flood impact. The existing conditions model results show that the 2.5m diameter CNR culvert (BR02), located about 240 m downstream of Culvert C2, does not have sufficient capacity to convey the Regional flow of the creek. This results in Regional storm flooding of a large area upstream of the CNR culvert, including the Maplehurst Correctional Complex and Regional Road 25. Model details and results are included in **Appendix D** and **Figures 1** and **2**. The model shows that the water elevation upstream of CNR culvert (BR02) during Regional Storm is at elevation 208.46m. This will cause flooding of the following areas:

- Regional Road 25: the road will be flooded from south of Steeles Avenue to Chisholm Drive. The water depth will increase to a maximum of 1.0m north of Steeles Avenue.
- Chisholm Drive: This road will be inundated
- Maplehurst Correctional Complex: All the facility will be subject to severe flooding impacts during Regional storm events.
- Developments west of Regional Road 25: About 20 to 60 m wide strip to the west of Reg. Rd. 25 will be subject to flooding.

To mitigate flooding during the Regional Storm event, it is proposed to increase the flow capacity of the CNR culvert BR02 by adding two, 1.8m diameter, circular relief culverts, one at each side of the existing culvert. Culvert C2 discharges into Tributary NW-2-G3, which runs parallel to Regional Road 25. This culvert will be extended by 10.0 m at the downstream side to discharge away from the proposed road embankment. A natural channel is proposed to replace Tributary NW-2-G3. The natural channel will convey the flow from the extended Culvert C2 and will run for 120 m before joining Tributary NW-2-G3, about 40 m south of Market Drive.

The HEC-RAS model was updated to include the flood mitigation scenario, including the realigned channel. The model results show that under proposed conditions, the Regional Storm water elevation, upstream of the CNR culvert, will drop from the existing condition elevation of 208.46 m to an elevation of 204.63 m. Accordingly, the flood impact will be mitigated as follows (refer to **Figures 1** and **2**):

- Regional Road 25 and the developments west of Regional Road 25: will be completely free of flooding during all storms up to the Regional storm event.
- The access road to Maplehurst Correctional Complex: will be completely free of flooding during all storms up to the Regional storm event.
- Maplehurst Correctional Complex: Most of the facility will be completely free of flooding during all storms up to the Regional Storm event. Only a small portion of the south parking lot will be subject to flooding during Regional Storm event, however the water depth at this location will be reduced to less than 0.50, which is a considerable reduction compared to the existing conditions.

Figures 10A to 10E provide cross-sections of the proposed Regional Road 25 and **Figure 9** shows the existing Tributary NW-2-G3 and the proposed natural channel, which runs parallel to Regional Road 25 between Stations 25+640 and 25+480. The figures show a minor encroachment of the proposed widened road on to the flood plain, at limited locations, during Regional Storm events. Introducing the two relief culverts at the CNR crossing has considerably reduced the proposed Regional storm water elevation. Therefore, the post development flood plain is not affected by the widened road embankment. The total volume of the road fill within the floodplain is limited to about 400 m^3, which must be compensated by an equal amount of excavation within the flood plain. A summary of the existing and proposed culvert parameters and hydraulic analysis results is provided in **Table 5** to **Table 7**.

It is noted that CH is intending to re-evaluate the flood hazard associated with the larger tributaries of Sixteen Mile Creek, which flow through urban Milton, as part of the National Disaster Mitigation Program. The project is planned to be completed by March 31, 2020, and the results of the study will impact the findings of this EA, involving culvert replacement, and elimination of a portion of the concrete lined channel that crosses the Maplehurst site. This new information from the CH study should be utilized to update the drainage and SWM design at the detailed design stage.

3.1.7 Summary of Culverts:

Table 5 : Culverts Drainage Areas and Flows

Culvert ID	Drainage Area (ha)	Events	Flow (m^3/s)	Road Low Point Elevation
C1	58.9	5-Year	1.65	206.00
		50-Year	3.61	
		100-Year	4.25	
		Regional	6.86	
C2	362.9	10-Year	2.91	206.75
		50-Year	4.24	
		100-Year	4.74	
		Regional	30.32	
C3	362.9	10-Year	2.91	206.80
		50-Year	4.24	
		100-Year	4.74	
		Regional	30.32	
C4	658.0	10-Year	5.2	212.05
		50-Year	7.27	
		100-Year	8.19	
		Regional	36.29	
BR02	362.9	10-Year	2.91	212.0
		50-Year	4.24	
		100-Year	4.74	
		Regional	30.32	

Table 6 : Proposed Culverts Parameters

Culvert ID	Location	Span Size (mm)	Length (m)	Type (material)
C1	Just north of Steeles (south of the railway)	2100 x 1200	57	concrete box
	Proposed Change: No Change			
C2	"Kinked" culvert that crosses RR25 just south of Chisholm			
C21	Across RRD25	6000 x 2000	78	open footing concrete box
C22	Upstream End of C21	6000 x 2000	10	open footing
	Proposed Change: Extend C21by 16m at the downstream side Replace C22 by 6000x200mm box culvert (to be done by others)			
C3	Culvert that crosses Chisholm	3000 x 2400	32	open footing
	Proposed Change: Extend by 3 and 6m at the upstream and downstream sides respectively			
C4	Crosses RR25 just north of Highway 401	3000 x 2400	60	concrete box
	Proposed Change: No Change			
BR02	200m east of RRD25	2500	35	concrete pipe
		2 x 1800	35	concrete pipe
	Proposed Change: Provide 2 relief culverts to accommodate Regional flow			

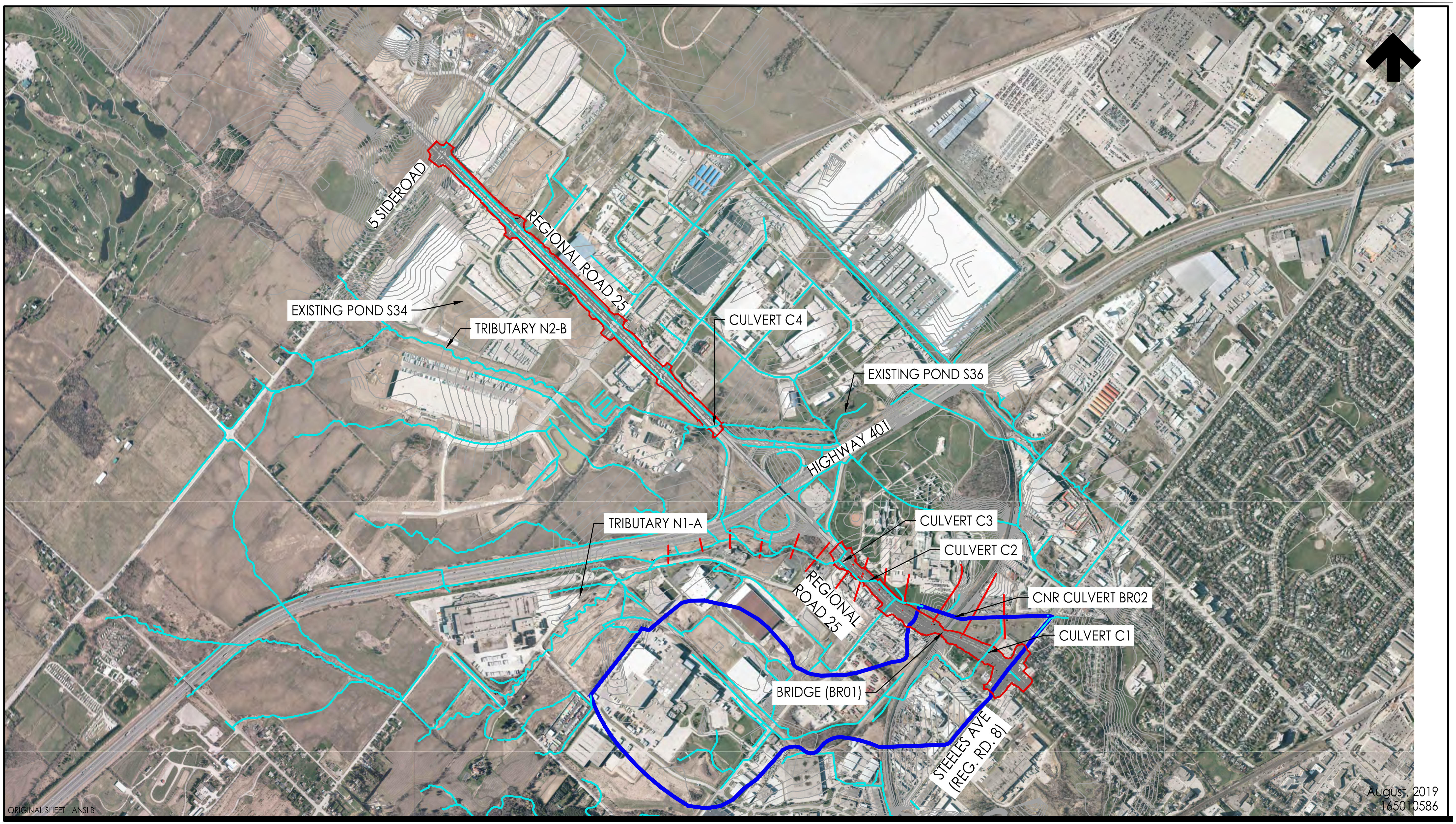
Table 7 : Culverts Hydraulic Parameters

Culvert ID	Events	Existing				Proposed			
		TWL (m)	HWL (m)	FB m	OT (Y/N)	TWL (m)	HWL (m)	FB (m)	OT (Y/N)
C1	5-Year	203.40	203.89	2.11	No	203.40	203.89	2.11	No
	50-Year	203.50	204.36	1.64	No	203.50	204.44	1.56	No
	100-Year	203.50	204.48	1.52	No	203.50	204.58	1.42	No
	Region Storm	203.60	204.95	1.05	No	203.60	205.79	0.21	No
C2	10-Year	203.15	203.51	3.24	No	203.15	203.53	3.22	No
	50-Year	203.25	203.63	3.12	No	203.25	203.66	3.09	No
	100-Year	203.33	203.67	3.08	No	203.28	203.70	3.05	No
	Region Storm	208.46	208.46	-1.71	Yes	204.47	205.16	1.59	No
C3*	10-Year	204.24	204.33	2.47	No	203.99	204.18	2.62	No
	50-Year	204.42	204.54	2.26	No	204.09	204.47	2.33	No
	100-Year	203.48	204.62	2.18	No	204.12	204.43	2.37	No
	Region Storm	208.46	208.46	-1.66	Yes	205.22	207.05	-0.25	Yes
C4	10-Year	208.83	209.07	2.98	No	208.83	209.07	2.98	No
	50-Year	208.90	209.36	2.69	No	208.90	209.36	2.69	No
	100-Year	208.92	209.48	2.57	No	208.92	209.48	2.57	No
	Region Storm	209.21	211.83	0.22	No	209.21	211.83	0.22	No
BR02	10-Year	202.10	202.92	7.08	No	201.79	202.62	9.38	No
	50-Year	202.27	203.16	6.84	No	201.89	202.75	9.25	No
	100-Year	202.32	203.24	6.76	No	201.93	202.80	9.20	No
	Region Storm	204.01	208.31	1.69	No	203.06	204.50	7.50	No

OT = Overtopping (of roadway)
FB = Freeboard
TWL = Tailwater Level
HWL = Computed Headwater Level
Reg = Regional Storm
**This culvert will convey the 100-year flow, with 1.60m free board. The road will be flooded during Regional storms, this is acceptable for collector roads as per Section 1.1.26.7Town of Milton Design Criteria*

4.0 REFERENCES

- *Preliminary Design Report Highway 401 Improvements from Trafalgar Road to Regional Road 25;* prepared by URS, March 2015*;*
- *Engineering and Parks Standards, Town of Milton, August 2014;*
- *Stormwater Management Report, Escarpment Business Community West, Part of Lot 3, 4 and 5, Concession, Town of Milton (24T-88027/M, Regional Municipality of Halton, July 2010; revised February 2011;*
- *Halton Region Conservation Authority, Floodline Mapping Study of the Sixteen Mile Creek, General Report*, prepared by The Proctor & Redfern Group, prepared for Environment Canada, February 18, 1988;
- *Halton Region Conservation Authority, Floodline mapping Study of the Sixteen Mile Creek, Technical Report*, prepared by The Proctor & Redfern Group, prepared for Environment Canada, February 18, 1988;
- *Ontario Regulation 162/06 Permit Application, Site 9 Culvert Rehabilitation, Martin Street, Town of Milton,* Halton Region 2016 and 2017 Bridge Culvert Rehabilitation and Replacement Program, prepared by AECOM, December 20, 2016;
- *Functional Stormwater and Environmental Management Strategy – Highway 401 Industrial/Business Park Secondary Plan Area*, Town of Milton, revised July 2000, by Phillips Engineering Ltd (Highway 401 FSEMS Report);
- Phillips Engineering Ltd., 2003. *16 Mile Creek West Trib Rehab, Hydraulic Analysis and Assessment,* Jan 2003 [Philips 2003]; and
- *Regional Road 25 Improvements, Class Environmental Assessment study, Highway 401 to Campbellville Road, Environmental Study Report*, prepared by URS Canada Inc., April 2006.
- *Stantec SWM Report – Regional Rd. 25*



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2019/08/15 3:09 PM By: Moura, David

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Legend

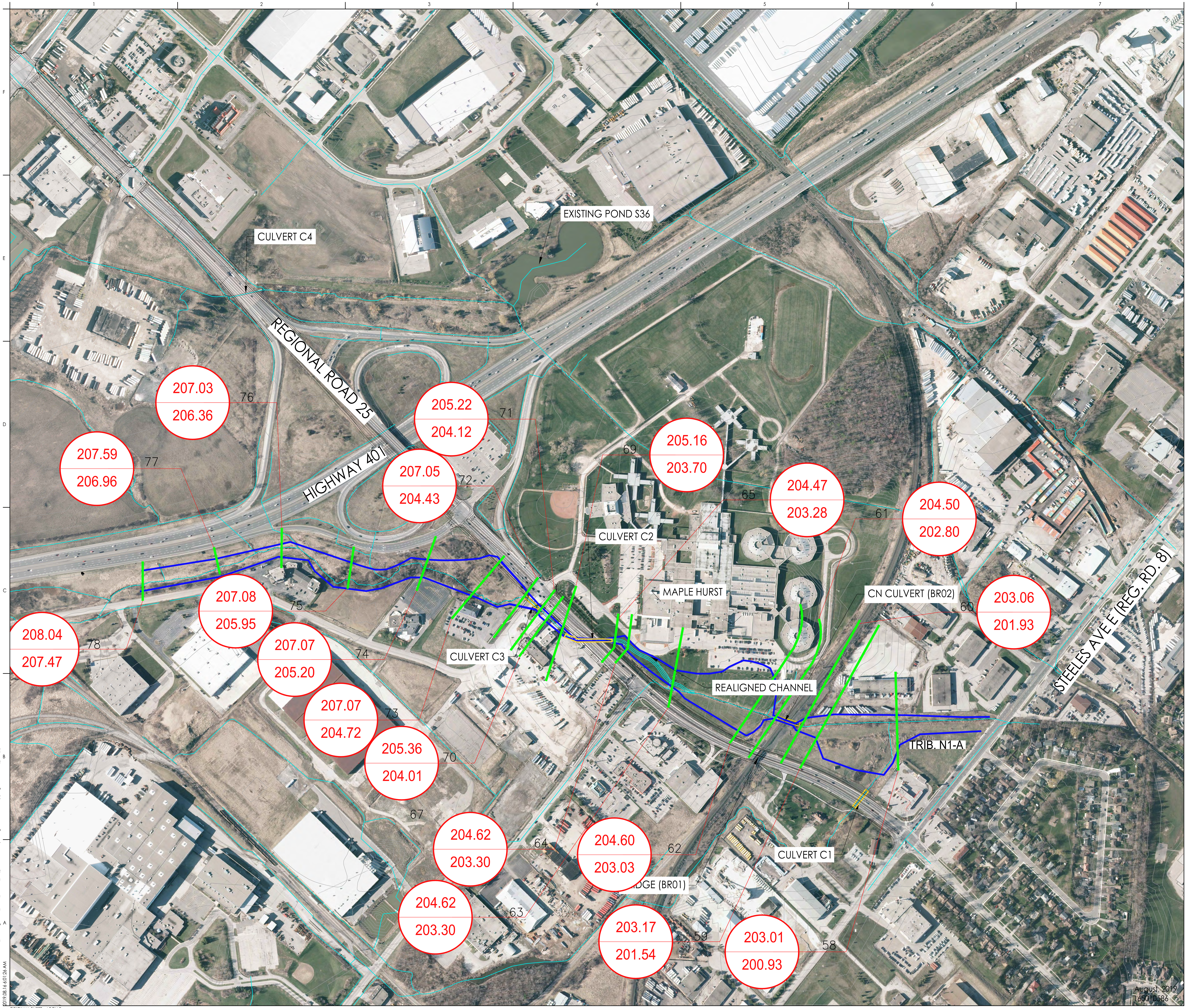
CROSSING C1 DRAINAGE BOUNDARY
SITE BOUNDARY
CREEKS, STORM SEWERS, AND DITCHES
FOAK 11_DAT SECTIONS

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
1

Title
EXISTING CONDITIONS

Scale
1:15000



ORIGINAL SHEET - ARCH E

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Legend

- REGIONAL FLOOD LINE
- CREEKS
- 75 SECTION ID
- EXISTING/PROPOSED CULVERT
- SITE BOUNDARY
- 204.01 / 202.32 PROPOSED REGIONAL WATER LEVEL / PROPOSED 100-YEAR WATER LEVEL
- CONTOUR LINE

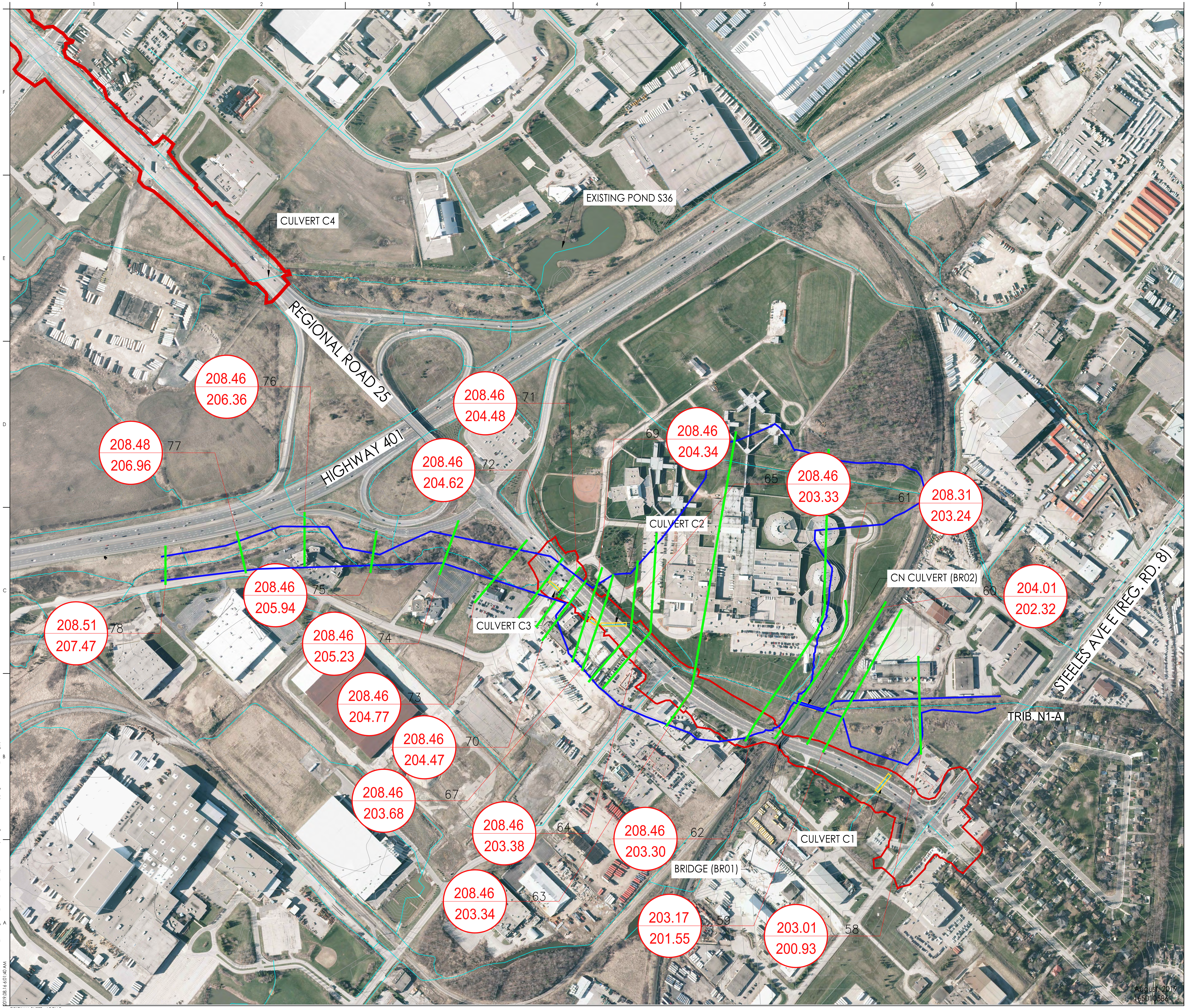
LICENSED PROFESSIONAL ENGINEER
M.A. MUKHTAR
100137118
Aug 26, 2019
PROVINCE OF ONTARIO

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
3

Title
PROPOSED REGIONAL AND 100 - YEAR FLOOD PLAINS

Scale
N.T.S



ORIGINAL SHEET - ARCH E

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Legend

- REGIONAL FLOOD LINE
- CREEKS
- 75 SECTION ID
- EXISTING/PROPOSED CULVERT
- SITE BOUNDARY
- 204.01 PROPOSED REGIONAL WATER LEVEL
- 202.32 PROPOSED 100-YEAR WATER LEVEL
- CONTOUR LINE

PROFESSIONAL ENGINEER
M. A. MUKHTAR
100137118
PROVINCE OF ONTARIO

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
2

Title
EXISTING REGIONAL AND 100 - YEAR FLOOD PLAINS

Scale
N.T.S

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Legend

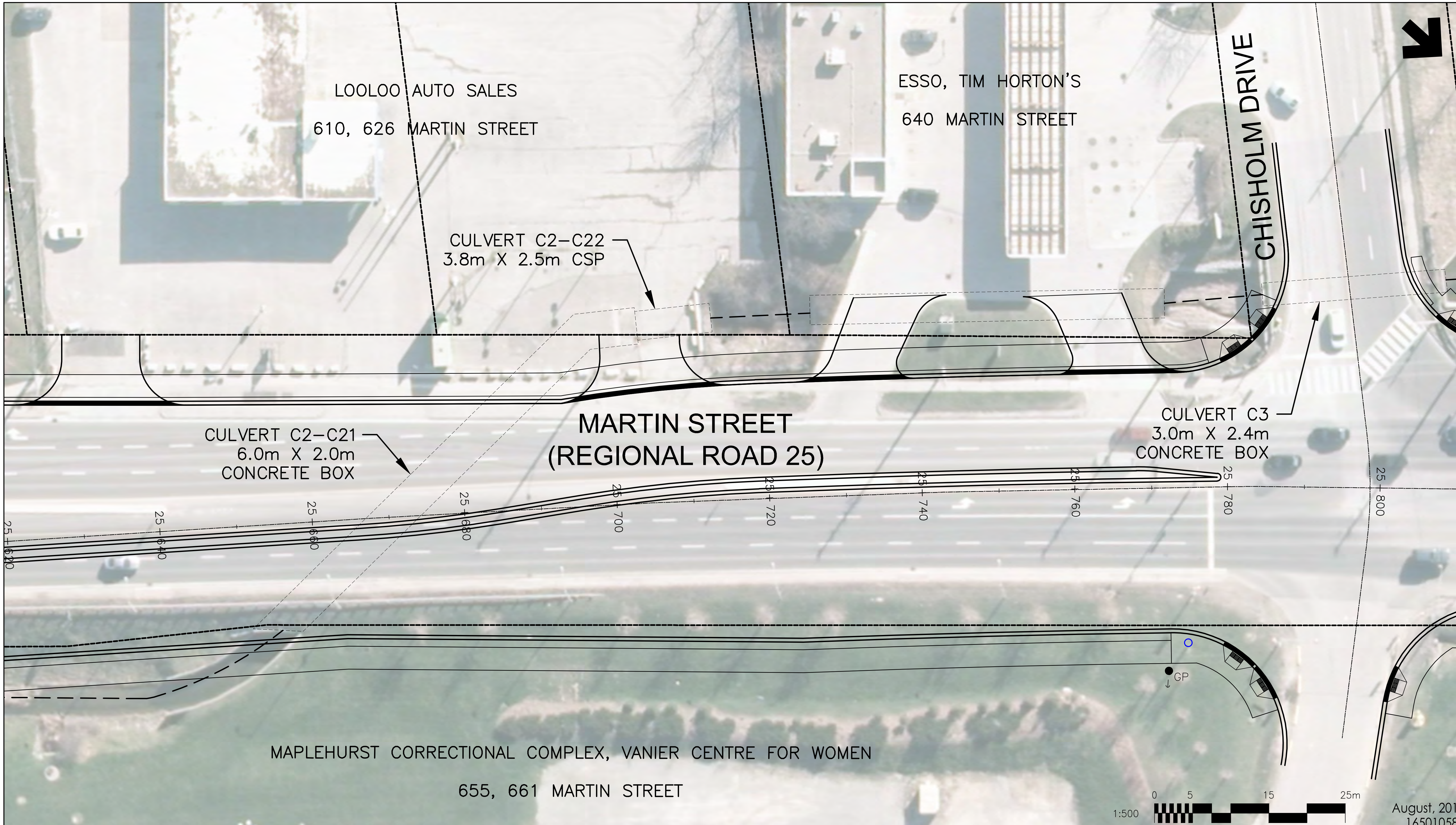
- WATERCOURSE CENTERLINE
- CULVERT CROSSING
- PROPOSED ROAD CONSTRUCTION

Notes

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
4

Title
WATER CROSSING 1



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Legend

- WATERCOURSE CENTERLINE
- CULVERT CROSSING
- PROPOSED ROAD CONSTRUCTION

Notes

Client/Project

HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.

5

Title

WATER CROSSING 2 AND 3

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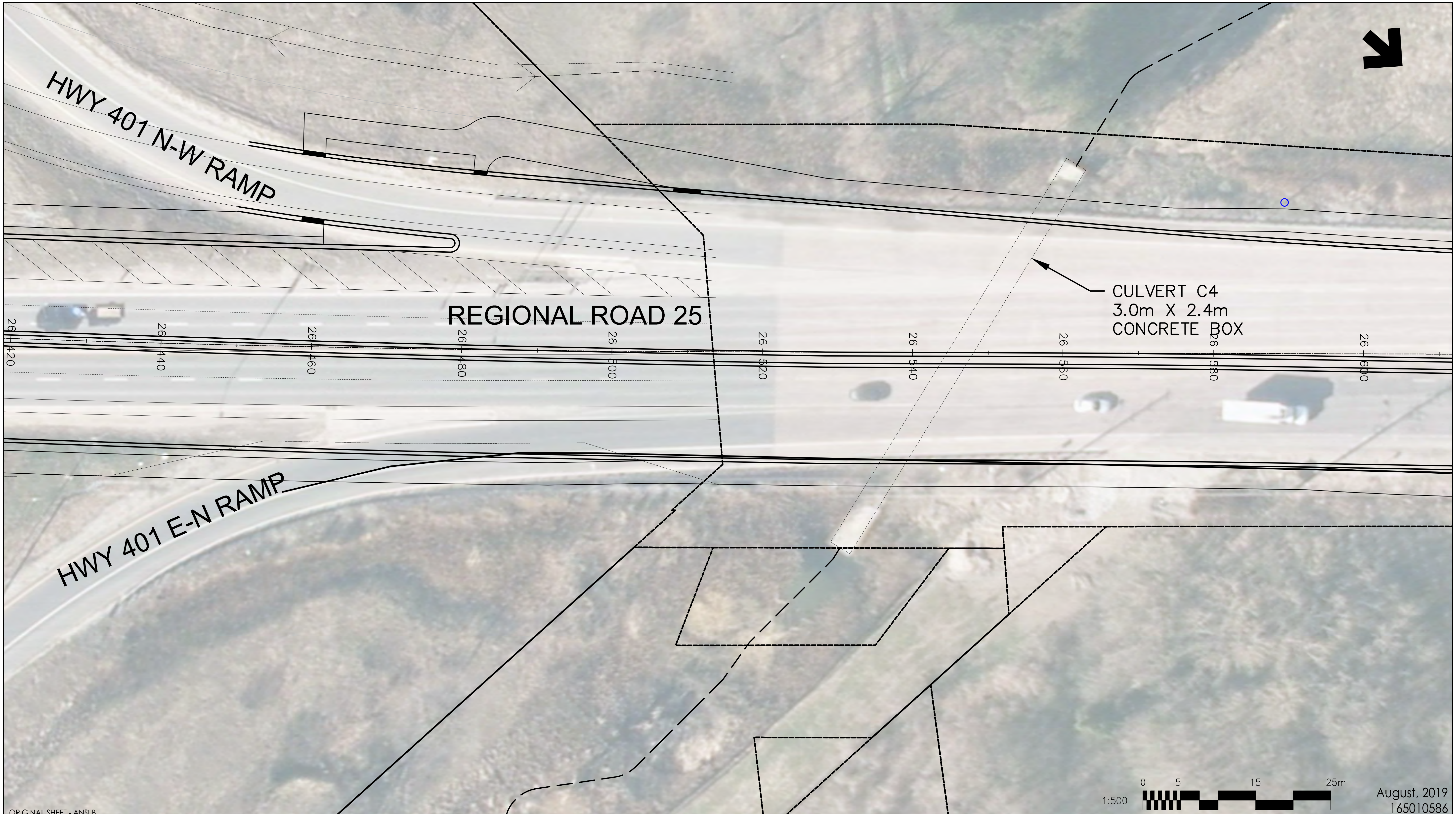

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Legend

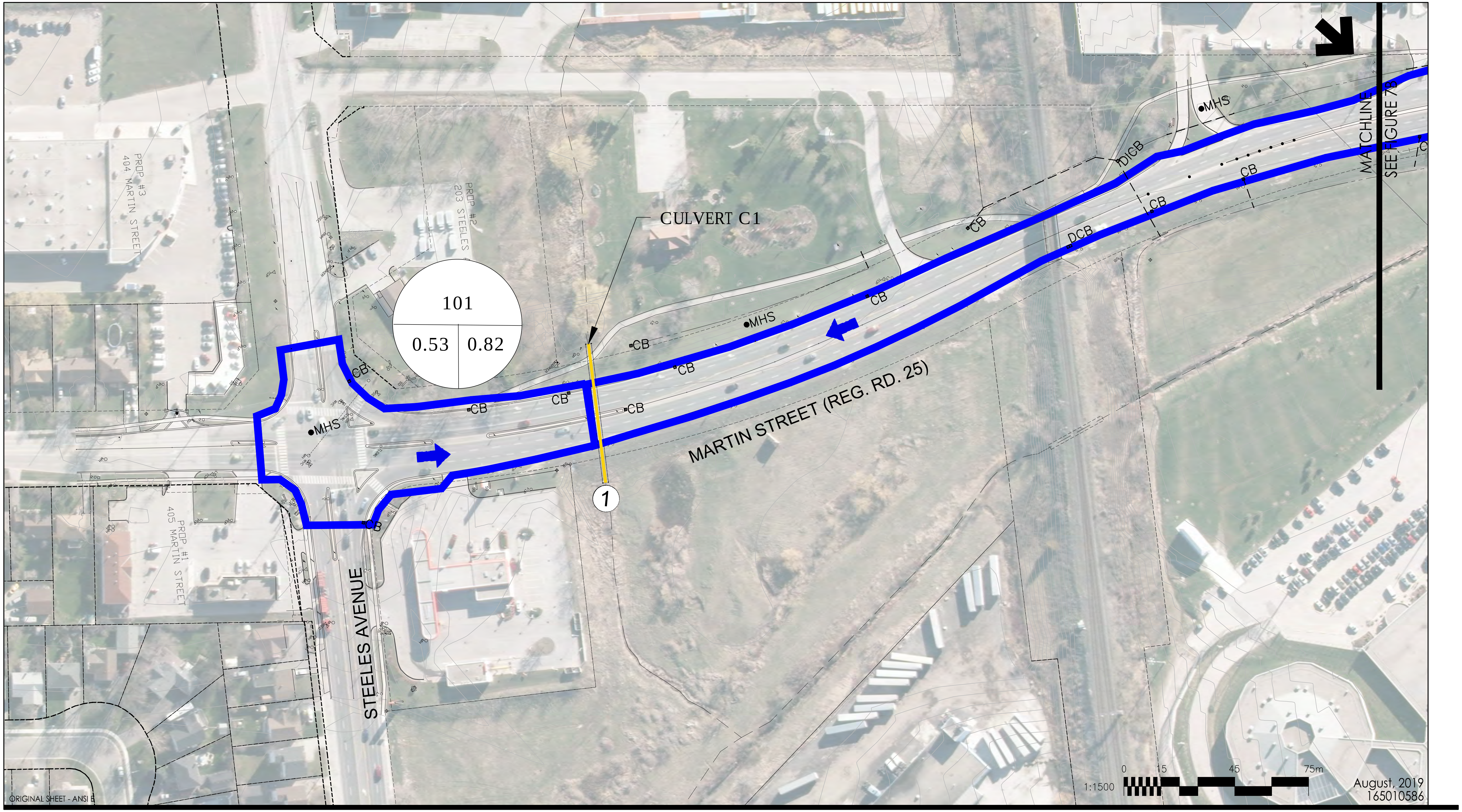
- WATERCOURSE CENTERLINE
- CULVERT CROSSING
- PROPOSED ROAD CONSTRUCTION

Notes

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
6

Title
WATER CROSSING 4



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165010586

Legend

EXISTING DRAINAGE BOUNDARY
1 EXISTING OUTLET
EXISTING STORM SEWER
FLOW DIRECTION
EXISTING CULVERT

CATCHMENT ID: 101
AREA (ha): 3.71
RUNOFF COEFFICIENT: 0.82

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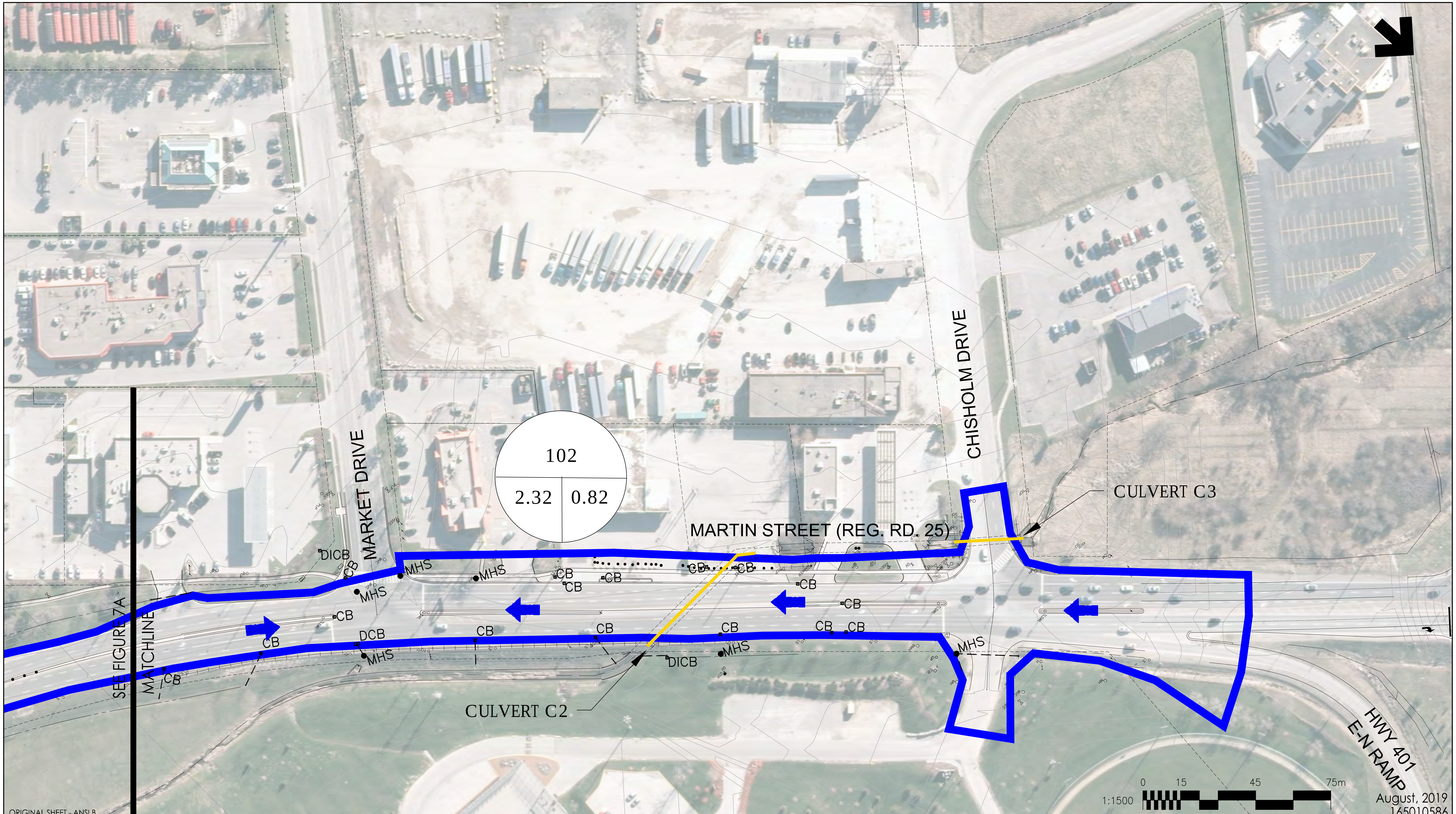
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
7A

Title
Existing Drainage Conditions



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Legend

- EXISTING DRAINAGE BOUNDARY
- 1 EXISTING OUTLET
- EXISTING STORM SEWER
- FLOW DIRECTION
- EXISTING CULVERT

CATCHMENT ID 101
AREA (ha) 3.71
RUNOFF COEFFICIENT 0.82

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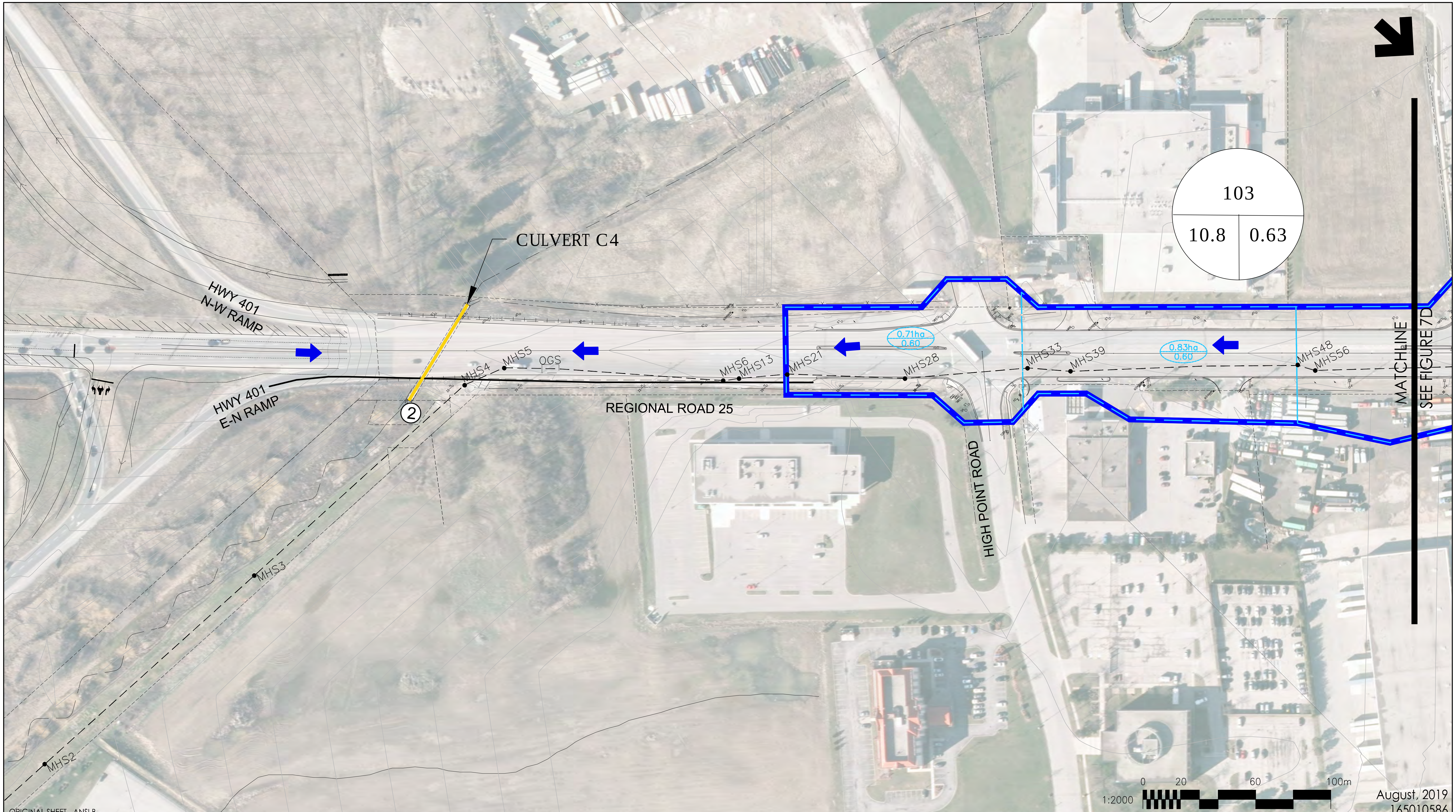
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
7B

Title
Existing Drainage Conditions



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165010586

Legend

- EXISTING DRAINAGE BOUNDARY
- ① EXISTING OUTLET
- EXISTING STORM SEWER
- FLOW DIRECTION
- EXISTING SUBCATCHMENT AREA

0.71ha — SUBCATCHMENT AREA
0.60 — RUNOFF COEFFICIENT

101 — CATCHMENT ID
AREA (ha) — 3.71
0.82 — RUNOFF COEFFICIENT

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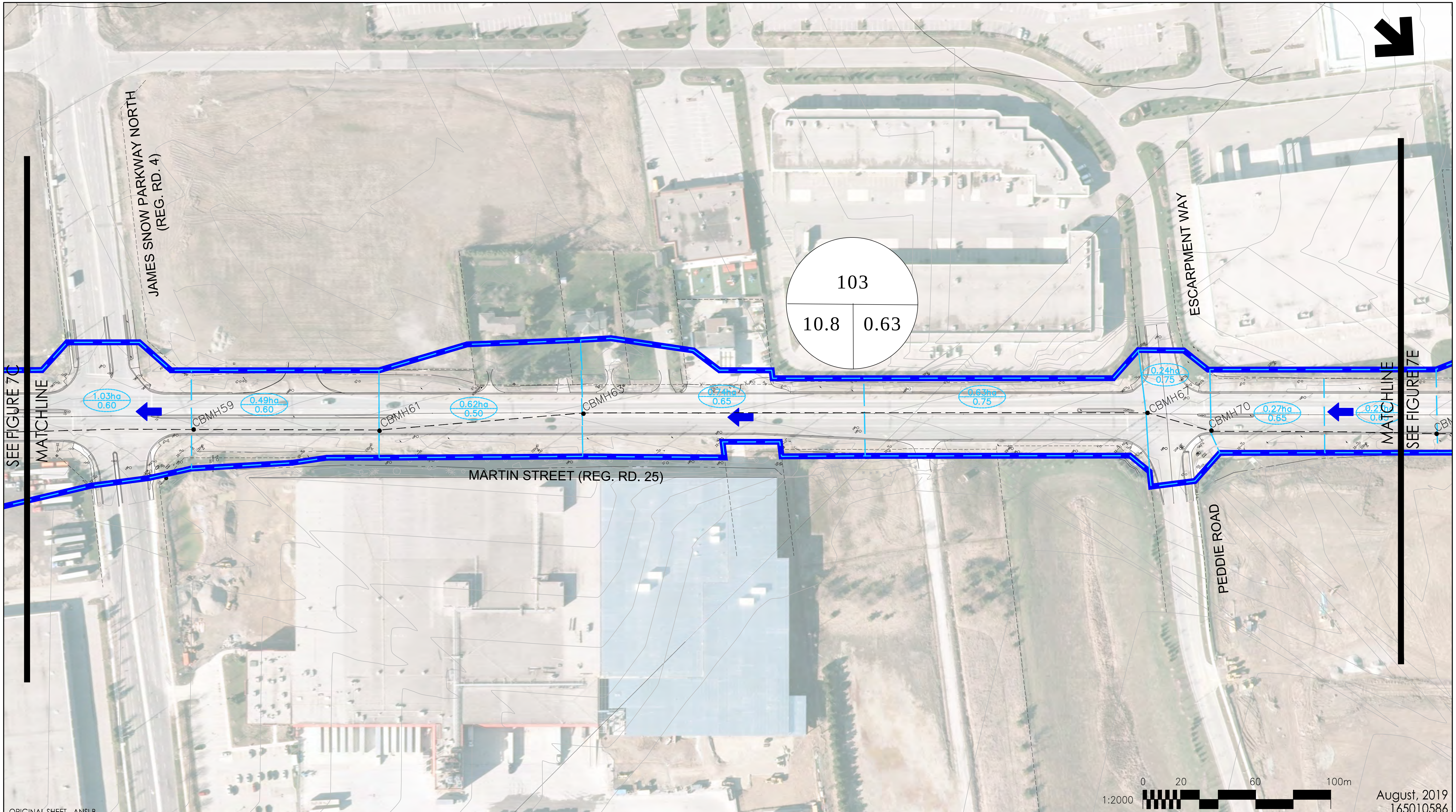
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
7C

Title
Existing Drainage Conditions



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Legend

- EXISTING DRAINAGE BOUNDARY
- 1 EXISTING OUTLET
- EXISTING STORM SEWER
- FLOW DIRECTION
- EXISTING SUBCATCHMENT AREA

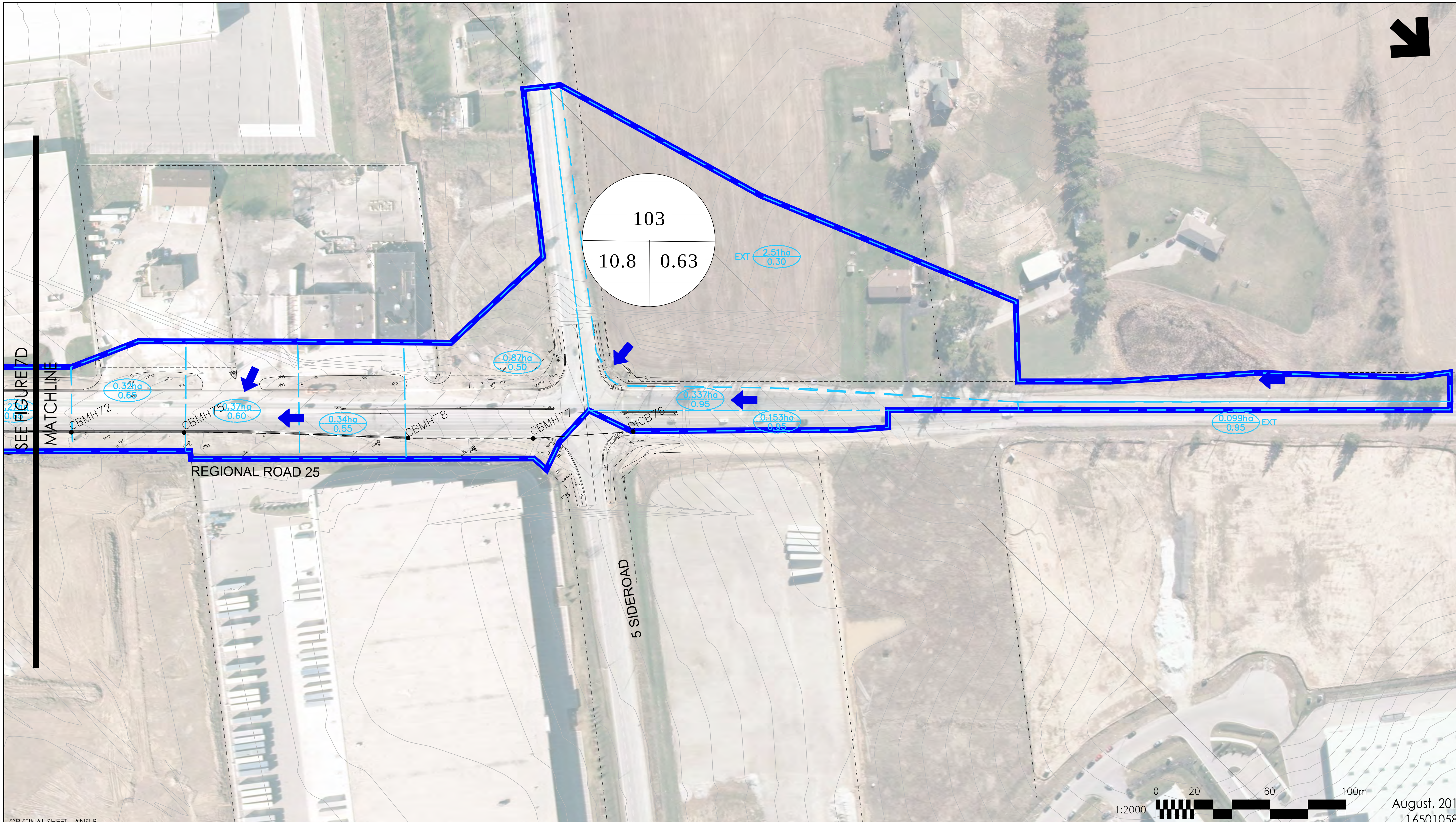
0.71ha — SUBCATCHMENT AREA
0.60 — RUNOFF COEFFICIENT

101 — CATCHMENT ID
AREA (ha) — 3.71
RUNOFF COEFFICIENT — 0.82

Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
7D

Title
Existing Drainage Conditions



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165010586

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Legend

- EXISTING DRAINAGE BOUNDARY
- 1 EXISTING OUTLET
- EXISTING STORM SEWER
- FLOW DIRECTION
- EXISTING SUBCATCHMENT AREA

0.71ha SUBCATCHMENT AREA
0.60 RUNOFF COEFFICIENT

101 CATCHMENT ID
3.71 AREA (ha)
0.82 RUNOFF COEFFICIENT

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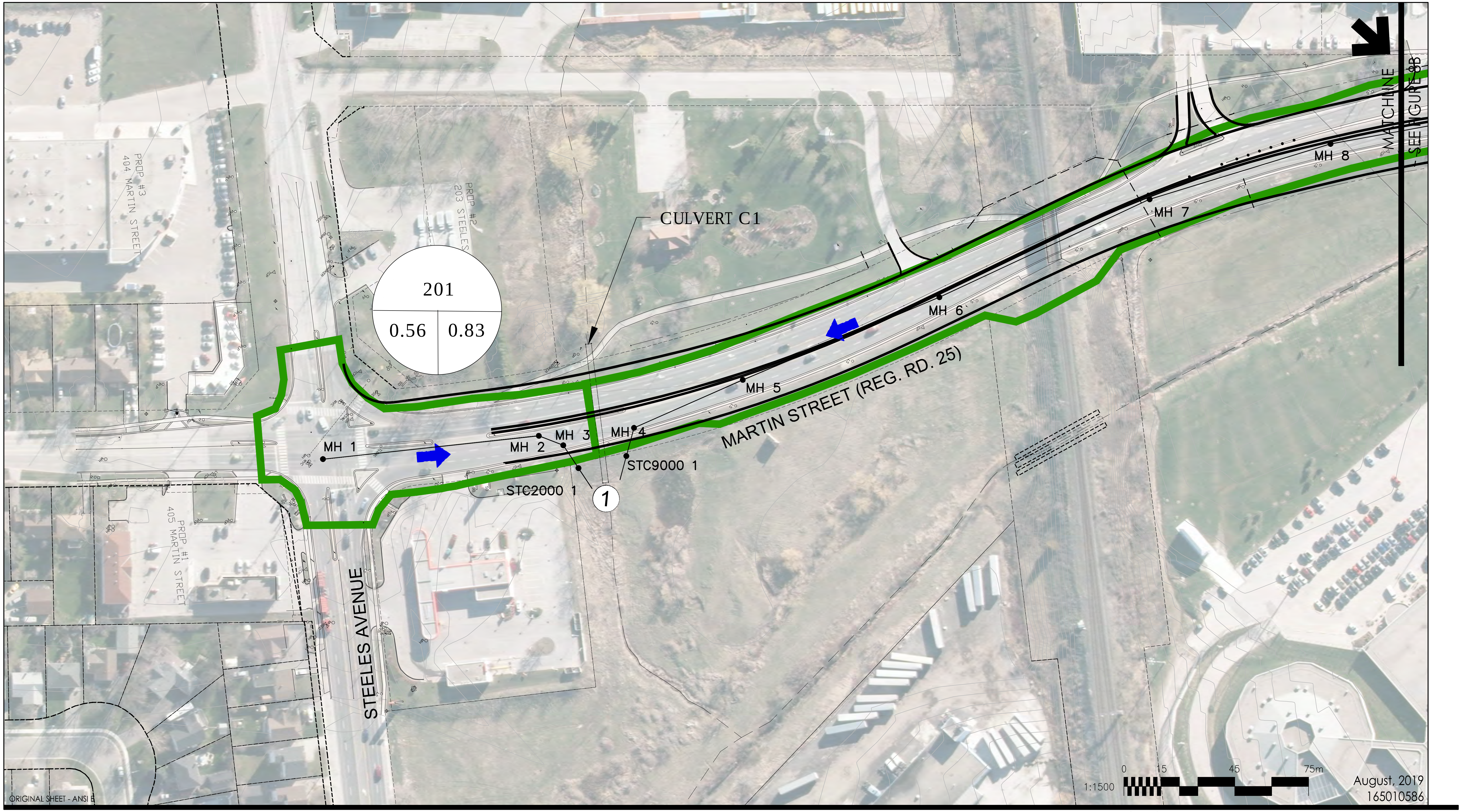
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
7E

Title
Existing Drainage Conditions



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165010586

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ORIGINAL SHEET - ANSI E

Legend

- PROPOSED DRAINAGE BOUNDARY
- PROPOSED ROAD WIDENING
- EXISTING OUTLET
- PROPOSED STORM SEWER
- FLOW DIRECTION
- EXISTING STORM SEWER

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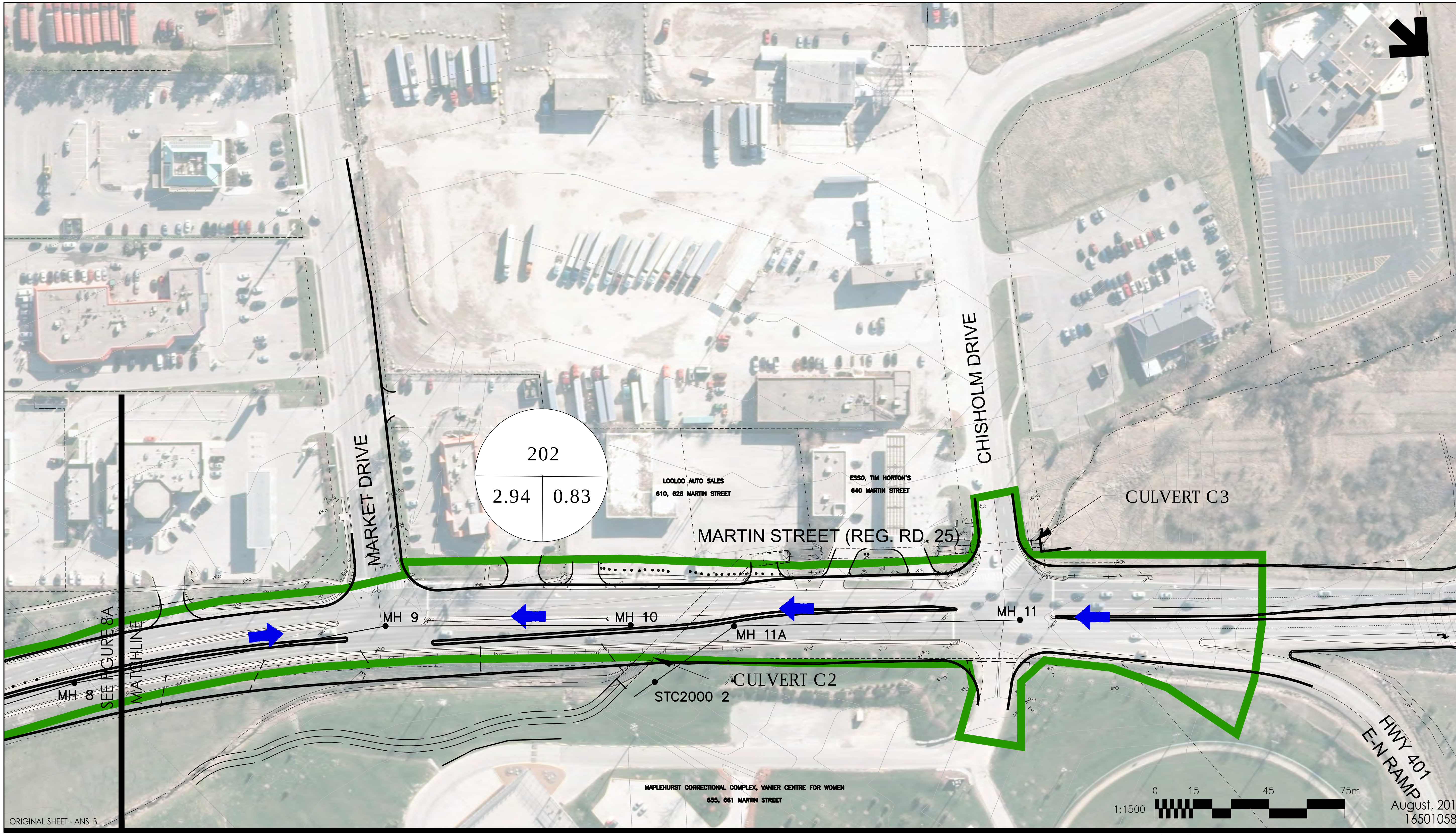
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.

8A

Title

Proposed Drainage Conditions



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PROPOSED DRAINAGE BOUNDARY
PROPOSED ROAD WIDENING
1 EXISTING OUTLET
PROPOSED STORM SEWER
FLOW DIRECTION
EXISTING STORM SEWER

CATCHMENT ID 101
AREA (ha) 3.71
RUNOFF COEFFICIENT 0.82

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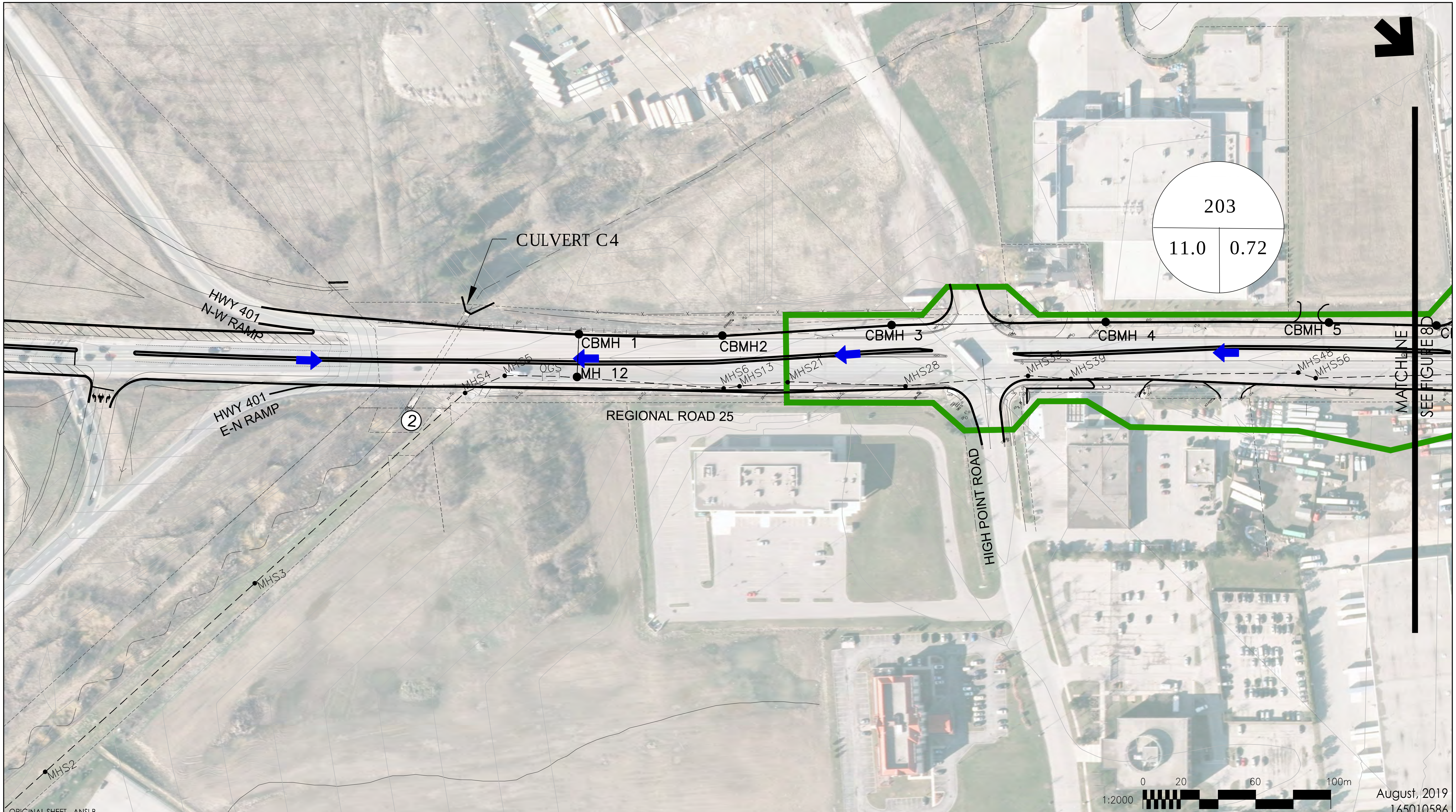
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
8B

Title
Proposed Drainage Conditions



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2019/08/19 11:08 AM By: Moura, David

Legend

PROPOSED DRAINAGE BOUNDARY
PROPOSED ROAD WIDENING
1 EXISTING OUTLET
PROPOSED STORM SEWER
FLOW DIRECTION
EXISTING STORM SEWER

CATCHMENT ID	AREA (ha)	RUNOFF COEFFICIENT
101	3.71	0.82

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HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
8C

Title
Proposed Drainage Conditions

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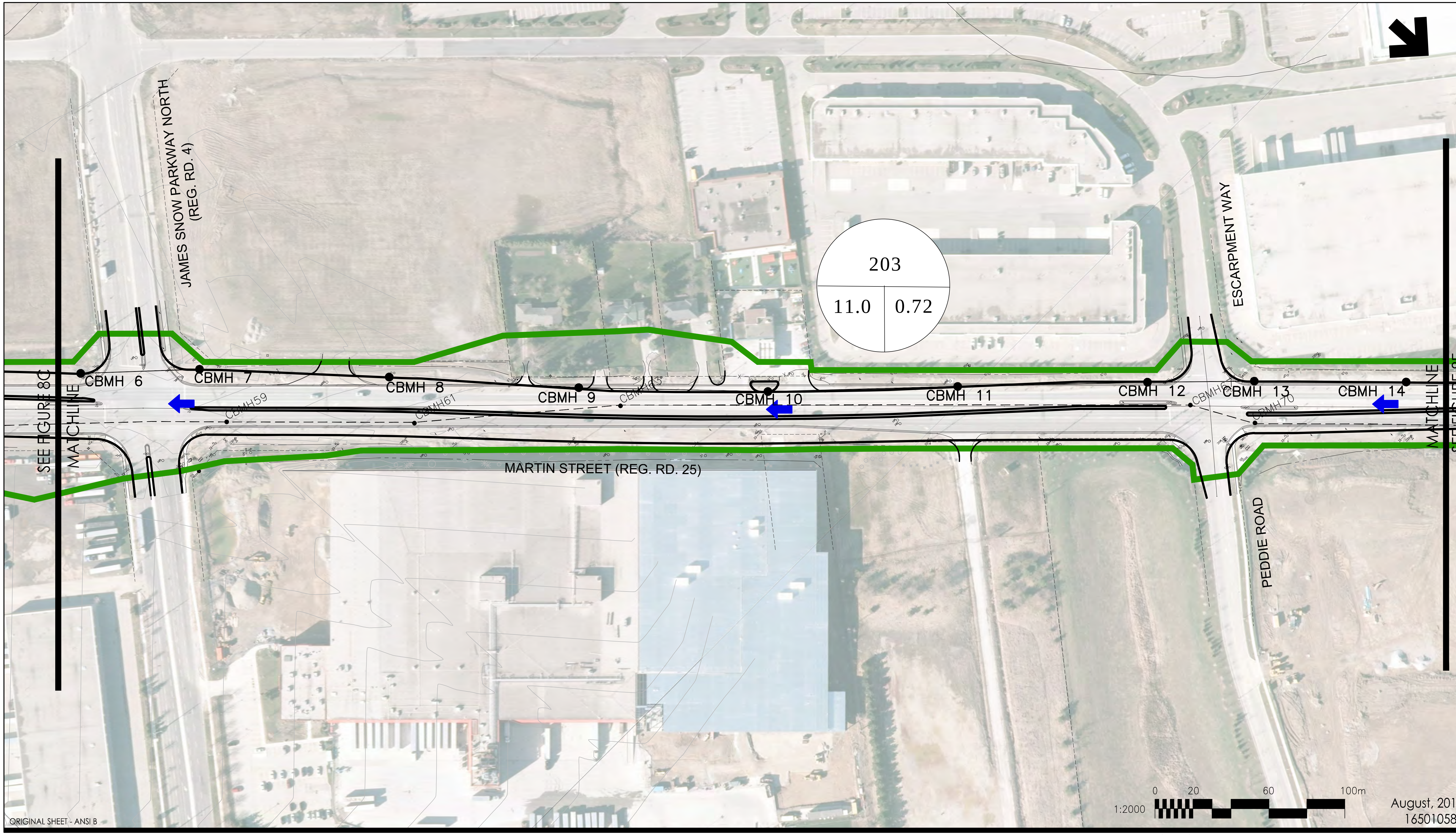

Legend

PROPOSED DRAINAGE BOUNDARY
PROPOSED ROAD WIDENING
1 EXISTING OUTLET
PROPOSED STORM SEWER
FLOW DIRECTION
EXISTING STORM SEWER

CATCHMENT ID: 101
AREA (ha): 3.71
RUNOFF COEFFICIENT: 0.82

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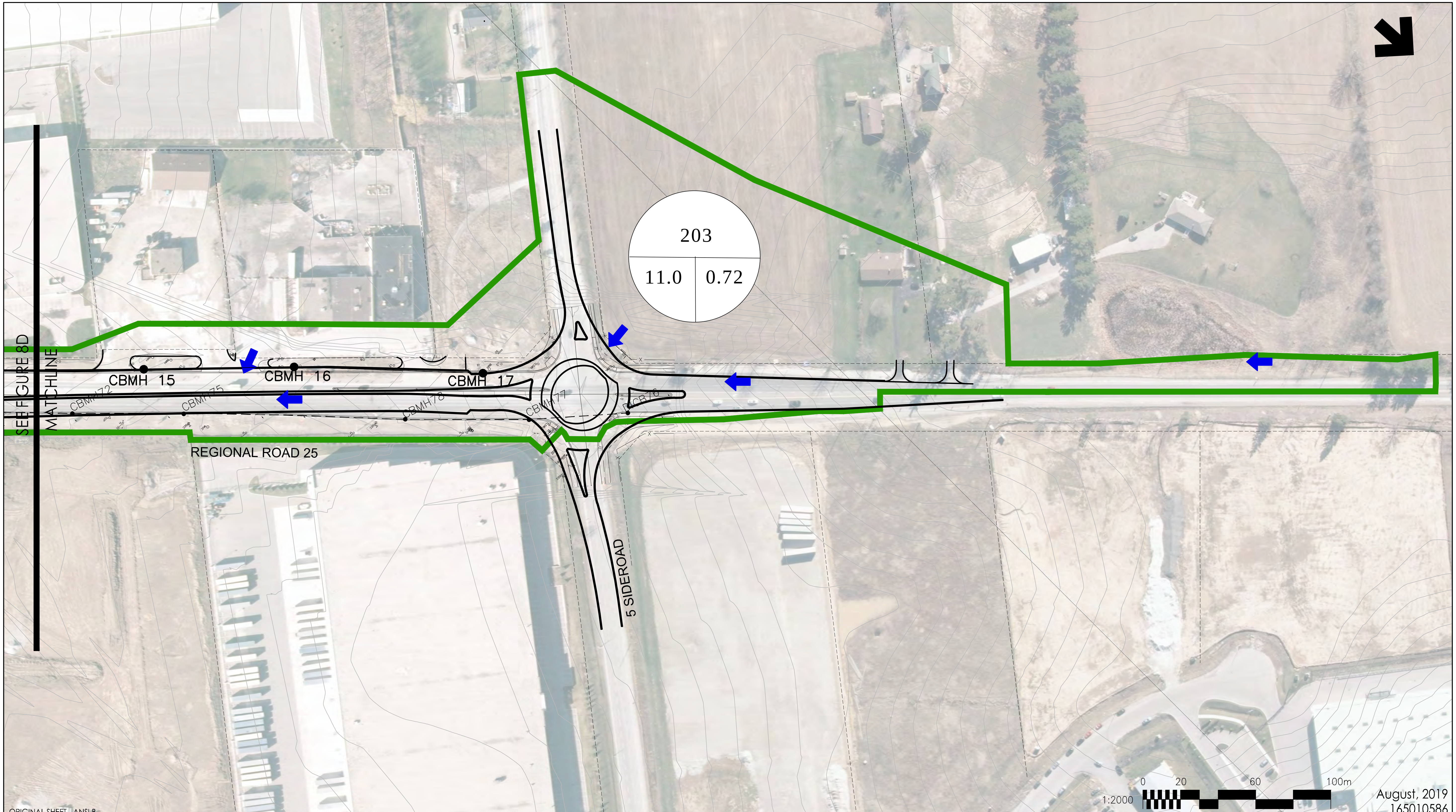
Client/Project
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
8D

Title
Proposed Drainage Conditions



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Legend

- PROPOSED DRAINAGE BOUNDARY
- PROPOSED ROAD WIDENING
- EXISTING OUTLET
- PROPOSED STORM SEWER
- FLOW DIRECTION
- EXISTING STORM SEWER

CATCHMENT ID: 101
AREA (ha): 3.71
RUNOFF COEFFICIENT: 0.82

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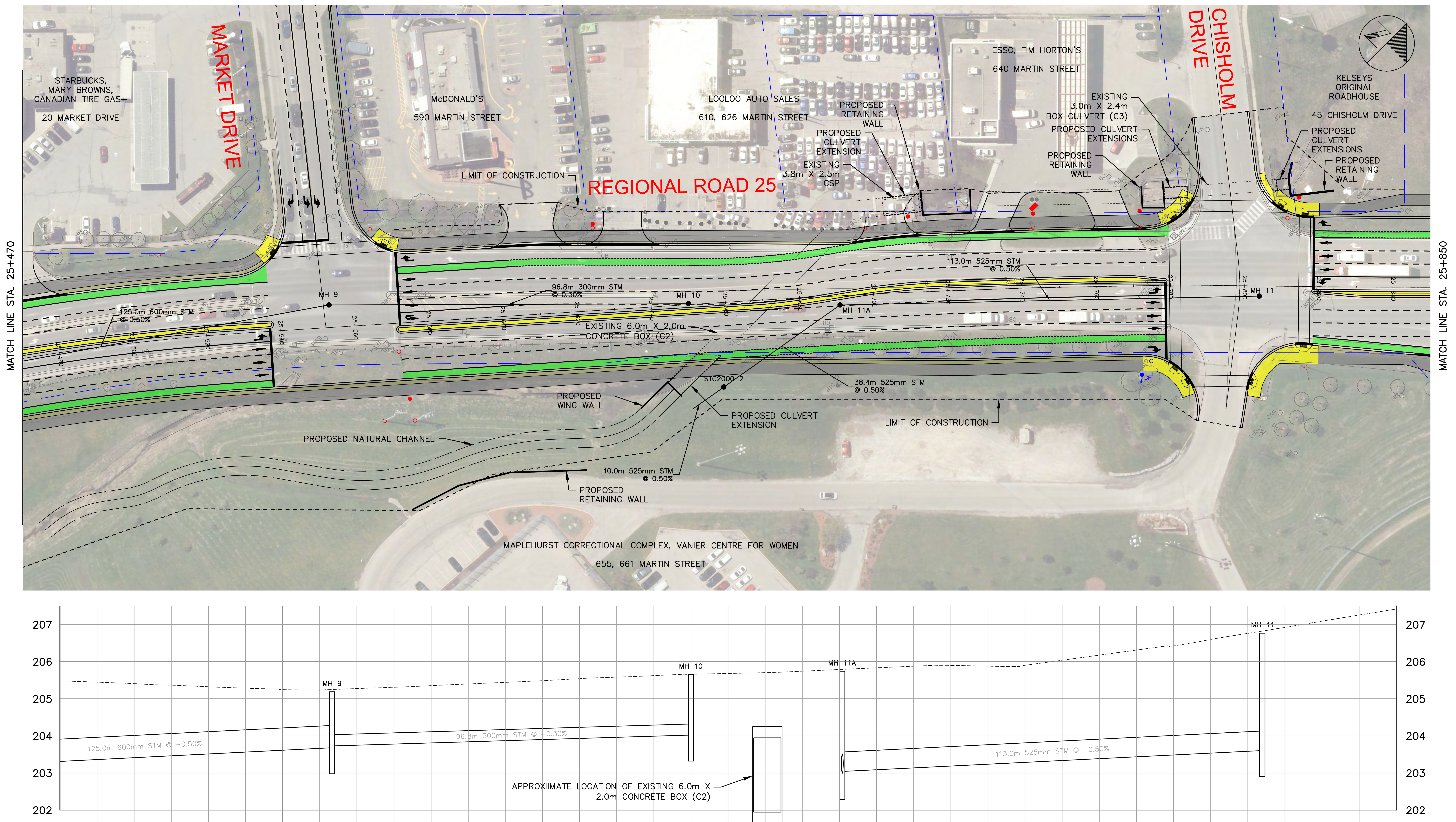
HALTON REGION
REGIONAL ROAD 25
STEELES AVE (REG. RD 8) to 5 SIDEROAD

Figure No.
8E

Title
Proposed Drainage Conditions



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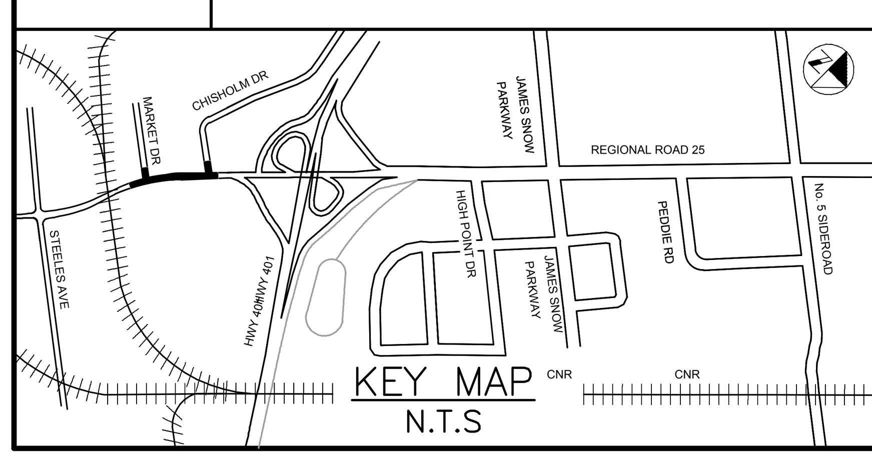
CHAINAGE	25+500	25+520	25+540	25+560	25+580	25+600	25+620	25+640	25+660	25+680	25+700	25+720	25+740	25+760	25+780	25+800	25+820	CHAINAGE



LEGEND

PROPOSED BIKE LANE
PROPOSED MULTI–USE PATHWAY
EXISTING PROPERTY LINE
EXISTING HYDRO POLE
PROPOSED HYDRO POLE
EXISTING GUY POLE
PROPOSED GUY POLE

DESIGN	DM	CH'KD	GM	DATE August 19
DRAWN	DM	CH'KD	GM	
SCALE 1:500 HORIZ. 0 5 10 20 / 1:50 VERT. 0 0.5 1 2				REFERENCES

NO.	DATE	BY	REVISIONS	MANU	CAD

Stantec Consulting Ltd.
100–300 Hagey Boulevard
Waterloo ON Canada
N2L 0A4
Tel. 519.579.4410
Fax. 519.579.6733
www.stantec.com

Halton REGION

REGIONAL ROAD 25
STEELES AVE (REG. RD 8) TO 5 SIDEROAD
MARKET DRIVE TO CHISHOLM DRIVE

PRELIMINARY PREFERRED DESIGN
STA: 25+470 TO STA: 25+850

CONSULTANT FILE NO.	REGIONAL DRAWING NO.
CONTRACT NO.	FIGURE NO. 9

Drawing: V:\01650\ACTIVE\165010586\10_DRAWINGS\10.4_SHEET_FILES\05_NEWC\165010586_MARKET DR TO CHISHOLM DESIGN ALTS.DWG
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Date: 08/16/2019 Time: 11:26:09 AM

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Fax. 519.579.6733
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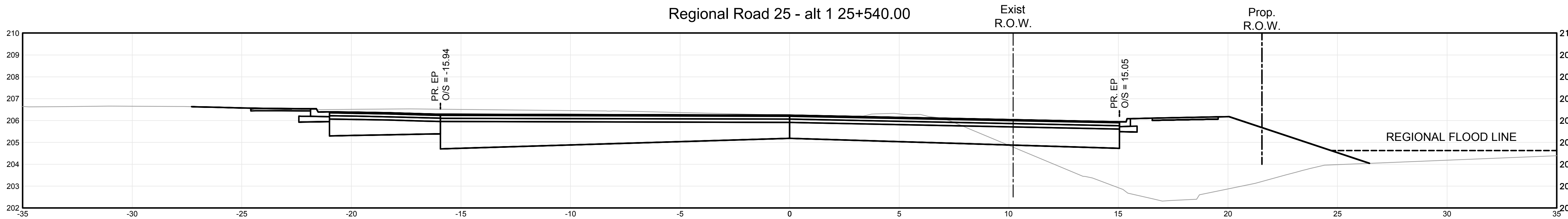
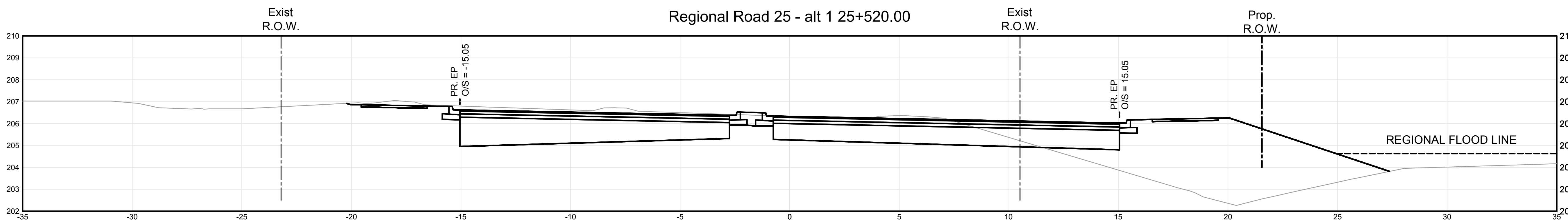
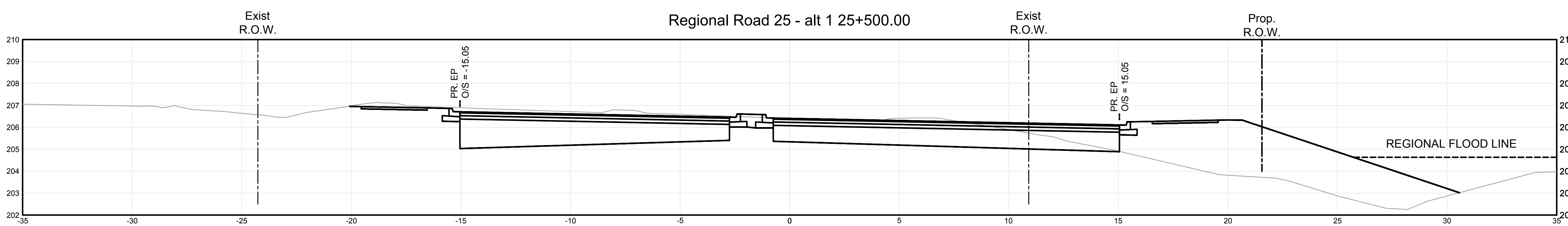
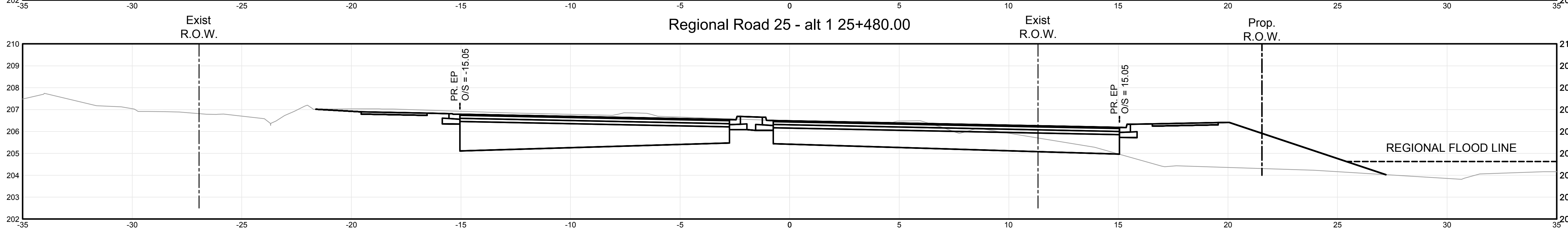
REGIONAL ROAD 25 - PRELIMINARY PREFERRED DESIGN
FIGURE 10A: ROAD CROSS SECTIONS

Project: 165010586
Date: August 16, 2019
Scale: Horiz.: 1:200
Scale: Vert: 1:200
Sheet No: CS–1





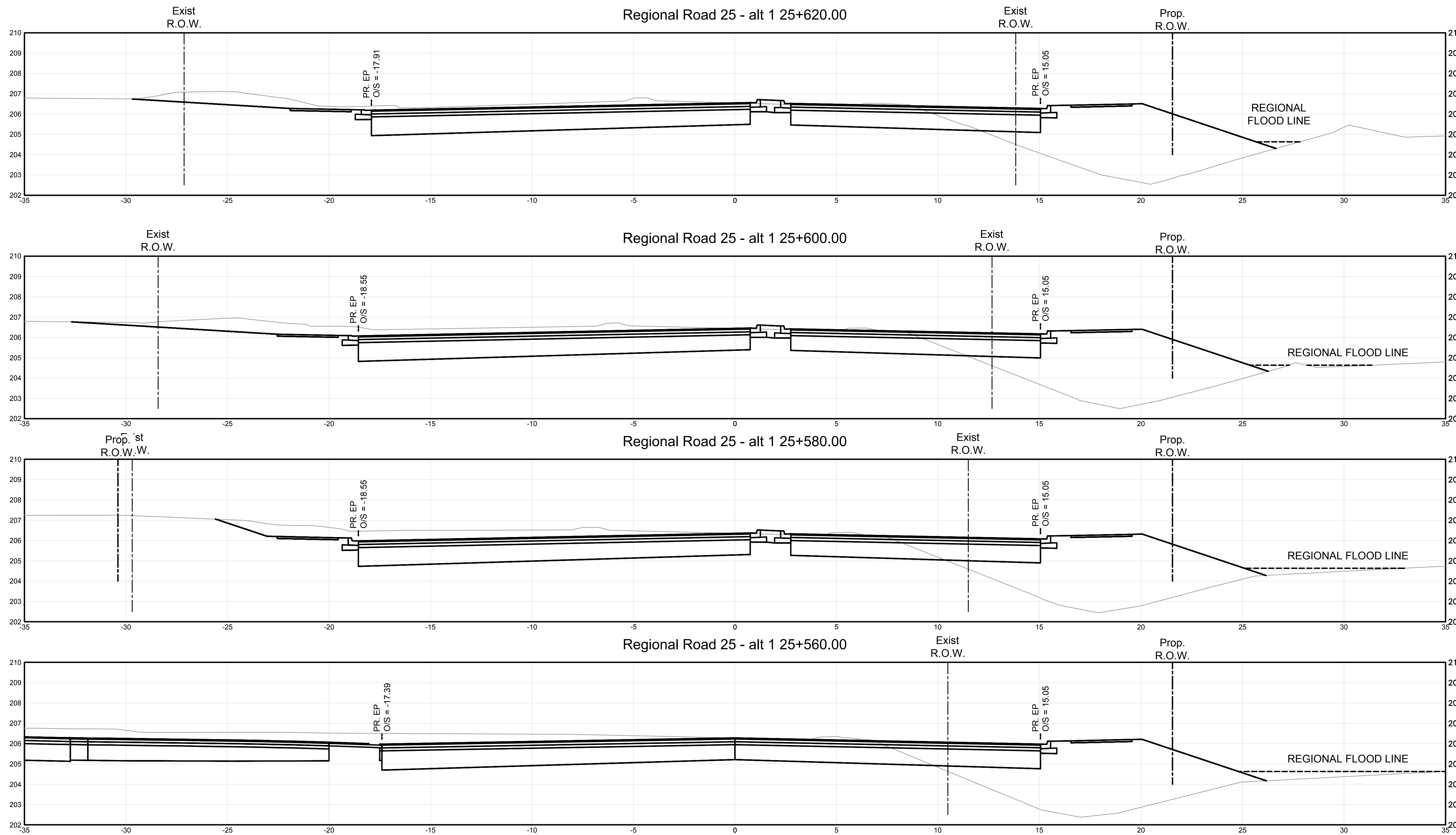




Stantec
Stantec Consulting Ltd.
100–300 Hagey Boulevard
Waterloo ON Canada
N2L 0A4
Tel. 519.579.4410
Fax. 519.579.6733
www.stantec.com

REGIONAL ROAD 25 - PRELIMINARY PREFERRED DESIGN
FIGURE 10B: ROAD CROSS SECTIONS

Project: 165010586
Date: August 16, 2019
Scale: Horiz.: 1:200
Scale: Vert: 1:200
Sheet No: CS–2



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Fax. 519.579.6733
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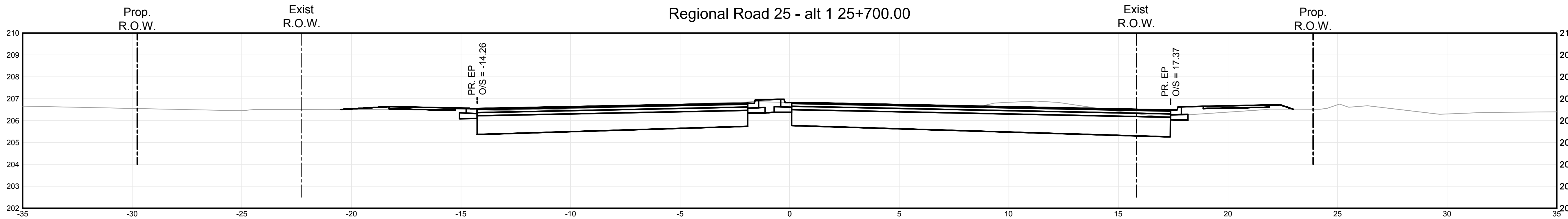
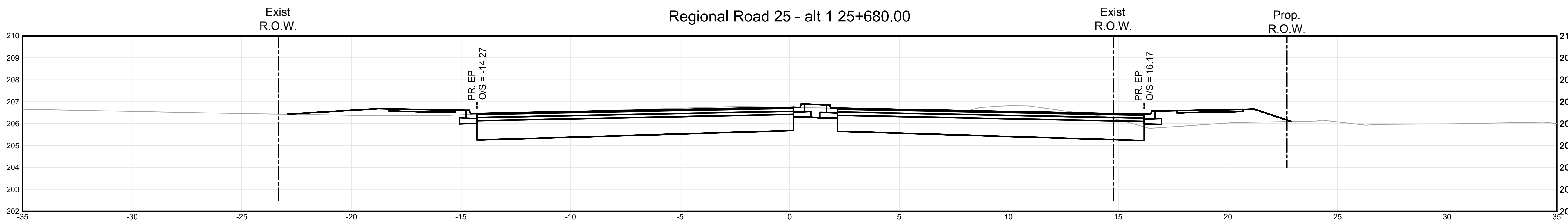
REGIONAL ROAD 25 - PRELIMINARY PREFERRED DESIGN
FIGURE 10C: ROAD CROSS SECTIONS

Project: 165010586
Date: August 16, 2019
Scale: Horiz.: 1:200
Scale: Vert: 1:200
Sheet No: CS–3

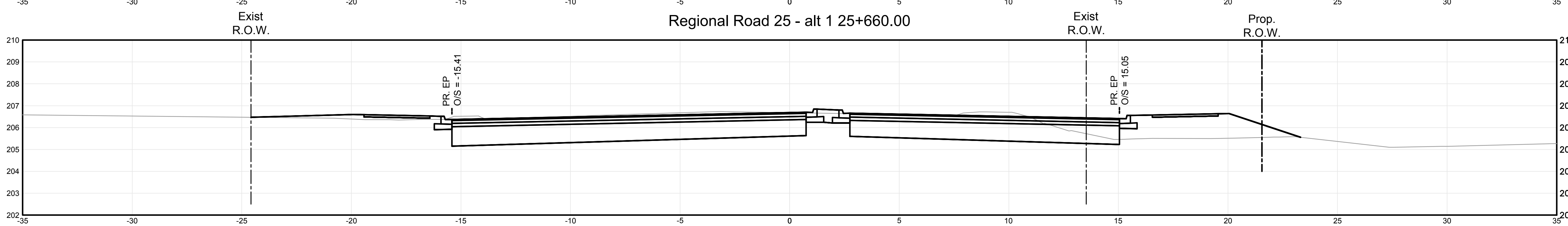
Regional Road 25 - alt 1 25+700.00



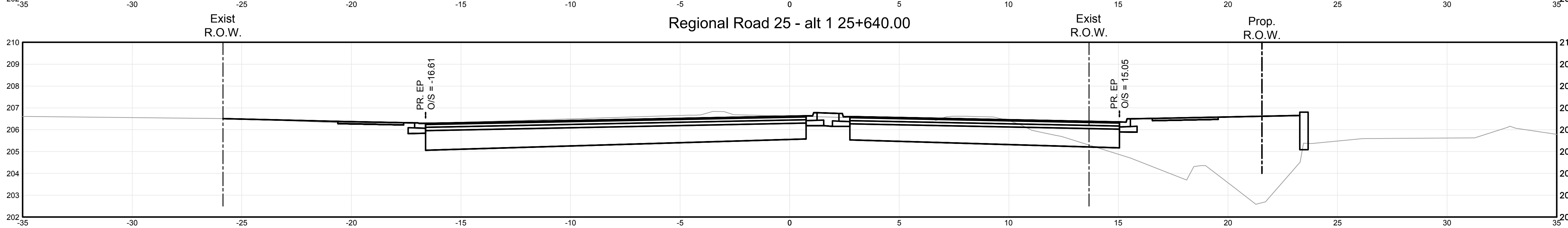
Regional Road 25 - alt 1 25+680.00



Regional Road 25 - alt 1 25+660.00



Regional Road 25 - alt 1 25+640.00



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Fax. 519.579.6733
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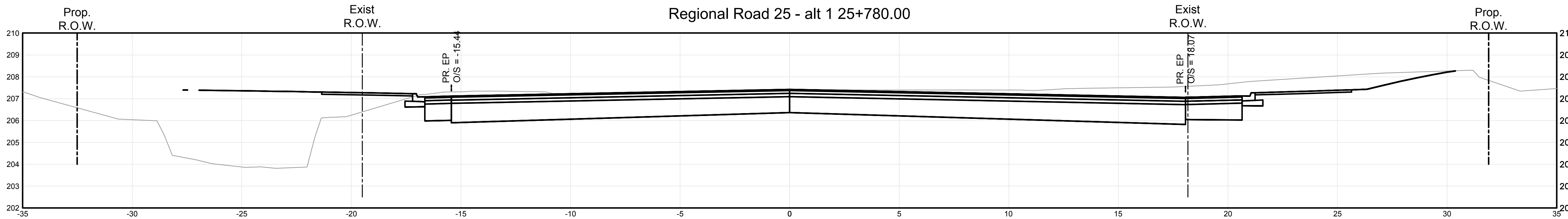
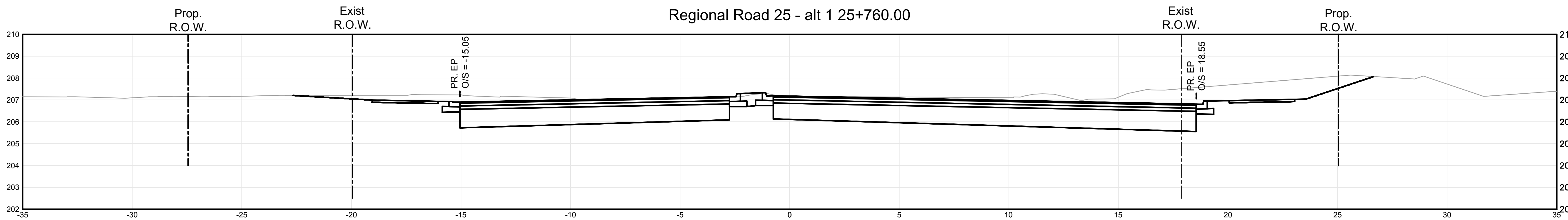
REGIONAL ROAD 25 - PRELIMINARY PREFERRED DESIGN
FIGURE 10D: ROAD CROSS SECTIONS

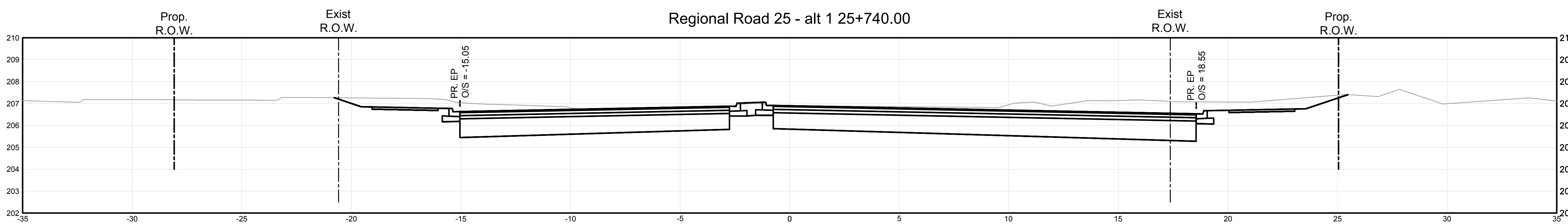
Project: 165010586
Date: August 16, 2019
Scale: Horiz.: 1:200
Scale: Vert: 1:200
Sheet No: CS–4



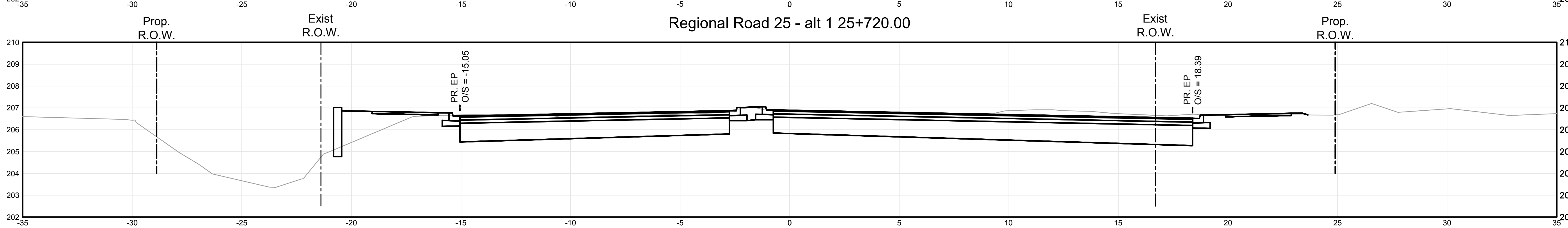
Regional Road 25 - alt 1 25+780.00



Regional Road 25 - alt 1 25+760.00



Regional Road 25 - alt 1 25+740.00



Regional Road 25 - alt 1 25+720.00

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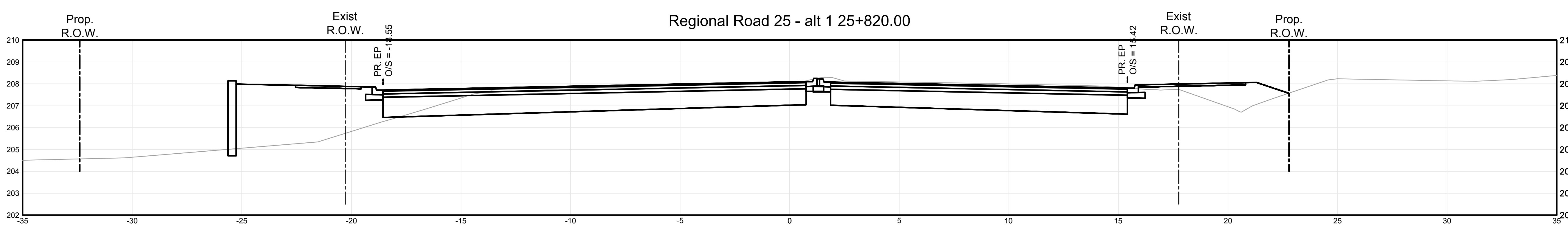
REGIONAL ROAD 25 - PRELIMINARY PREFERRED DESIGN
FIGURE 10E: ROAD CROSS SECTIONS

Project: 165010586
Date: August 16, 2019
Scale: Horiz.: 1:200
Scale: Vert: 1:200
Sheet No: CS–5



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2019/08/16 11:29 AM By: Moura, David

APPENDICES

Appendices A to D

Appendix A BACKGROUND INFORMATION

Background Information

HEC-RAS Model Nodes and Flows

Regional Road 25
HEC-RAS Modelling and Reports

1. Summary of the submitted models

HEC-RAS Model	Version	Culverts	Tributary
FOAK11	5.3	Culverts C2, C3 and CN BR02	N1-A
RR25 Channel	5.3	Culvert C4	N2-B
Culvert C1	5.3	Culvert C1	N1-A

2. Model 1: HEC-RAS Model FOAK11 (Culverts C2, C3 and CN BR02)

Original HEC2 model received from CH

The model includes culverts C2 and C3 (RRD25) in addition to CN culvert BR2

The model was converted to HEC-RAS version 5.3 which includes the following two plans:

2.1 Plans and Geometry

Plan Title	Plan No.	Description	Geometry File	Flow File
Existing Conditions Plan	P01	Converted HEC2 model received from CH	Imported Geom 01	From FSEMS
Proposed Conditions Plan	P02	Updated by adding two 1.8m pipe releif culverts at each side of the CNR culvert to mitigate RRD25 flooding	Propoced CNR	From FSEMS

2.2 Model Crossings

Crossing	Model Station	Culvert Description	River	Reach
C2	65.5	Bridge #12 Road 25 St103 (Culvert C2)	River-2	Reach-1
C3	71.5	Bridge #14 CHISHOLM STREET St104 (Culvert C3)	River-2	Reach-1
BR02	60.5	Bridge #11 CNR STRUCTURE 102 (CNR Culvert BR02)	River-2	Reach-1

3. Model 2: HEC-RAS RR25 Channel (Culvert C4)

3.1 Plans and Geometry

Plan	Plan No.	Description	Geometry File	Flow File
Existing Conditions Plan	p01	Same as original model received from CH	Existing Conditions	Ex Channel
Proposed Conditions - No Meandering	p05	Proposed conditions for flows > 2-year Does not include meandering channel length	Proposed Conditions - No Meandering	PROP Channel
Proposed Conditions - No Meandering	p06	Proposed conditions for storm flows <= 2-year. Includes meandering channel lengths.	Proposed Conditions - With Meandering	PROP Channel

3.2 Crossings

Crossing	Station	Culvert Description	River	Reach
C2	472	RR25	16 Mile Creek	Tributary N2B

4. Model 2: HEC-RAS Culvert C1 (Culvert C1)

4.1 Plans and Geometry

Plan	Plan No.	Description	Geometry File	Flow File
Proposed Conditions	p01	New model	Cul C1	Proposed flows

4.2 Crossings

Crossing	Station	Culvert Description	River	Reach
C1	4.5	Culvert C1 North of Steels Av.	16 Mile Creek	Tributary N1A

Regional Road 25 Flood Impact Analysis

Model Flows

1. Flows from the Highway 401 Industrial Park, Secondary Plan Area , Town of Milton were used

Below is a summary of Table 4.5 from the above study showing the flows related to the HEC-RAS model

Table 4.5 of Secondary Plan

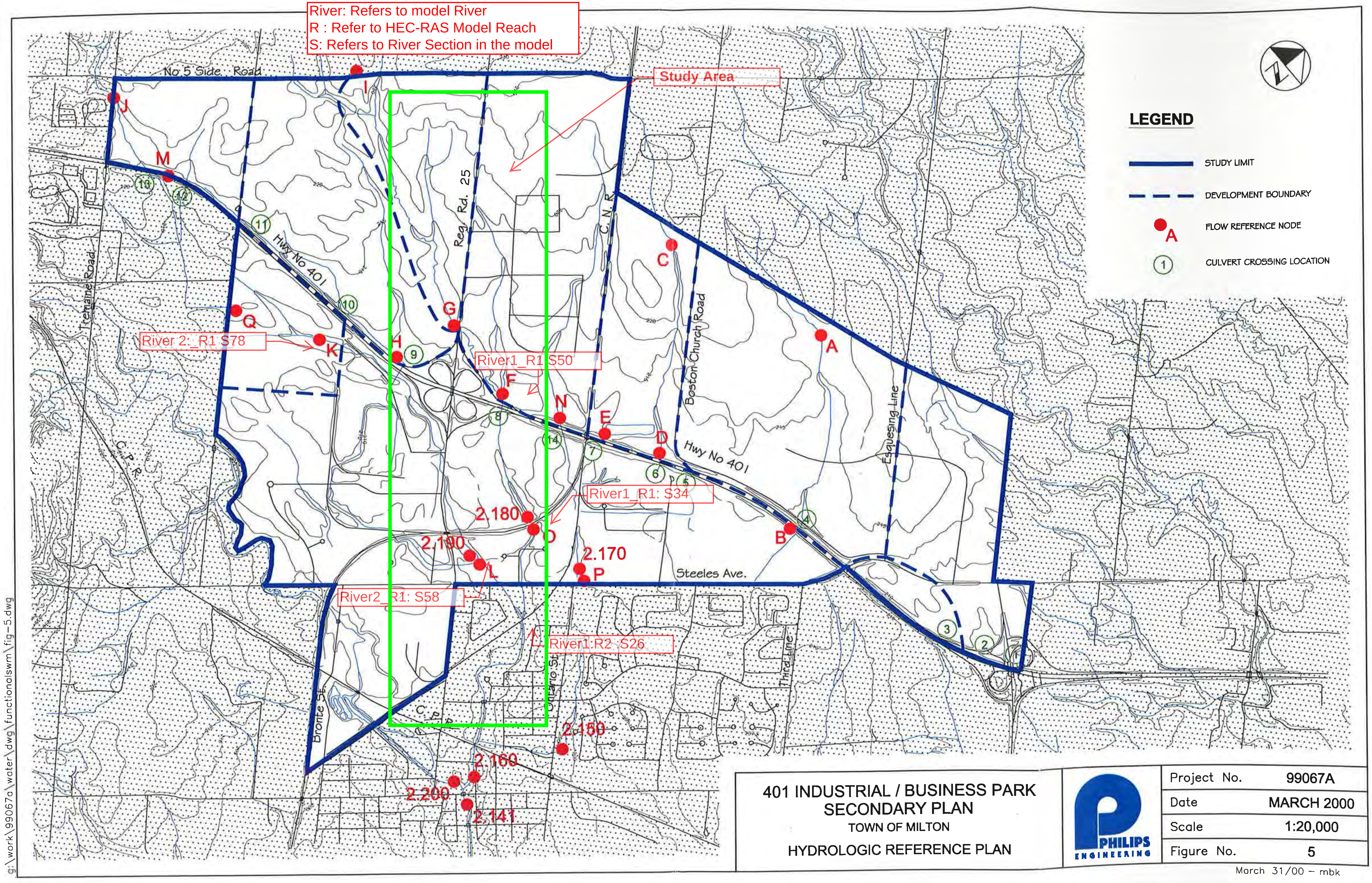
Proposed Land Use with SWM (Development Notrh of Highway 401)

Location/Node					Drainage Area (ha)
Map	**Model**	**Sec No.**	**River**	**Reach**	
K full	1.93	78	RIVER-2	Reach-1	362.9
L full	0.44	58	RIVER-2	Reach-1	621.7
F full	2.68	50	RIVER-1	Reach-1	658
O full	1.73	34	RIVER-1	Reach-1	717.3

Node		Frequency Flows (m^3/s)						
Map	**Sec No.**	**2**	**5**	**10**	**25**	**50**	**100**	**Reg**
K full	78	1.22	2.24	2.91	3.52	4.24	4.74	30.32
L full	58	4.28	6.06	7.23	8.36	9.81	10.9	62.34
F full	50	3.02	4.31	5.2	6.09	7.27	8.19	43.11
O full	34	4	5.39	6.34	7.26	8.48	9.42	49.65

2. The table below shows flows imported from HEC-2 Model FOAK11

Location/Node				Frequency Flows (m^3/s)					
Model	**Sec No.**	**River**	**Reach**	**2**	**10**	**25**	**50**	**100**	**Reg**
1.91	38	RIVER-1	Reach-1	9.3	11.2	13.9	16.3	18.1	52.5
1.836	36	RIVER-1	Reach-1	9.3	11.2	13.9	16.3	18.1	52.5
1.64	31	RIVER-1	Reach-1	16.1	18.7	22.4	25.7	28.3	77.5
1.32	26	RIVER-1	Reach-2	16.7	19.4	23.3	27.1	30.1	78.1
0.51	13	RIVER-1	Reach-2	26.1	30.5	36.9	42.3	46.3	129.5
0.07	2	RIVER-1	Reach-2	28.4	33.1	39.9	45.8	50.1	130.8
11.62	1	RIVER-1	Reach-2	39.0	47.8	60.9	73.1	82.4	436.1
0.58	59	RIVER-2	Reach-1	4.5	5.6	7.1	8.4	9.4	28.7
0.057	52	RIVER-2	Reach-1	10.1	11.8	14.4	16.5	18.1	51.5


River: Refers to model River
R : Refer to HEC-RAS Model Reach
S: Refers to River Section in the model
Study Area
LEGEND
STUDY LIMIT
DEVELOPMENT BOUNDARY
FLOW REFERENCE NODE
CULVERT CROSSING LOCATION
No 5 Side Road
Hwy No 401
Reg. Rd. 25
C.N.R.
Boston Church Road
Esquesing Line
Tremaine Road
C.P.R.
Steeles Ave.
Bronte St.
Ontario St.
Third Line
River 2:_R1 S78
River1_R1 S50
River1_R1: S34
River2_R1: S58
River1:R2 :S26
2.180
2.190
2.170
2.150
2.160
2.200
2.141
401 INDUSTRIAL / BUSINESS PARK
SECONDARY PLAN
TOWN OF MILTON
HYDROLOGIC REFERENCE PLAN
PHILIPS ENGINEERING
Project No. 99067A
Date MARCH 2000
Scale 1:20,000
Figure No. 5
March 31/00 - mbk
g:\work\99067a\water\dwg\functionalswm\fig-5.dwg

Proposed Stormwater Management Flood Impact Mitigation Performance

The performance of the proposed stormwater management facilities has been undertaken based on continuous hydrologic simulation and frequency analysis. Table 4.5 provides a summary of the peak flow rates under proposed development conditions including stormwater management.

TABLE 4.5
PROPOSED LAND USE WITH SWM (DEVELOPMENT NORTH OF HIGHWAY 401)
FREQUENCY FLOWS (m^3/s)

Location/Node	Drainage Area (ha)	Frequency (years)							
		1.25	2	5	10	20	50	100	Regional
A	52.8	0.052	0.130	0.270	0.390	0.510	0.680	0.810	4.48
B(local)	105.7	1.45	2.01	2.89	3.55	4.25	5.24	6.06	13.06
B (full)	173.6	0.900	1.12	1.41	1.59	1.75	1.96	2.12	19.30
C	71.6	0.120	0.250	0.480	0.660	0.850	1.11	1.31	5.90
D (local)	43.8	0.800	1.11	1.53	1.81	2.09	2.45	2.72	5.43
D (full)	115.4	0.280	0.510	0.890	1.15	1.40	1.73	1.97	10.73
E	29.4	0.097	0.160	0.270	0.350	0.420	0.520	0.600	3.69
F(local)	99.0	1.30	1.82	2.57	3.10	3.62	4.33	4.89	10.92
F(full)	658.0	2.12	3.02	4.31	5.20	6.09	7.27	8.19	43.11
G (local)	85.2	0.460	0.910	1.64	2.15	2.64	3.25	3.69	9.67
G(full)[1]	482.2	0.900	1.87	3.30	4.15	4.88	5.72	6.30	26.57
H(full)	98.6	0.320	0.530	0.850	1.08	1.32	1.63	1.87	17.80
I	397.0	0.590	1.22	2.37	3.25	4.15	5.39	6.35	28.99
J	158.2	0.250	0.530	1.02	1.39	1.78	2.30	2.71	12.35
K(full)[1]	362.9	0.620	1.22	2.24	2.91	3.52	4.24	4.74	30.32
L(local)	160.2	2.18	3.05	4.30	5.16	6.01	7.15	8.04	17.98
L(full)	621.7	2.99	4.28	6.06	7.23	8.36	9.81	10.9	62.34
M(local)[1]	62.5	0.170	0.310	0.520	0.660	0.800	0.970	1.10	7.20
M(full)	220.7	0.390	0.810	1.50	1.99	2.48	3.11	3.58	17.86
N	76.8	0.850	1.18	1.65	1.98	2.30	2.73	3.07	8.25
O(local)	59.3	1.15	1.61	2.25	2.69	3.12	3.69	4.13	7.81
O(full)	717.3	2.99	4.00	5.39	6.34	7.26	8.48	9.42	49.65
P(local)	93.9	1.01	1.40	2.02	2.47	2.94	3.62	4.17	9.05
P(full)	412.3	2.03	2.72	3.72	4.44	5.16	6.14	6.92	42.30
Q(local)	99.6	0.200	0.380	0.690	0.920	1.16	1.50	1.76	8.23

[1] - analysis results based on Wakeby Distribution
Local - flow from local catchment only (ref. Figure A-1)
Full - total flow from all upstream catchment areas including potential spill from catchment 2040 to 2024 (ref. Figure A-1)

Table 4.6 provides a summary of the differences in "pre" and "post" development flow rates. The hydrologic modeling for proposed development conditions .

Appendix B PROPOSED QUALITY CONTROL

OGS Sizing Report

South of Highway 401

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	10/24/2017
Project Name	Regional Road 25
Project Number	160610586
Location	Town of Milton

Designer Information

Company	Stantec
Contact	Mustafa

Notes

outlet 1 north of Steeles

Drainage Area

Total Area (ha)	0.56
Imperviousness (%)	90

The Stormceptor System model STC 2000 achieves the water quality objective removing 83% TSS for a City of Toronto (clay, silt and sand) particle size distribution and 96% runoff volume.

Rainfall

Name	TORONTO CENTRAL
State	ON
ID	100
Years of Records	1982 to 1999
Latitude	45°30'N
Longitude	90°30'W

Water Quality Objective

TSS Removal (%)	80
Runoff Volume (%)	90

Upstream Storage

Storage (ha-m)	Discharge (L/s)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %	Runoff Volume %
STC 300	69	83
STC 750	77	93
STC 1000	78	93
STC 1500	79	93
STC 2000	**83**	**96**
STC 3000	84	96
STC 4000	87	98
STC 5000	88	98
STC 6000	90	99
STC 9000	92	100
STC 10000	92	100
STC 14000	94	100

Stormceptor®

Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

City of Toronto (clay, silt and sand)

Particle Size μm	Distribution %	Specific Gravity	Settling Velocity m/s		Particle Size μm	Distribution %	Specific Gravity	Settling Velocity m/s
10	20	2.65	0.0004					
30	10	2.65	0.0008					
50	10	2.65	0.0022					
95	20	2.65	0.0063					
265	20	2.65	0.0366					
1000	20	2.65	0.1691					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor version 1.0
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 300 is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 750 to STC 6000 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 300	STC 750 to STC 6000	STC 9000 to STC 14000
Single inlet pipe	75 mm	25 mm	75 mm
Multiple inlet pipes	75 mm	75 mm	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Imbrium Systems Inc., 1-800-565-4801.

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	10/24/2017
Project Name	Regional Road 25
Project Number	160610586
Location	Town of Milton

Designer Information

Company	Stantec
Contact	Mustafa

Notes

outlet 1A north of Steeles

Drainage Area

Total Area (ha)	2.94
Imperviousness (%)	90

The Stormceptor System model STC 9000 achieves the water quality objective removing 80% TSS for a City of Toronto (clay, silt and sand) particle size distribution and 94% runoff volume.

Rainfall

Name	TORONTO CENTRAL
State	ON
ID	100
Years of Records	1982 to 1999
Latitude	45°30'N
Longitude	90°30'W

Water Quality Objective

TSS Removal (%)	80
Runoff Volume (%)	90

Upstream Storage

Storage (ha-m)	Discharge (L/s)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %	Runoff Volume %
STC 300	46	44
STC 750	57	67
STC 1000	58	67
STC 1500	58	67
STC 2000	65	79
STC 3000	66	79
STC 4000	71	87
STC 5000	72	87
STC 6000	75	91
STC 9000	**80**	**94**
STC 10000	79	94
STC 14000	83	96

Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

City of Toronto (clay, silt and sand)

Particle Size μm	Distribution %	Specific Gravity	Settling Velocity m/s		Particle Size μm	Distribution %	Specific Gravity	Settling Velocity m/s
10	20	2.65	0.0004					
30	10	2.65	0.0008					
50	10	2.65	0.0022					
95	20	2.65	0.0063					
265	20	2.65	0.0366					
1000	20	2.65	0.1691					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor version 1.0
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 300 is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 750 to STC 6000 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 300	STC 750 to STC 6000	STC 9000 to STC 14000
Single inlet pipe	75 mm	25 mm	75 mm
Multiple inlet pipes	75 mm	75 mm	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Imbrium Systems Inc., 1-800-565-4801.

Existing OGS Sizing Report

North of Highway 401

Brief Stormceptor Sizing Report - Regional Road 25

Project Information & Location			
Project Name	Regional Road 25	**Project Number**	165010586
City	Milton	**State/ Province**	Ontario
Country	Canada	**Date**	6/14/2019
Designer Information		**EOR Information (optional)**	
Name	Mustafa Mukhtar	**Name**	
Company	Stantec	**Company**	
Phone #	905-415-6421	**Phone #**	
Email	mustafa.mukhtar@stantec.com	**Email**	

Stormwater Treatment Recommendation
The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	Regional Road 25
Target TSS Removal (%)	65
TSS Removal (%) Provided	69
Recommended Stormceptor Model	STC 9000

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
Stormceptor Model	**% TSS Removal Provided**
STC 300	24
STC 750	45
STC 1000	47
STC 1500	47
STC 2000	52
STC 3000	53
STC 4000	59
STC 5000	59
STC 6000	63
STC 9000	69
STC 10000	68
STC 14000	73
StormceptorMAX	Custom

Stormceptor® FORTERRA

Sizing Details

Drainage Area

Total Area (ha)	11.0
Imperviousness %	67.6

Rainfall

Station Name	TORONTO PEARSON AP
State/Province	Ontario
Station ID #	8733
Years of Records	44
Latitude	43°41'N
Longitude	79°38'W

Water Quality Objective

TSS Removal (%)	65.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (L)	
Peak Conveyed Flow Rate (L/s)	
Water Quality Flow Rate (L/s)	

Up Stream Storage

Storage (ha-m)	Discharge (cms)
0.000	0.000

Up Stream Flow Diversion

Max. Flow to Stormceptor (cms)	

Particle Size Distribution (PSD)
The selected PSD defines TSS removal

City of Toronto PSD

Particle Diameter (microns)	Distribution %	Specific Gravity
10.0	20.0	2.65
30.0	10.0	2.65
50.0	10.0	2.65
95.0	20.0	2.65
265.0	20.0	2.65
1000.0	20.0	2.65

Notes

• Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
• Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
• For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
http://www.imbriumsystems.com/technical-specifications

Existing OGS North of Highway 401
Original Design

Stormceptor Sizing Detailed Report

PCSWMM for Stormceptor

Project Information

Date	May 2010
Project Name	Regional Road 25
Project Number	160210504
Location	Milton

Stormwater Quality Objective

This report outlines how Stormceptor System can achieve a defined water quality objective through the removal of total suspended solids (TSS). Attached to this report is the Stormceptor Sizing Summary.

Stormceptor System Recommendation

The Stormceptor System model STC 9000 achieves the water quality objective removing 74% TSS for a Fine (organics, silts and sand) particle size distribution.

The Stormceptor System

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for all rainfall events, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.

Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Stormceptor is the only oil and sediment separator on the market sized to remove TSS for a wide range of particle sizes, including fine sediments (clays and silts), that are often overlooked in the design of other stormwater treatment devices.

Small storms dominate hydrologic activity, US EPA reports

"*Early efforts in stormwater management focused on flood events ranging from the 2-yr to the 100-yr storm. Increasingly stormwater professionals have come to realize that small storms (i.e. < 1 in. rainfall) dominate watershed hydrologic parameters typically associated with water quality management issues and BMP design. These small storms are responsible for most annual urban runoff and groundwater recharge. Likewise, with the exception of eroded sediment, they are responsible for most pollutant washoff from urban surfaces. Therefore, the small storms are of most concern for the stormwater management objectives of ground water recharge, water quality resource protection and thermal impacts control.*"

"*Most rainfall events are much smaller than design storms used for urban drainage models. In any given area, most frequently recurrent rainfall events are small (less than 1 in. of daily rainfall).*"

"Continuous simulation offers possibilities for designing and managing BMPs on an individual site-by-site basis that are not provided by other widely used simpler analysis methods. Therefore its application and use should be encouraged."

– US EPA Stormwater Best Management Practice Design Guide, Volume 1 – General Considerations, 2004

Design Methodology

Each Stormceptor system is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology from up-to-date local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective.

The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing (summary of analysis presented in Appendix 2):

- Site parameters
- Continuous historical rainfall, including duration, distribution, peaks (Figure 1)
- Interevent periods
- Particle size distribution
- Particle settling velocities (Stokes Law, corrected for drag)
- TSS load (Figure 2)
- Detention time of the system

The Stormceptor System maintains continuous positive TSS removal for all influent flow rates. Figure 3 illustrates the continuous treatment by Stormceptor throughout the full range of storm events analyzed. It is clear that large events do not significantly impact the average annual TSS removal. There is no decline in cumulative TSS removal, indicating scour does not occur as the flow rate increases.

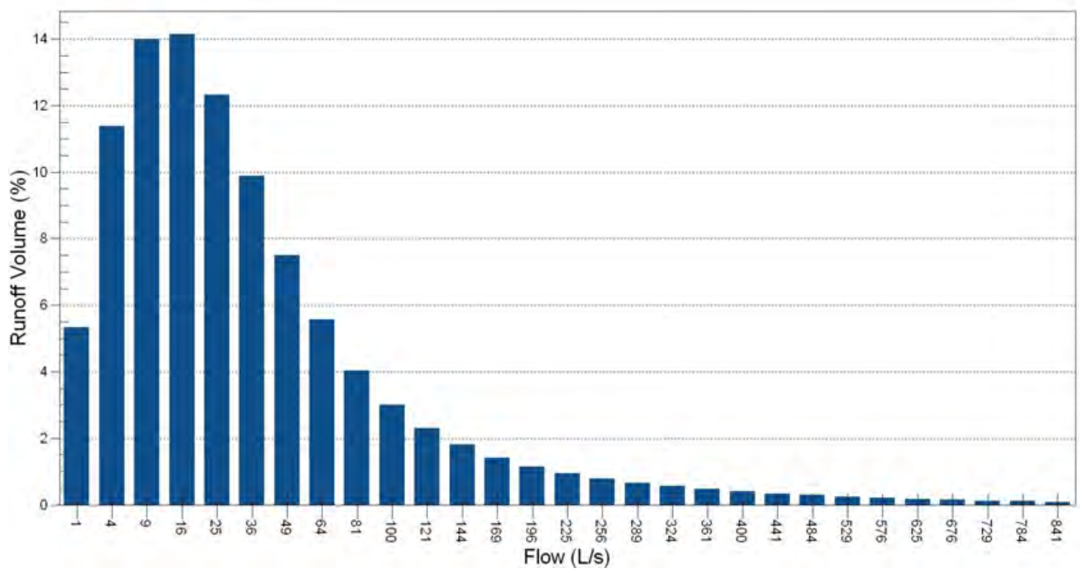


Figure 1. Runoff Volume by Flow Rate for TORONTO CENTRAL – ON 100, 1982 to 1999 for 10.83 ha, 48% impervious. Small frequent storm events represent the majority of annual rainfall volume. Large infrequent events have little impact on the average annual TSS removal, as they represent a small percentage of the total annual volume of runoff.

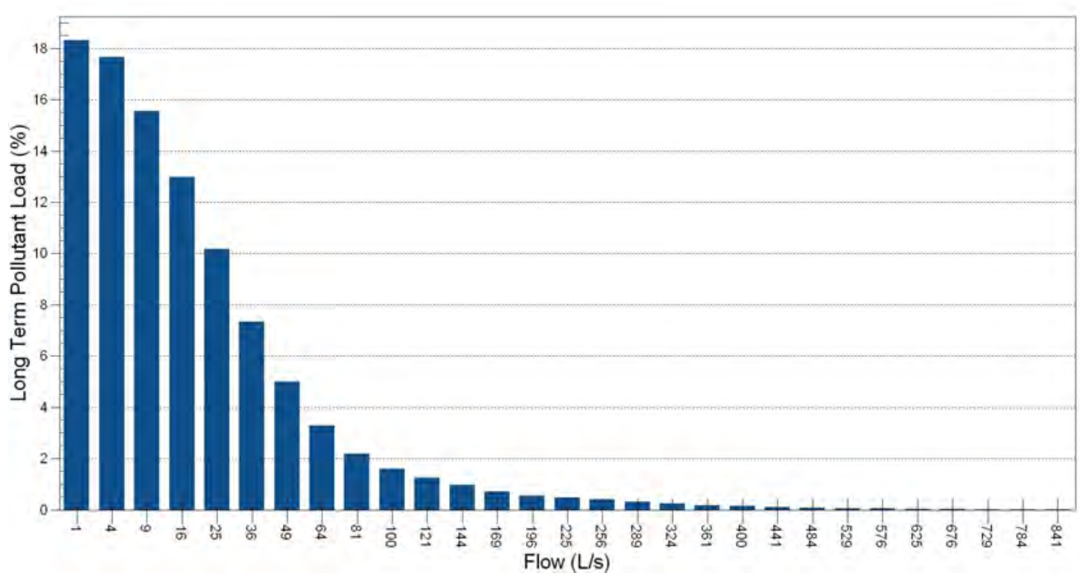
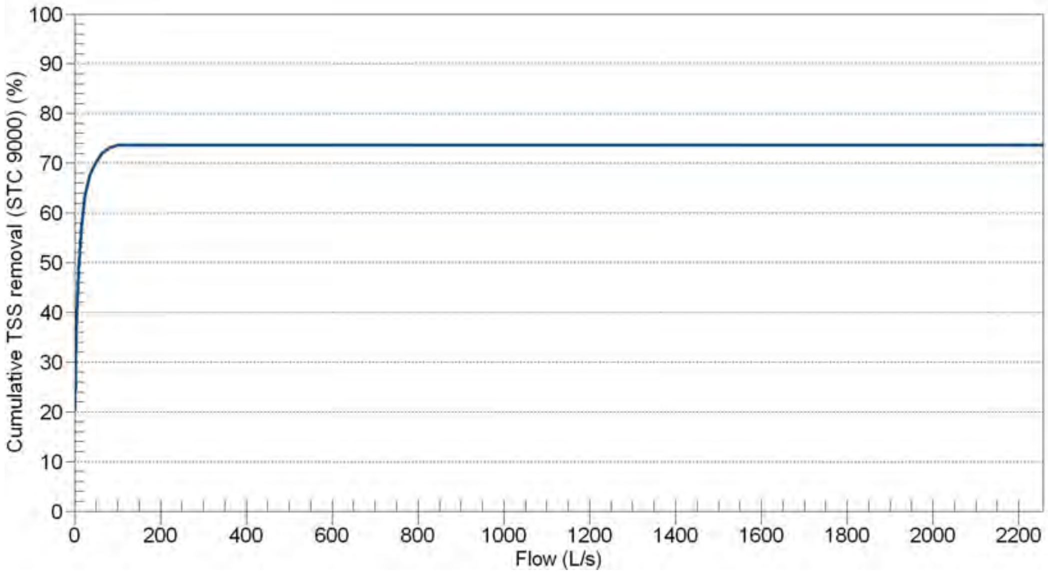


Figure 2. Long Term Pollutant Load by Flow Rate for TORONTO CENTRAL – 100, 1982 to 1999 for 10.83 ha, 48% impervious. The majority of the annual pollutant load is transported by small frequent storm events. Conversely, large infrequent events carry an insignificant percentage of the total annual pollutant load.



Stormceptor Model	STC 9000	Drainage Area (ha)	10.83
TSS Removal (%)	74	Impervious (%)	48

Figure 3. Cumulative TSS Removal by Flow Rate for TORONTO CENTRAL – 100, 1982 to 1999. Stormceptor continuously removes TSS throughout the full range of storm events analyzed. Note that large events do not significantly impact the average annual TSS removal. Therefore no decline in cumulative TSS removal indicates scour does not occur as the flow rate increases.

Stormceptor®

Appendix 1
Stormceptor Design Summary

Project Information

Date	May 2010
Project Name	Regional Road 25
Project Number	160210504
Location	Milton

Designer Information

Company	Stantec Consulting
Contact	Tim Gallagher

Notes

N/A

Drainage Area

Total Area (ha)	10.83
Imperviousness (%)	48

The Stormceptor System model STC 9000 achieves the water quality objective removing 74% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	TORONTO CENTRAL
State	ON
ID	100
Years of Records	1982 to 1999
Latitude	45°30'N
Longitude	90°30'W

Water Quality Objective

TSS Removal (%)	70

Upstream Storage

Storage (ha-m)	Discharge (L/s)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 300	34
STC 750	47
STC 1000	48
STC 1500	48
STC 2000	56
STC 3000	57
STC 4000	64
STC 5000	64
STC 6000	69
STC 9000	**74**
STC 10000	73
STC 14000	78

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Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

Fine (organics, silts and sand)								
Particle Size µm	Distribution %	Specific Gravity	Settling Velocity m/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity m/s
20	20	1.3	0.0004					
60	20	1.8	0.0016					
150	20	2.2	0.0108					
400	20	2.65	0.0647					
2000	20	2.65	0.2870					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor version 1.0
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 300 is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 750 to STC 6000 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 300	STC 750 to STC 6000	STC 9000 to STC 14000
Single inlet pipe	75 mm	25 mm	75 mm
Multiple inlet pipes	75 mm	75 mm	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Imbrium Systems Inc., 1-800-565-4801.

Appendix 2
Summary of Design Assumptions

SITE DETAILS

Site Drainage Area

Total Area (ha)	10.83	Imperviousness (%)	48

Surface Characteristics

Width (m)	658
Slope (%)	2
Impervious Depression Storage (mm)	0.508
Pervious Depression Storage (mm)	5.08
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Infiltration Parameters

Horton's equation is used to estimate infiltration

Max. Infiltration Rate (mm/h)	61.98
Min. Infiltration Rate (mm/h)	10.16
Decay Rate (s^{-1})	0.00055
Regeneration Rate (s^{-1})	0.01

Maintenance Frequency

Sediment build-up reduces the storage volume for sedimentation. Frequency of maintenance is assumed for TSS removal calculations.

Maintenance Frequency (months)	12

Evaporation

Daily Evaporation Rate (mm/day)	2.54

Dry Weather Flow

Dry Weather Flow (L/s)	No

Upstream Attenuation

Stage-storage and stage-discharge relationship used to model attenuation upstream of the Stormceptor System is identified in the table below.

Storage ha-m	Discharge L/s
0	0

PARTICLE SIZE DISTRIBUTION

Particle Size Distribution

Removing fine particles from runoff ensures the majority of pollutants, such as heavy metals, hydrocarbons, free oils and nutrients are not discharged into natural water resources. The table below identifies the particle size distribution selected to define TSS removal for the design of the Stormceptor System.

Fine (organics, silts and sand)								
Particle Size µm	Distribution %	Specific Gravity	Settling Velocity m/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity m/s
20	20	1.3	0.0004					
60	20	1.8	0.0016					
150	20	2.2	0.0108					
400	20	2.65	0.0647					
2000	20	2.65	0.2870					

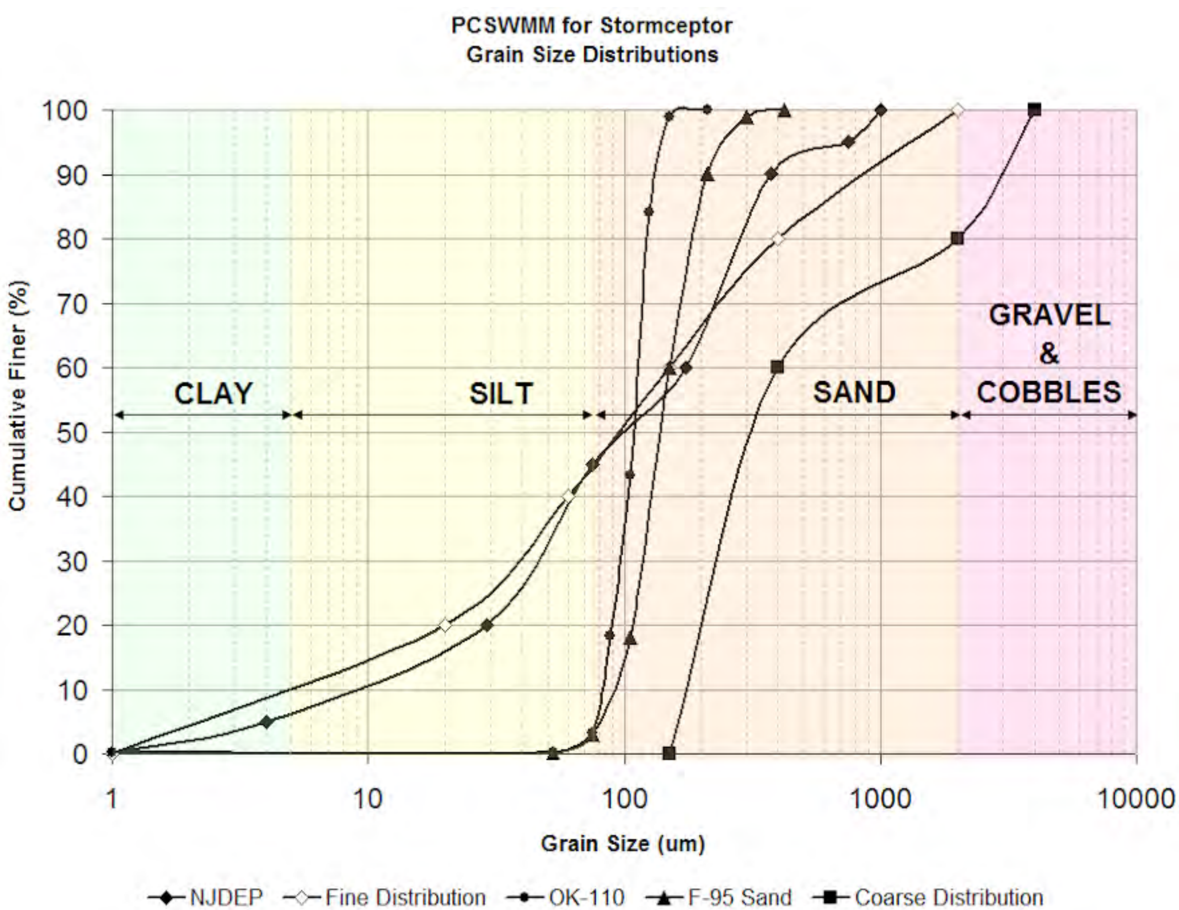

Figure 1. PCSWMM for Stormceptor standard design grain size distributions.

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TSS LOADING

TSS Loading Parameters

TSS Loading Function	Buildup / Washoff

Parameters

Target Event Mean Concentration (EMC) (mg/L)	125
Exponential Buildup Power	0.4
Exponential Washoff Exponential	0.2

HYDROLOGY ANALYSIS

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of the Stormceptor System are based on the average annual removal of TSS for the selected site parameters. The Stormceptor System is engineered to capture fine particles (silts and sands) by focusing on average annual runoff volume ensuring positive removal efficiency is maintained during all rainfall events, while preventing the opportunity for negative removal efficiency (scour).

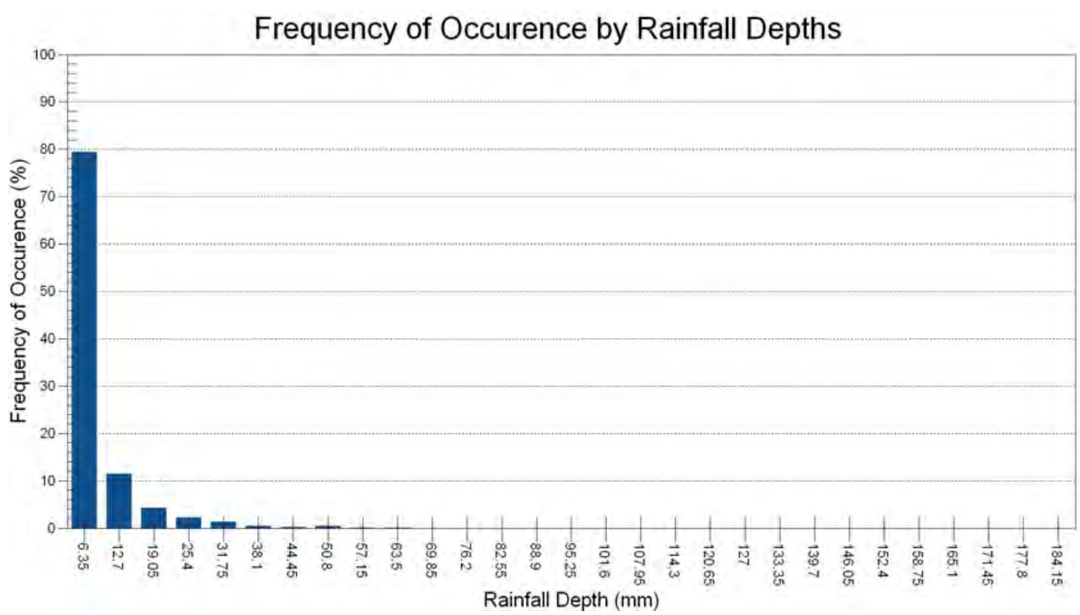
Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

Rainfall Station

Rainfall Station	TORONTO CENTRAL		
Rainfall File Name	ON100.NDC	Total Number of Events	3020
Latitude	45°30'N	Total Rainfall (mm)	13190.7
Longitude	90°30'W	Average Annual Rainfall (mm)	732.8
Elevation (m)		Total Evaporation (mm)	690.2
Rainfall Period of Record (y)	18	Total Infiltration (mm)	6837.5
Total Rainfall Period (y)	18	Percentage of Rainfall that is Runoff (%)	43.1

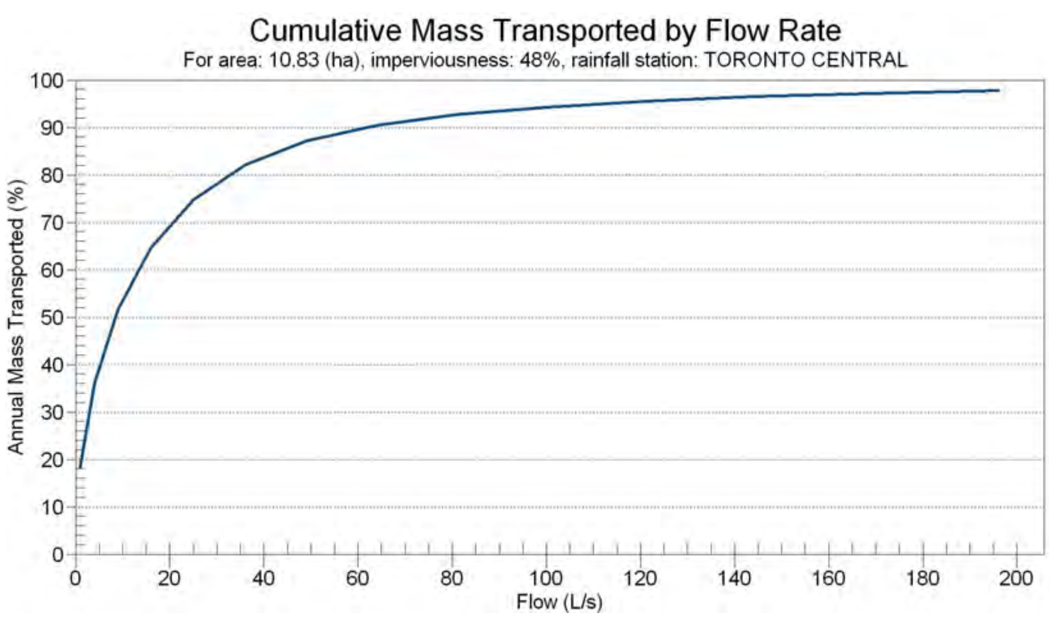
Rainfall Event Analysis

Rainfall Depth mm	No. of Events	Percentage of Total Events %	Total Volume mm	Percentage of Annual Volume %
6.35	2398	79.4	3626	27.5
12.70	346	11.5	3182	24.1
19.05	130	4.3	2037	15.4
25.40	66	2.2	1432	10.9
31.75	38	1.3	1075	8.2
38.10	16	0.5	545	4.1
44.45	7	0.2	292	2.2
50.80	13	0.4	611	4.6
57.15	2	0.1	106	0.8
63.50	2	0.1	121	0.9
69.85	0	0.0	0	0.0
76.20	0	0.0	0	0.0
82.55	1	0.0	79	0.6
88.90	1	0.0	85	0.6
95.25	0	0.0	0	0.0
101.60	0	0.0	0	0.0
107.95	0	0.0	0	0.0
114.30	0	0.0	0	0.0
120.65	0	0.0	0	0.0
127.00	0	0.0	0	0.0
133.35	0	0.0	0	0.0
139.70	0	0.0	0	0.0
146.05	0	0.0	0	0.0
152.40	0	0.0	0	0.0
158.75	0	0.0	0	0.0
165.10	0	0.0	0	0.0
171.45	0	0.0	0	0.0
177.80	0	0.0	0	0.0
184.15	0	0.0	0	0.0
190.50	0	0.0	0	0.0
196.85	0	0.0	0	0.0
203.20	0	0.0	0	0.0
209.55	0	0.0	0	0.0
>209.55	0	0.0	0	0.0



Pollutograph

Flow Rate L/s	Cumulative Mass %
1	18.4
4	36.0
9	51.6
16	64.6
25	74.8
36	82.1
49	87.2
64	90.5
81	92.7
100	94.2
121	95.5
144	96.5
169	97.2
196	97.8
225	98.2
256	98.6
289	98.9
324	99.2
361	99.4
400	99.5
441	99.6
484	99.7
529	99.8
576	99.8
625	99.9
676	99.9
729	99.9
784	99.9
841	100.0
900	100.0



Appendix C STORM SEWER DESIGN SHEETS

Storm Sewer Design Sheet
R.R.25
The Regional Municipality of HALTON

Existing north of Hwy 401

Rainfall Intensity = $\dfrac{A}{(Tc+B)^c}$

	5-YEAR	100-YEAR
A=	959	1435
B=	5.7	5.2
c=	0.8024	0.7751

Starting Tc = 10 min

CB FLOW = 35 l/s

Mannings "n"= 0.013

Project: R.R.25 Widening
Project No: 160210504
Date: 12-May-10
Designed by: NV

STREET	FROM MH	TO MH	5-YR AREA (ha)	5-YR RUNOFF COEFFICIENT "R"	5-YR "AR"	5-YR ACCUM. "AR"	5-YR RAINFALL INTENSITY (mm/hr)	5-YR ACCUM. FLOW (m^3/s)	Total Flow (m^3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	ACC. TIME OF CONC. (min)	% Full
RR25 N	DICB76	CBMH77	2.51	0.35	0.88	0.88	105.25	0.257	0.257	8.00	2.00	450	0.403	2.535	10.053	64%
RR25 N	CBMH77	CBMH78	0.437	0.95	0.42	1.29	104.97	0.377	0.377	22.40	2.00	525	0.608	2.810	10.185	62%
RR25 N	CBMH78	CBMH75	0.153	0.95	0.15	1.44	104.26	0.417	0.417	46.80	2.00	525	0.608	2.810	10.463	69%
RR25 N	CBMH75	CBMH72	0.87	0.70	0.61	2.05	102.82	0.585	0.585	72.20	2.00	600	0.868	3.071	10.855	67%
RR25 N	CBMH72	CBMH70	0.34	0.70	0.24	2.29	100.87	0.641	0.641	56.20	2.00	600	0.868	3.071	11.160	74%
RR25 N	CBMH70	CBMH67	0.37	0.70	0.26	2.55	99.40	0.703	0.703	60.00	1.50	675	1.029	2.877	11.507	68%
RR25 N	CBMH67	CBMH63	0.32	0.70	0.22	2.77	97.79	0.752	0.752	60.00	1.00	750	1.113	2.520	11.904	68%
RR25 N	CBMH63	CBMH61	0.27	0.70	0.19	2.96	96.01	0.789	0.789	60.00	0.50	825	1.014	1.899	12.431	78%
RR25 N	CBMH61	CBMH59	0.27	0.70	0.19	3.15	93.77	0.820	0.820	60.00	1.50	750	1.363	3.086	12.755	60%
RR25 N	CBMH59	MHS56	0.24	0.75	0.18	3.33	92.45	0.854	0.854	36.40	0.50	900	1.279	2.012	13.057	67%
RR25 N	MHS56	MHS48	0.63	0.75	0.47	3.80	91.25	0.963	0.963	150.00	0.50	900	1.279	2.012	14.299	75%
RR25 N	MHS48	MHS39	0.74	0.65	0.48	4.28	86.67	1.031	1.031	150.00	0.50	900	1.279	2.012	15.541	81%
RR25 N	MHS39	MHS33	0.62	0.70	0.43	4.71	82.58	1.081	1.081	108.60	0.50	975	1.584	2.122	16.394	68%
RR25 N	MHS33	MHS28	0.49	0.70	0.34	5.06	80.01	1.124	1.124	100.00	0.50	975	1.584	2.122	17.179	71%
RR25 N	MHS28	MHS21	1.03	0.70	0.72	5.78	77.80	1.249	1.249	150.00	0.50	975	1.584	2.122	18.357	79%
RR25 N	MHS21	MHS13	0.83	0.70	0.58	6.36	74.73	1.320	1.320	145.50	0.50	975	1.584	2.122	19.500	83%
RR25 N	MHS13	MHS6	0.71	0.70	0.50	6.86	72.00	1.371	1.371	125.90	0.50	975	1.584	2.122	20.488	87%
RR25 N	MHS6	STC9000	0	0.00	0.00	6.86	69.81	1.330	1.330	121.00	0.50	975	1.584	2.122	21.439	84%
RR25 N	STC9000	MHS5	0	0.00	0.00	6.86	67.84	1.292	1.292	20.00	0.50	975	1.584	2.122	21.596	82%
RR25 N	MHS5	MHS4	0	0.00	0.00	6.86	67.53	1.286	1.286	23.80	0.50	975	1.584	2.122	21.783	81%
RR25 N	MHS4	MHS3	0	0.00	0.00	6.86	67.16	1.279	1.279	150.00	0.35	975	1.325	1.776	23.190	97%
RR25 N	MHS3	MHS2	0	0.00	0.00	6.86	64.52	1.229	1.229	150.00	0.35	975	1.325	1.776	24.598	93%
RR25 N	MHS2	MHS1	0	0.00	0.00	6.86	62.11	1.183	1.183	54.70	0.35	975	1.325	1.776	25.112	89%
RR25 N	MHS1	POND	0	0.00	0.00	6.86	61.27	1.167	1.167	69.60	0.35	975	1.325	1.776	25.765	88%

Storm Sewer Design Sheet
R.R.25 Proposed Conditions_ Existing Storm Sewer
The Regional Municipality of HALTON

North of Highway

Rainfall Intensity = A / (Tc+B)^c

	5-YEAR	100-YEAR
A=	959	1435
B=	5.7	5.2
c=	0.8024	0.7751

Starting Tc = 10 min

CB FLOW = 35 l/s

Mannings "n"= 0.013

Project: R.R.25 Widening
Project No: 160210504
Date: 12-May-10
Designed by: 0

STREET	FROM MH	TO MH	5-YR AREA (ha)	5-YR RUNOFF COEFFICIENT "R"	5-YR "AR"	5-YR ACCUM. "AR"	5-YR RAINFALL INTENSITY (mm/hr)	5-YR ACCUM. FLOW (m^3/s)	Total Flow (m^3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	ACC. TIME OF CONC. (min)	% Full
RR25 N	DICB76	CBMH77	2.2	0.45	0.99	0.99	105.25	0.289	0.289	8.00	2.00	450	0.403	2.535	10.053	72%
RR25 N	CBMH77	CBMH78	0.437	0.95	0.42	1.41	104.97	0.410	0.410	22.40	2.00	525	0.608	2.810	10.185	67%
RR25 N	CBMH78	CBMH75	0.153	0.95	0.15	1.55	104.26	0.449	0.449	46.80	2.00	525	0.608	2.810	10.463	74%
RR25 N	CBMH75	CBMH72	0.726	0.80	0.58	2.13	102.82	0.609	0.609	72.20	2.00	600	0.868	3.071	10.855	70%
RR25 N	CBMH72	CBMH70	0.1	0.80	0.08	2.21	100.87	0.620	0.620	56.20	2.00	600	0.868	3.071	11.160	71%
RR25 N	CBMH70	CBMH67	0	0.80	0.00	2.21	99.40	0.611	0.611	60.00	1.50	675	1.029	2.877	11.507	59%
RR25 N	CBMH67	CBMH63	0.1	0.80	0.08	2.29	97.79	0.622	0.622	60.00	1.50	675	1.029	2.877	11.855	60%
RR25 N	CBMH63	CBMH61	0.1	0.80	0.08	2.37	96.23	0.634	0.634	60.00	1.00	750	1.113	2.520	12.252	57%
RR25 N	CBMH61	CBMH59	0.27	0.80	0.22	2.59	94.52	0.679	0.679	60.00	1.50	750	1.363	3.086	12.576	50%
RR25 N	CBMH59	MHS56	0.24	0.80	0.19	2.78	93.17	0.719	0.719	36.40	0.50	900	1.279	2.012	12.877	56%
RR25 N	MHS56	MHS48	0.63	0.80	0.50	3.28	91.96	0.839	0.839	150.00	0.50	900	1.279	2.012	14.120	66%
RR25 N	MHS48	MHS39	0.76	0.80	0.61	3.89	87.30	0.944	0.944	150.00	0.50	975	1.584	2.122	15.298	60%
RR25 N	MHS39	MHS33	0.62	0.80	0.50	4.39	83.35	1.016	1.016	108.60	0.50	975	1.584	2.122	16.151	64%
RR25 N	MHS33	MHS28	0.49	0.80	0.39	4.78	80.73	1.072	1.072	100.00	0.50	975	1.584	2.122	16.936	68%
RR25 N	MHS28	MHS21	1.03	0.80	0.82	5.60	78.47	1.221	1.221	150.00	0.50	975	1.584	2.122	18.114	77%
RR25 N	MHS21	MHS13	0.6	0.75	0.45	6.05	75.34	1.267	1.267	145.50	0.50	975	1.584	2.122	19.256	80%
RR25 N	MHS13	MHS6	0.4	0.75	0.30	6.35	72.56	1.281	1.281	125.90	0.50	975	1.584	2.122	20.245	81%
RR25 N	MHS6	STC9000	0	0.00	0.00	6.35	70.34	1.241	1.241	121.00	0.50	975	1.584	2.122	21.195	78%
RR25 N	STC9000	MHS5	0	0.00	0.00	6.35	68.34	1.206	1.206	20.00	0.50	975	1.584	2.122	21.352	76%
RR25 N	MHS5	MHS4	0	0.00	0.00	6.35	68.02	1.200	1.200	23.80	1.00	975	2.240	3.002	21.484	54%
RR25 N	MHS4	MHS3	0	0.00	0.00	6.35	67.75	1.196	1.196	150.00	0.35	975	1.325	1.776	22.892	90%
RR25 N	MHS3	MHS2	0	0.00	0.00	6.35	65.06	1.148	1.148	150.00	0.35	975	1.325	1.776	24.300	87%
RR25 N	MHS2	MHS1	0	0.00	0.00	6.35	62.60	1.105	1.105	54.70	0.35	975	1.325	1.776	24.813	83%
RR25 N	MHS1	POND	0	0.00	0.00	6.35	61.75	1.090	1.090	69.60	0.35	975	1.325	1.776	25.467	82%

Storm Sewer Design Sheet

R.R.25 Proposed New Sewer System North of Highway 401

The Regional Municipality of HALTON

Rainfall Intensity = $\dfrac{A}{(Tc+B)^c}$

	5-YEAR	100-YEAR
A=	959	1435
B=	5.7	5.2
c=	0.8024	0.7751

Starting Tc = 10 min

CB FLOW = 35 l/s

Mannings "n"= 0.013

Project: R.R.25 Widening
Project No: 160210504
Date: 26-Aug-10
Designed by: 0

STREET	FROM MH	TO MH	5-YR AREA (ha)	5-YR RUNOFF COEFFICIENT "R"	5-YR "AR"	5-YR ACCUM. "AR"	5-YR RAINFALL INTENSITY (mm/hr)	5-YR ACCUM. FLOW (m^3/s)	Total Flow (m^3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	ACC. TIME OF CONC. (min)	% Full
RR25 N	CBMH17	CBMH16	0.31	0.45	0.14	0.14	105.25	0.041	0.041	98.00	1.00	300	0.097	1.368	11.194	42%
RR25 N	CBMH16	CBMH15	0	0.95	0.00	0.14	99.24	0.038	0.038	78.00	1.00	300	0.097	1.368	12.144	40%
RR25 N	CBMH15	CBMH14	0	0.95	0.00	0.14	94.98	0.037	0.037	78.00	1.00	300	0.097	1.368	13.094	38%
RR25 N	CBMH14	CBMH13	0.144	0.80	0.12	0.25	91.10	0.064	0.064	78.00	1.00	300	0.097	1.368	14.045	67%
RR25 N	CBMH13	CBMH12	0.24	0.80	0.19	0.45	87.57	0.109	0.109	55.00	1.00	375	0.175	1.587	14.622	62%
RR25 N	CBMH12	CBMH11	0.37	0.80	0.30	0.74	85.57	0.177	0.177	96.00	1.00	450	0.285	1.793	15.515	62%
RR25 N	CBMH11	CBMH10	0.22	0.80	0.18	0.92	82.67	0.211	0.211	96.00	1.50	450	0.349	2.196	16.243	60%
RR25 N	CBMH10	MH9	0.17	0.80	0.14	1.05	80.46	0.236	0.236	96.00	1.50	450	0.349	2.196	16.972	68%
RR25 N	MH9	CBCBMH8	0	0.80	0.00	1.05	78.37	0.230	0.230	96.00	1.50	450	0.349	2.196	17.701	66%
RR25 N	CBCBMH8	CBMH7	0	0.80	0.00	1.05	76.41	0.224	0.224	96.00	1.50	450	0.349	2.196	18.430	64%
RR25 N	CBMH7	CBMH6	0	0.80	0.00	1.05	74.55	0.218	0.218	61.00	1.50	450	0.349	2.196	18.893	63%
RR25 N	CBMH6	CBMH5	0	0.80	0.00	1.05	73.42	0.215	0.215	59.00	1.50	450	0.349	2.196	19.341	62%
RR25 N	CBMH5	CBMH4	0	0.80	0.00	1.05	72.37	0.212	0.212	119.00	1.50	450	0.349	2.196	20.244	61%
RR25 N	CBMH4	CBMH3	0	0.80	0.00	1.05	70.34	0.206	0.206	114.00	1.50	450	0.349	2.196	21.109	59%
RR25 N	CBMH3	CBMH2	0	0.80	0.00	1.05	68.51	0.201	0.201	92.00	1.50	450	0.349	2.196	21.808	58%
RR25 N	CBMH2	CBMH1	0.23	0.75	0.17	1.23	67.11	0.229	0.229	76.00	1.50	450	0.349	2.196	22.385	66%
RR25 N	CBMH1	MH12	0.31	0.75	0.23	1.46	66.00	0.268	0.268	23.00	1.55	450	0.355	2.232	22.557	75%

Storm Sewer Design Sheet

R.R.25 Proposed New Sewer System

The Regional Municipality of HALTON South of Highway

Rainfall Intensity = $\frac{A}{(Tc+B)^c}$

	5-YEAR	100-YEAR
A=	959	1435
B=	5.7	5.2
c=	0.8024	0.7751
Starting Tc =	10 min	

CB FLOW = 35 l/s

Mannings "n"= 0.013

Project: R.R.25 Widening
Project No: 160210504
Date: 20-Aug-19
Designed by: 0

STREET	FROM MH	TO MH	5-YR AREA (ha)	5-YR RUNOFF COEFFICIENT "R"	5-YR "AR"	5-YR ACCUM. "AR"	5-YR RAINFALL INTENSITY (mm/hr)	5-YR ACCUM. FLOW (m^3/s)	Total Flow (m^3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	ACC. TIME OF CONC. (min)	% Full
RR25 N	MH1	MH2	0.56	0.83	0.46	0.46	105.25	0.136	0.136	88.70	0.50	450	0.201	1.268	11.166	67%
RR25 N	MH2	MH3	0	0.00	0.00	0.46	99.37	0.128	0.128	11.00	0.50	450	0.201	1.268	11.311	64%
RR25 N	MH3	OGS1	0	0.83	0.00	0.46	98.69	0.127	0.127	11.20	0.50	450	0.201	1.268	11.458	63%
RR25 N	MH11	MH11A	0.42	0.83	0.35	0.35	105.25	0.102	0.102	1112.20	0.50	450	0.201	1.268	24.624	51%
RR25 N	MH11A	OGS3	0	0.00	0.00	0.35	62.06	0.060	0.060	38.30	0.50	450	0.201	1.268	25.127	30%
RR25 N	MH10	MH9	0.42	0.83	0.35	0.35	105.25	0.102	0.102	97.60	0.60	375	0.136	1.230	11.323	75%
RR25 N	MH9	MH8	0.42	0.83	0.35	0.70	98.64	0.191	0.191	125.60	0.50	525	0.304	1.405	12.813	63%
RR25 N	MH8	MH7	0.42	0.83	0.35	1.05	92.21	0.268	0.268	77.50	0.50	600	0.434	1.536	13.654	62%
RR25 N	MH7	MH6	0.42	0.83	0.35	1.39	88.98	0.345	0.345	94.00	0.50	600	0.434	1.536	14.674	79%
RR25 N	MH6	MH5	0.42	0.83	0.35	1.74	85.39	0.413	0.413	87.30	0.50	675	0.594	1.661	15.550	70%
RR25 N	MH5	MH4	0.42	0.83	0.35	2.09	82.55	0.480	0.480	48.40	0.50	675	0.594	1.661	16.036	81%
RR25 N	MH4	OGS2	0	0.00	0.00	2.09	81.07	0.471	0.471	11.80	0.50	675	0.594	1.661	16.154	79%

Appendix D HYDRAULIC AND HYDROLOGIC MODELING

Regional Road 25
HEC-RAS Modelling and Reports

1. Summary of the submitted models

HEC-RAS Model	Version	Culverts	Tributary
FOAK11	5.3	Culverts C2, C3 and CN BR02	N1-A
RR25 Channel	5.3	Culvert C4	N2-B
Culvert C1	5.3	Culvert C1	N1-A

2. Model 1: HEC-RAS Model FOAK11 (Culverts C2, C3 and CN BR02)

Original HEC2 model received from CH

The model includes culverts C2 and C3 (RRD25) in addition to CN culvert BR2

The model was converted to HEC-RAS version 5.3 which includes the following two plans:

2.1 Plans and Geometry

Plan Title	Plan No.	Description	Geometry File	Flow File
Existing Conditions Plan	P01	Converted HEC2 model received from CH	Imported Geom 01	From FSEMS
Proposed Plan 2	P02	Updated by adding two 1.8m pipe releif culverts at each side of the CNR culvert to mitigate RRD25 flooding	Proposed CNR	From FSEMS

2.2 Model Crossings

Crossing	Model Station	Culvert Description	River	Reach
C2	65.5	Bridge #12 Road 25 St103 (Culvert C2)	River-2	Reach-1
C3	71.5	Bridge #14 CHISHOLM STREET St104 (Culvert C3)	River-2	Reach-1
BR02	60.5	Bridge #11 CNR STRUCTURE 102 (CNR Culvert BR02)	River-2	Reach-1

3. Model 2: HEC-RAS RR25 Channel (Culvert C4)

3.1 Plans and Geometry

Plan	Plan No.	Description	Geometry File	Flow File
Existing Conditions Plan	p01	Same as original model received from CH	Existing Conditions	Ex Channel
Proposed Conditions - No Meandering	p05	Proposed conditions for flows > 2-year Does not include meandering channel length	Proposed Conditions - No Meandering	PROP Channel
Proposed Conditions - No Meandering	p06	Proposed conditions for storm flows <= 2-year. Includes meandering channel lengths.	Proposed Conditions - With Meandering	PROP Channel

3.2 Crossings

Crossing	Station	Culvert Description	River	Reach
C2	472	RR25	16 Mile Creek	Tributary N2B

4. Model 2: HEC-RAS Culvert C1 (Culvert C1)

4.1 Plans and Geometry

Plan	Plan No.	Description	Geometry File	Flow File
Proposed Conditions	p01	New model	Cul C1	Proposed flows

4.2 Crossings

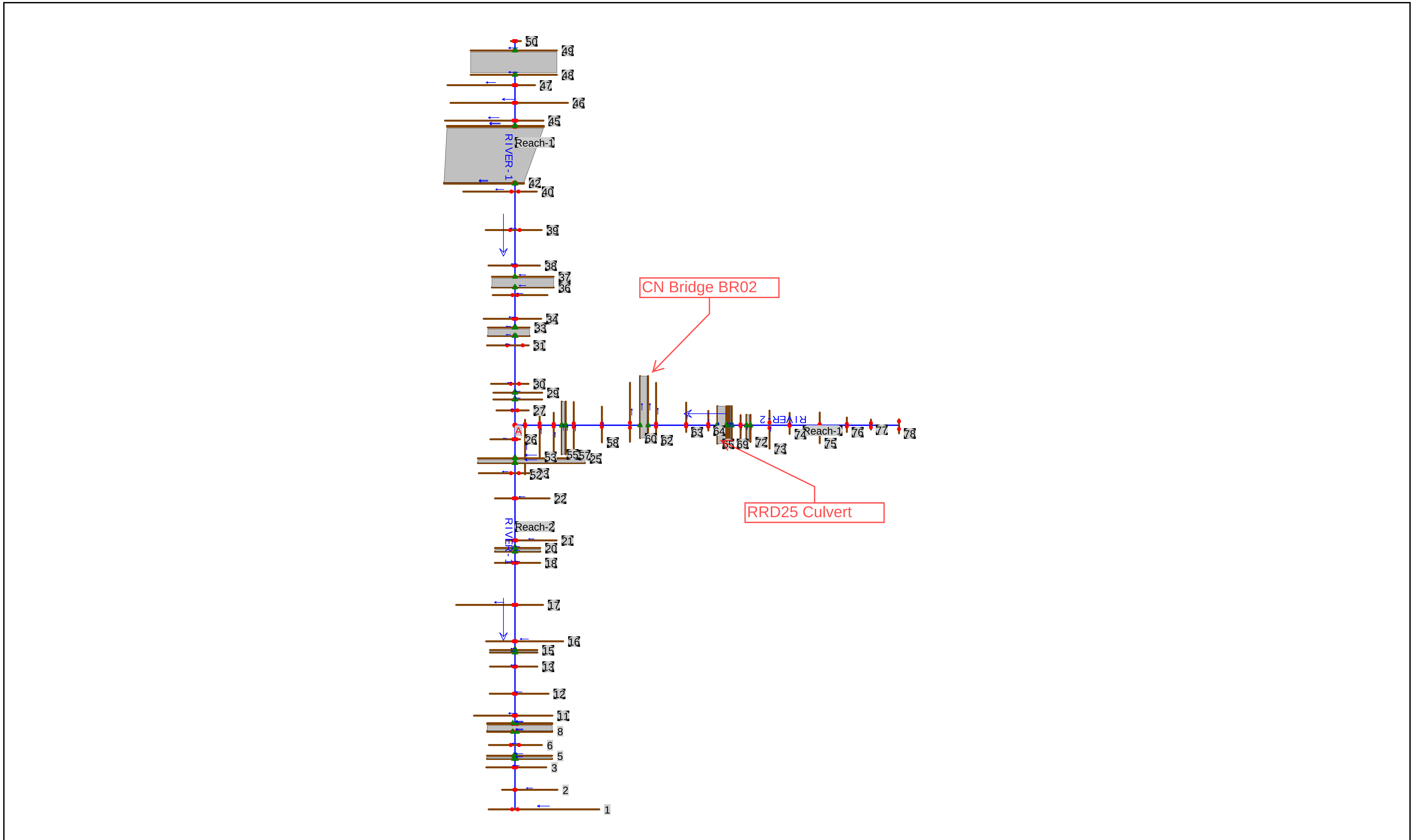
Crossing	Station	Culvert Description	River	Reach
C1	4.5	Culvert C1 North of Steels Av.	16 Mile Creek	Tributary N1A

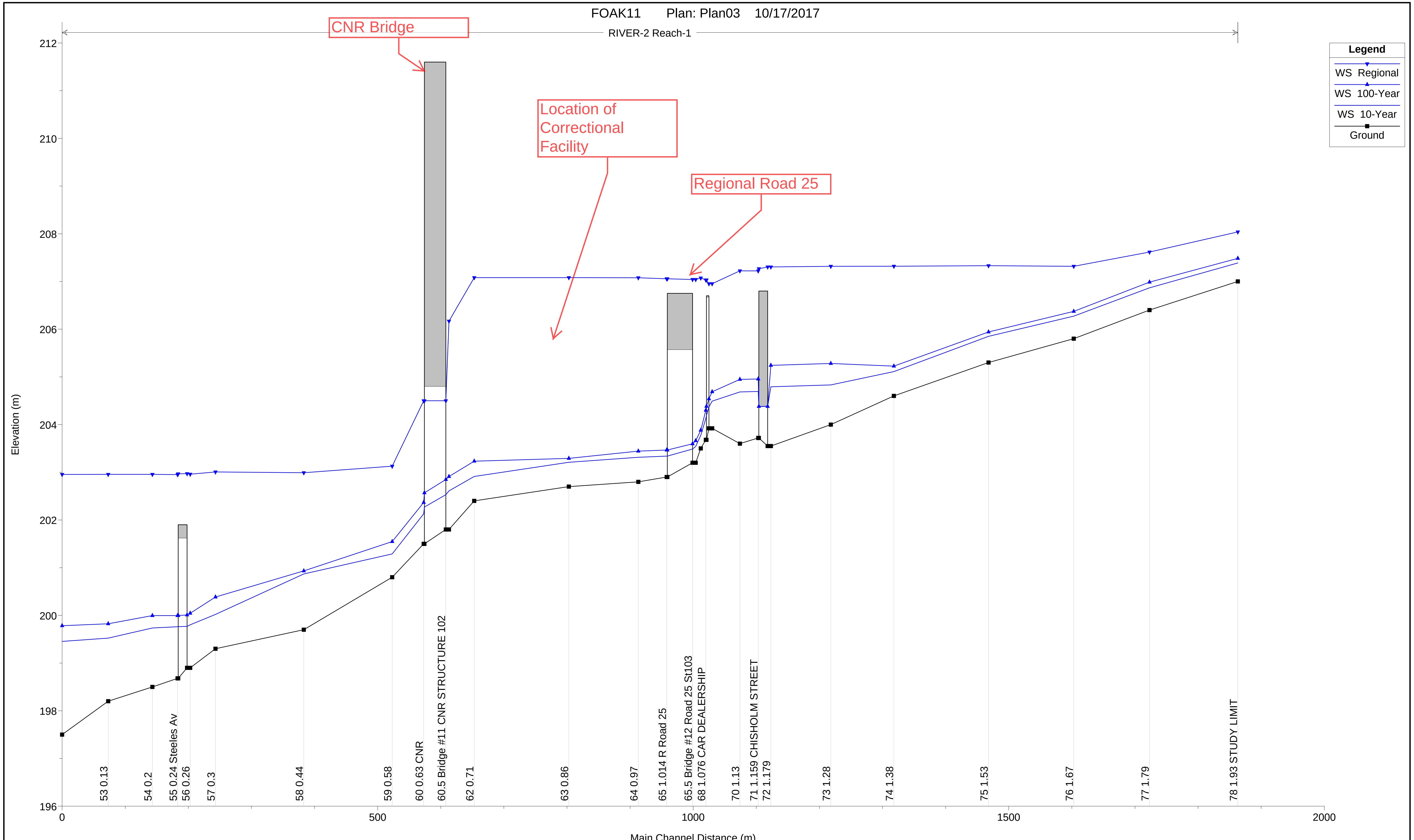
OAKVILLE CREEK FLOODLINE MAPPING EO83147

H.R.C.A.

FOAK11 - W-D BRANCH

Culvert C2 and CNR Bridge 02


CN Bridge BR02
RRD25 Culvert
Reach-1
Reach-2
RIVER-1
RIVER-2



FOAK11 Plan: Plan03 10/17/2017
RIVER-2 Reach-1
CNR Bridge
Location of Correctional Facility
Regional Road 25
Legend
WS Regional
WS 100-Year
WS 10-Year
Ground
Elevation (m)
Main Channel Distance (m)
53 0.13
54 0.2
55 0.24 Steeles Av
56 0.26
57 0.3
58 0.44
59 0.58
60 0.63 CNR
60.5 Bridge #11 CNR STRUCTURE 102
62 0.71
63 0.86
64 0.97
65 1.014 R Road 25
65.5 Bridge #12 Road 25 St103
68 1.076 CAR DEALERSHIP
70 1.13
71 1.159 CHISHOLM STREET
72 1.179
73 1.28
74 1.38
75 1.53
76 1.67
77 1.79
78 1.93 STUDY LIMIT

HEC-RAS Plan: P02   River: RIVER-2   Reach: Reach-1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	78	2-Year	1.22	207.00	207.26		207.27	0.004022	0.55	2.21	13.05	0.43
Reach-1	78	5-Year	2.24	207.00	207.34		207.36	0.004104	0.65	3.42	15.99	0.45
Reach-1	78	10-Year	2.91	207.00	207.39		207.41	0.004029	0.70	4.18	17.57	0.46
Reach-1	78	25-Year	3.52	207.00	207.42		207.45	0.004179	0.74	4.75	18.67	0.47
Reach-1	78	50-Year	4.24	207.00	207.45		207.48	0.004452	0.80	5.33	19.72	0.49
Reach-1	78	100-Year	4.74	207.00	207.47		207.51	0.004513	0.82	5.76	20.47	0.50
Reach-1	78	Regional	30.32	207.00	208.04		208.13	0.004204	1.31	23.19	39.35	0.54
Reach-1	77	2-Year	1.22	206.40	206.68		206.70	0.004123	0.63	1.94	9.68	0.45
Reach-1	77	5-Year	2.24	206.40	206.79		206.82	0.003705	0.71	3.14	11.89	0.44
Reach-1	77	10-Year	2.91	206.40	206.84		206.87	0.003701	0.79	3.74	15.09	0.45
Reach-1	77	25-Year	3.52	206.40	206.88		206.92	0.003457	0.83	4.44	18.35	0.45
Reach-1	77	50-Year	4.24	206.40	206.93		206.97	0.003096	0.86	5.43	22.13	0.43
Reach-1	77	100-Year	4.74	206.40	206.96		207.00	0.002969	0.88	6.09	24.33	0.43
Reach-1	77	Regional	30.32	206.40	207.59		207.68	0.002586	1.50	25.76	35.48	0.47
Reach-1	76	2-Year	1.22	205.80	206.16		206.19	0.004555	0.66	1.84	9.12	0.47
Reach-1	76	5-Year	2.24	205.80	206.25		206.28	0.005513	0.84	2.67	10.71	0.54
Reach-1	76	10-Year	2.91	205.80	206.30		206.34	0.005344	0.89	3.27	11.73	0.54
Reach-1	76	25-Year	3.52	205.80	206.33		206.38	0.006095	0.98	3.59	12.22	0.58
Reach-1	76	50-Year	4.24	205.80	206.34		206.41	0.007784	1.13	3.76	12.49	0.66
Reach-1	76	100-Year	4.74	205.80	206.36		206.43	0.008360	1.19	3.97	12.81	0.68
Reach-1	76	Regional	30.32	205.80	207.03		207.20	0.006728	1.80	16.89	26.20	0.70
Reach-1	75	2-Year	1.22	205.30	205.69		205.70	0.002881	0.46	2.66	16.14	0.36
Reach-1	75	5-Year	2.24	205.30	205.79		205.80	0.002438	0.49	4.53	21.81	0.35
Reach-1	75	10-Year	2.91	205.30	205.87		205.88	0.002339	0.42	6.93	41.27	0.33
Reach-1	75	25-Year	3.52	205.30	205.91		205.91	0.002113	0.41	8.66	50.27	0.31
Reach-1	75	50-Year	4.24	205.30	205.94		205.94	0.001812	0.42	10.20	50.99	0.30
Reach-1	75	100-Year	4.74	205.30	205.95		205.96	0.001789	0.43	10.98	51.35	0.30
Reach-1	75	Regional	30.32	205.30	207.08		207.09	0.000144	0.42	76.39	63.61	0.11
Reach-1	74	2-Year	1.22	204.60	205.07	204.93	205.10	0.006069	0.73	1.67	8.81	0.54
Reach-1	74	5-Year	2.24	204.60	205.15	205.06	205.19	0.008126	0.86	2.61	13.54	0.62
Reach-1	74	10-Year	2.91	204.60	205.18	205.11	205.23	0.010480	0.99	2.94	14.82	0.71
Reach-1	74	25-Year	3.52	204.60	205.18	205.15	205.25	0.013977	1.16	3.06	15.26	0.82
Reach-1	74	50-Year	4.24	204.60	205.18	205.18	205.28	0.021611	1.43	2.97	14.95	1.02
Reach-1	74	100-Year	4.74	204.60	205.20	205.20	205.30	0.021377	1.45	3.28	16.07	1.02

HEC-RAS Plan: P02   River: RIVER-2   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	74	Regional	30.32	204.60	207.07		207.08	0.000061	0.33	92.38	71.35	0.08
Reach-1	73	2-Year	1.22	204.00	204.30		204.33	0.009779	0.85	1.44	8.71	0.67
Reach-1	73	5-Year	2.24	204.00	204.41		204.45	0.006762	0.86	2.60	11.68	0.58
Reach-1	73	10-Year	2.91	204.00	204.48		204.52	0.005027	0.82	3.54	13.60	0.52
Reach-1	73	25-Year	3.52	204.00	204.55		204.58	0.003784	0.78	4.54	15.39	0.46
Reach-1	73	50-Year	4.24	204.00	204.64		204.66	0.002747	0.72	5.88	17.52	0.40
Reach-1	73	100-Year	4.74	204.00	204.69		204.72	0.002227	0.69	6.92	18.99	0.36
Reach-1	73	Regional	30.32	204.00	207.07		207.07	0.000029	0.29	139.98	91.16	0.06
Reach-1	72	2-Year	1.22	203.55	203.89	203.77	203.94	0.002278	0.97	1.26	3.93	0.53
Reach-1	72	5-Year	2.24	203.55	204.07	203.88	204.14	0.001844	1.16	1.93	4.36	0.51
Reach-1	72	10-Year	2.91	203.55	204.18	203.95	204.26	0.001689	1.25	2.32	4.89	0.51
Reach-1	72	25-Year	3.52	203.55	204.27	204.00	204.36	0.001585	1.33	2.65	5.33	0.50
Reach-1	72	50-Year	4.24	203.55	204.37	204.06	204.47	0.001490	1.40	3.02	5.83	0.50
Reach-1	72	100-Year	4.74	203.55	204.43	204.10	204.54	0.001436	1.45	3.26	6.16	0.49
Reach-1	72	Regional	30.32	203.55	207.05	205.45	207.06	0.000105	0.89	81.25	101.73	0.15
Reach-1	71.5		Culvert									
Reach-1	71	2-Year	1.22	203.32	203.80	203.54	203.82	0.000722	0.69	1.78	5.00	0.32
Reach-1	71	5-Year	2.24	203.32	203.94	203.65	203.99	0.001032	0.97	2.30	5.71	0.39
Reach-1	71	10-Year	2.91	203.32	203.99	203.72	204.06	0.001339	1.17	2.49	5.96	0.46
Reach-1	71	25-Year	3.52	203.32	204.04	203.77	204.13	0.001570	1.32	2.66	6.19	0.50
Reach-1	71	50-Year	4.24	203.32	204.09	203.83	204.20	0.001808	1.49	2.85	6.45	0.54
Reach-1	71	100-Year	4.74	203.32	204.12	203.87	204.25	0.001972	1.60	2.97	6.61	0.57
Reach-1	71	Regional	30.32	203.32	205.22	205.22	206.17	0.004564	4.32	7.02	19.82	1.00
Reach-1	70	2-Year	1.22	203.30	203.76	203.59	203.79	0.004044	0.85	1.43	4.28	0.47
Reach-1	70	5-Year	2.24	203.30	203.89	203.72	203.95	0.005212	1.10	2.03	4.93	0.55
Reach-1	70	10-Year	2.91	203.30	203.91	203.78	204.01	0.007350	1.34	2.17	5.07	0.66
Reach-1	70	25-Year	3.52	203.30	203.94	203.84	204.06	0.009016	1.52	2.31	5.21	0.73
Reach-1	70	50-Year	4.24	203.30	203.98	203.90	204.13	0.010306	1.68	2.52	5.40	0.79
Reach-1	70	100-Year	4.74	203.30	204.01	203.93	204.17	0.010889	1.77	2.68	5.55	0.81
Reach-1	70	Regional	30.32	203.30	205.36		205.56	0.003260	2.05	17.41	20.51	0.53
Reach-1	69	2-Year	1.22	203.22	203.38	203.38	203.46	0.011402	1.22	1.00	6.49	0.99
Reach-1	69	5-Year	2.24	203.22	203.46	203.46	203.57	0.010191	1.49	1.50	6.55	1.00

HEC-RAS Plan: P02 River: RIVER-2 Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	69	10-Year	2.91	203.22	203.53	203.50	203.64	0.006721	1.46	2.00	6.60	0.84
Reach-1	69	25-Year	3.52	203.22	203.59	203.54	203.70	0.005459	1.47	2.39	6.64	0.78
Reach-1	69	50-Year	4.24	203.22	203.66	203.58	203.77	0.004663	1.50	2.82	6.68	0.74
Reach-1	69	100-Year	4.74	203.22	203.70	203.61	203.82	0.004296	1.53	3.10	6.71	0.72
Reach-1	69	Regional	30.32	203.22	205.16	204.51	205.43	0.001541	2.29	13.24	7.68	0.53
Reach-1	65.5		Culvert									
Reach-1	65	2-Year	1.22	202.61	202.97	202.97	203.08	0.002846	1.46	0.84	3.88	1.00
Reach-1	65	5-Year	2.24	202.61	203.09	203.09	203.23	0.002579	1.67	1.34	4.71	1.00
Reach-1	65	10-Year	2.91	202.61	203.15	203.15	203.31	0.002480	1.77	1.64	5.09	1.00
Reach-1	65	25-Year	3.52	202.61	203.20	203.20	203.37	0.002420	1.85	1.90	5.40	1.00
Reach-1	65	50-Year	4.24	202.61	203.25	203.25	203.44	0.002328	1.92	2.21	5.75	0.99
Reach-1	65	100-Year	4.74	202.61	203.28	203.28	203.49	0.002339	1.98	2.39	5.96	1.00
Reach-1	65	Regional	30.32	202.61	204.47	204.21	204.88	0.000815	2.90	11.57	13.14	0.74
Reach-1	64	2-Year	1.22	202.20	202.91		202.92	0.000167	0.51	2.40	6.39	0.26
Reach-1	64	5-Year	2.24	202.20	203.08		203.10	0.000196	0.62	3.61	8.04	0.30
Reach-1	64	10-Year	2.91	202.20	203.15		203.18	0.000216	0.69	4.23	8.71	0.32
Reach-1	64	25-Year	3.52	202.20	203.21		203.24	0.000237	0.74	4.73	9.24	0.33
Reach-1	64	50-Year	4.24	202.20	203.27		203.30	0.000257	0.80	5.27	9.76	0.35
Reach-1	64	100-Year	4.74	202.20	203.30		203.34	0.000271	0.84	5.61	10.06	0.36
Reach-1	64	Regional	30.32	202.20	204.62		204.71	0.000144	1.36	32.38	38.11	0.32
Reach-1	63.667*	2-Year	1.22	202.21	202.90		202.92	0.000186	0.54	2.28	6.11	0.28
Reach-1	63.667*	5-Year	2.24	202.21	203.07		203.09	0.000218	0.66	3.40	7.50	0.31
Reach-1	63.667*	10-Year	2.91	202.21	203.14		203.17	0.000245	0.73	3.97	8.15	0.34
Reach-1	63.667*	25-Year	3.52	202.21	203.20		203.23	0.000270	0.80	4.42	8.62	0.36
Reach-1	63.667*	50-Year	4.24	202.21	203.25		203.29	0.000296	0.86	4.91	9.09	0.37
Reach-1	63.667*	100-Year	4.74	202.21	203.28		203.33	0.000315	0.91	5.22	9.36	0.39
Reach-1	63.667*	Regional	30.32	202.21	204.60		204.70	0.000171	1.48	30.41	36.63	0.35
Reach-1	63.333*	2-Year	1.22	202.23	202.90		202.91	0.000210	0.56	2.17	5.91	0.30
Reach-1	63.333*	5-Year	2.24	202.23	203.06		203.09	0.000242	0.69	3.24	7.17	0.33
Reach-1	63.333*	10-Year	2.91	202.23	203.13		203.16	0.000272	0.77	3.77	7.74	0.35
Reach-1	63.333*	25-Year	3.52	202.23	203.18		203.22	0.000302	0.84	4.19	8.17	0.38
Reach-1	63.333*	50-Year	4.24	202.23	203.24		203.28	0.000335	0.91	4.64	8.60	0.40
Reach-1	63.333*	100-Year	4.74	202.23	203.27		203.32	0.000359	0.96	4.91	8.86	0.41

HEC-RAS Plan: P02   River: RIVER-2   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	63.333*	Regional	30.32	202.23	204.63		204.68	0.000269	1.05	30.91	42.20	0.38
Reach-1	63	2-Year	1.22	202.24	202.89		202.91	0.000240	0.59	2.06	5.75	0.32
Reach-1	63	5-Year	2.24	202.24	203.05		203.08	0.000271	0.72	3.09	6.95	0.35
Reach-1	63	10-Year	2.91	202.24	203.12		203.15	0.000305	0.81	3.59	7.47	0.37
Reach-1	63	25-Year	3.52	202.24	203.17		203.21	0.000340	0.88	3.98	7.85	0.40
Reach-1	63	50-Year	4.24	202.24	203.22		203.27	0.000378	0.96	4.39	8.23	0.42
Reach-1	63	100-Year	4.74	202.24	203.25		203.31	0.000407	1.02	4.65	8.46	0.44
Reach-1	63	Regional	30.32	202.24	204.57		204.67	0.000193	1.45	27.63	35.05	0.36
Reach-1	62	2-Year	1.22	202.40	202.69	202.69	202.81	0.002853	1.52	0.80	3.47	1.01
Reach-1	62	5-Year	2.24	202.40	202.84	202.84	202.97	0.002664	1.63	1.37	5.05	1.00
Reach-1	62	10-Year	2.91	202.40	202.91	202.91	203.04	0.002719	1.60	1.82	7.09	1.01
Reach-1	62	25-Year	3.52	202.40	202.96	202.96	203.09	0.002695	1.61	2.19	8.39	1.01
Reach-1	62	50-Year	4.24	202.40	203.00	203.00	203.14	0.002770	1.66	2.55	9.49	1.03
Reach-1	62	100-Year	4.74	202.40	203.03	203.03	203.17	0.002548	1.70	2.80	9.94	1.00
Reach-1	62	Regional	30.32	202.40	204.60		204.63	0.000084	1.06	75.81	126.35	0.25
Reach-1	61.500*	2-Year	1.22	202.10	202.35		202.39	0.001923	0.89	1.40	5.92	0.57
Reach-1	61.500*	5-Year	2.24	202.10	202.51		202.55	0.001292	0.95	2.42	6.86	0.50
Reach-1	61.500*	10-Year	2.91	202.10	202.60		202.64	0.001159	0.99	3.04	7.52	0.49
Reach-1	61.500*	25-Year	3.52	202.10	202.67		202.72	0.001078	1.01	3.59	8.06	0.48
Reach-1	61.500*	50-Year	4.24	202.10	202.74		202.80	0.000999	1.04	4.23	8.64	0.47
Reach-1	61.500*	100-Year	4.74	202.10	202.79		202.85	0.000952	1.05	4.67	9.03	0.46
Reach-1	61.500*	Regional	30.32	202.10	204.59		204.63	0.000132	1.04	63.86	109.85	0.22
Reach-1	61	2-Year	1.22	201.80	202.36	201.96	202.37	0.000171	0.34	3.63	7.04	0.15
Reach-1	61	5-Year	2.24	201.80	202.52	202.04	202.53	0.000248	0.47	4.79	7.38	0.19
Reach-1	61	10-Year	2.91	201.80	202.61	202.09	202.62	0.000283	0.54	5.43	7.56	0.20
Reach-1	61	25-Year	3.52	201.80	202.68	202.13	202.70	0.000310	0.59	5.95	7.70	0.21
Reach-1	61	50-Year	4.24	201.80	202.75	202.17	202.78	0.000337	0.65	6.52	7.86	0.22
Reach-1	61	100-Year	4.74	201.80	202.80	202.19	202.83	0.000353	0.69	6.89	7.96	0.23
Reach-1	61	Regional	30.32	201.80	204.50	203.08	204.62	0.000425	1.50	20.23	86.01	0.30
Reach-1	60.5		Culvert									
Reach-1	60	2-Year	1.22	201.50	201.66	201.66	201.74	0.010797	1.25	0.98	6.21	1.00
Reach-1	60	5-Year	2.24	201.50	201.74	201.74	201.86	0.009751	1.52	1.47	6.37	1.01

HEC-RAS Plan: P02 River: RIVER-2 Reach: Reach-1 (Continued)

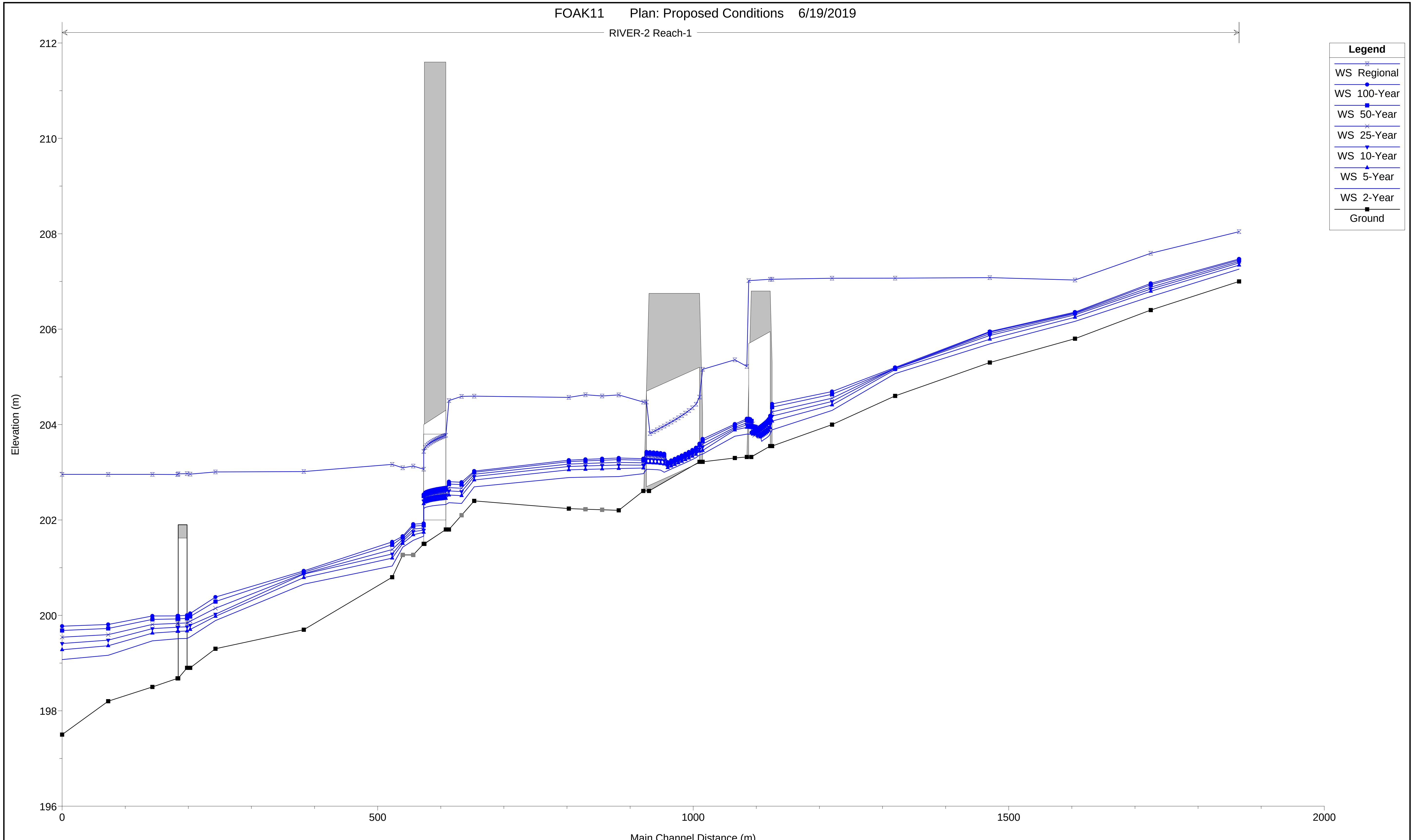
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	60	10-Year	2.91	201.50	201.79	201.79	201.92	0.009163	1.64	1.77	6.47	1.00
Reach-1	60	25-Year	3.52	201.50	201.83	201.83	201.98	0.008494	1.72	2.05	6.56	0.98
Reach-1	60	50-Year	4.24	201.50	201.89	201.87	202.04	0.007161	1.74	2.43	6.68	0.92
Reach-1	60	100-Year	4.74	201.50	201.93	201.90	202.08	0.006557	1.76	2.69	6.76	0.89
Reach-1	60	Regional	30.32	201.50	203.06	202.78	203.43	0.002989	2.69	11.27	10.12	0.72
Reach-1	59.667*	2-Year	1.22	201.27	201.57		201.59	0.001781	0.65	1.89	6.45	0.38
Reach-1	59.667*	5-Year	2.24	201.27	201.69		201.73	0.002111	0.84	2.65	6.81	0.43
Reach-1	59.667*	10-Year	2.91	201.27	201.76		201.80	0.002302	0.93	3.13	7.40	0.46
Reach-1	59.667*	25-Year	3.52	201.27	201.81		201.86	0.002408	0.99	3.55	7.89	0.47
Reach-1	59.667*	50-Year	4.24	201.27	201.87		201.93	0.002472	1.05	4.04	8.43	0.48
Reach-1	59.667*	100-Year	4.74	201.27	201.91		201.97	0.002485	1.08	4.39	8.79	0.49
Reach-1	59.667*	Regional	30.32	201.27	203.13		203.30	0.001429	1.84	17.95	15.97	0.45
Reach-1	59.333*	2-Year	1.22	201.27	201.43	201.43	201.51	0.017925	1.24	0.98	6.20	1.00
Reach-1	59.333*	5-Year	2.24	201.27	201.51	201.51	201.63	0.016111	1.52	1.48	6.33	1.00
Reach-1	59.333*	10-Year	2.91	201.27	201.55	201.55	201.69	0.015338	1.65	1.77	6.41	1.00
Reach-1	59.333*	25-Year	3.52	201.27	201.59	201.59	201.75	0.014840	1.75	2.01	6.48	1.00
Reach-1	59.333*	50-Year	4.24	201.27	201.63	201.63	201.81	0.014421	1.86	2.28	6.55	1.00
Reach-1	59.333*	100-Year	4.74	201.27	201.66	201.66	201.85	0.014264	1.93	2.46	6.60	1.01
Reach-1	59.333*	Regional	30.32	201.27	203.09		203.27	0.001890	1.88	17.36	15.41	0.47
Reach-1	59	2-Year	1.22	200.80	201.04	201.04	201.12	0.022661	1.29	0.95	5.73	1.01
Reach-1	59	5-Year	2.24	200.80	201.20		201.27	0.008418	1.13	1.98	6.80	0.67
Reach-1	59	10-Year	2.91	200.80	201.29		201.35	0.006412	1.12	2.60	7.37	0.60
Reach-1	59	25-Year	3.52	200.80	201.38		201.44	0.004699	1.06	3.31	7.97	0.53
Reach-1	59	50-Year	4.24	200.80	201.48		201.53	0.003654	1.03	4.12	8.61	0.47
Reach-1	59	100-Year	4.74	200.80	201.54		201.59	0.003224	1.02	4.67	9.01	0.45
Reach-1	59	Regional	30.32	200.80	203.17		203.21	0.000843	0.94	32.35	27.69	0.27
Reach-1	58	2-Year	4.28	199.70	200.66		200.69	0.002040	0.88	4.84	8.26	0.37
Reach-1	58	5-Year	6.06	199.70	200.79		200.84	0.002261	1.01	6.02	9.14	0.40
Reach-1	58	10-Year	7.23	199.70	200.86		200.92	0.002404	1.08	6.71	9.62	0.41
Reach-1	58	25-Year	8.36	199.70	200.88		200.95	0.003064	1.22	6.83	9.70	0.47
Reach-1	58	50-Year	9.81	199.70	200.90		201.00	0.003805	1.38	7.10	9.88	0.52
Reach-1	58	100-Year	10.90	199.70	200.93		201.04	0.004224	1.48	7.38	10.06	0.55
Reach-1	58	Regional	62.34	199.70	203.01		203.05	0.001293	0.88	71.97	93.35	0.31

HEC-RAS Plan: P02   River: RIVER-2   Reach: Reach-1 (Continued)

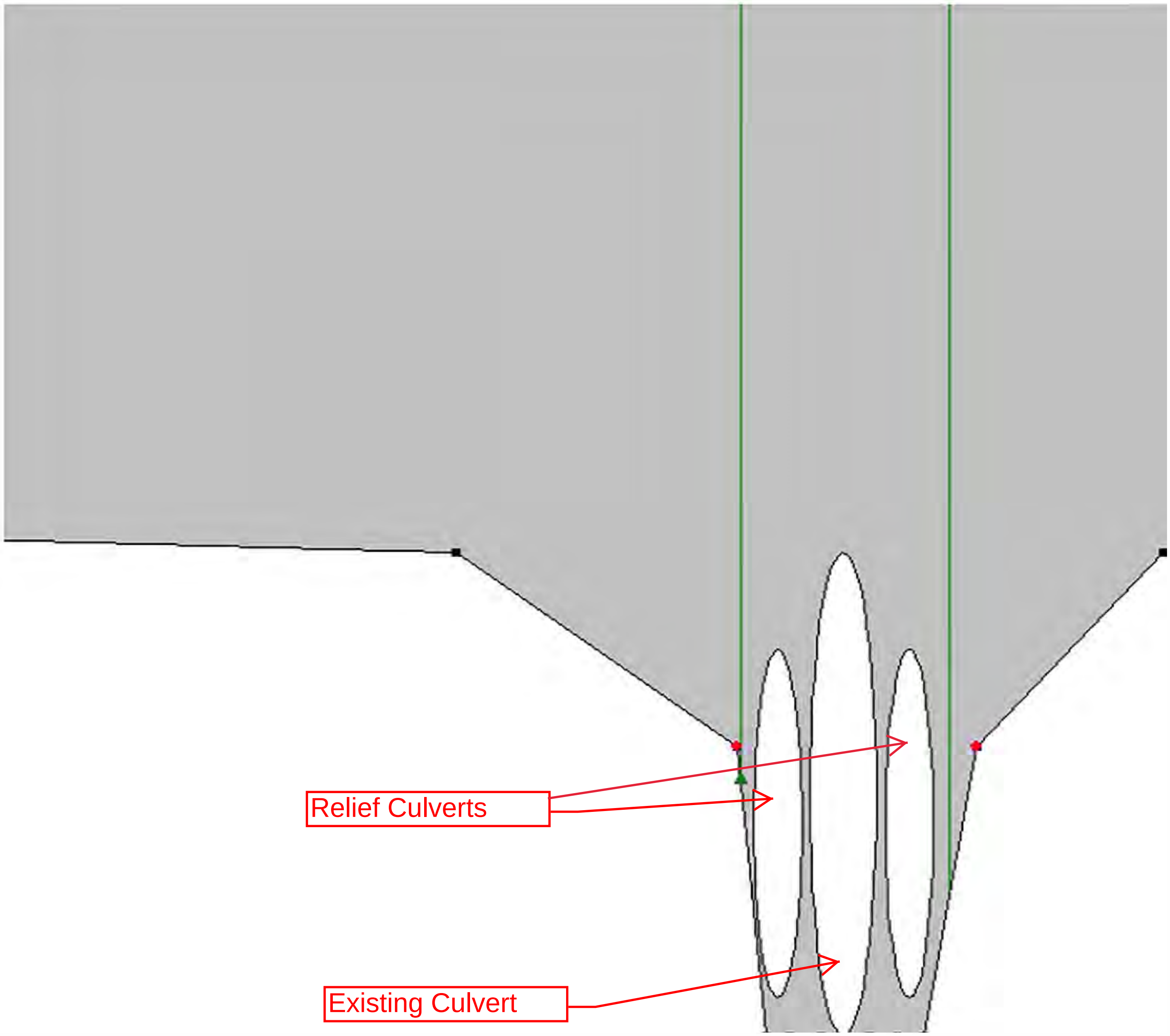
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	57	2-Year	4.28	199.30	199.89	199.89	200.03	0.019190	1.68	2.55	9.15	1.01
Reach-1	57	5-Year	6.06	199.30	199.98	199.98	200.14	0.018389	1.77	3.43	11.03	1.01
Reach-1	57	10-Year	7.23	199.30	200.02	200.02	200.19	0.017570	1.83	3.96	11.68	1.00
Reach-1	57	25-Year	8.36	199.30	200.15		200.27	0.008875	1.53	5.47	12.62	0.74
Reach-1	57	50-Year	9.81	199.30	200.29		200.38	0.005190	1.34	7.31	13.67	0.59
Reach-1	57	100-Year	10.90	199.30	200.38		200.46	0.003952	1.26	8.63	14.37	0.52
Reach-1	57	Regional	62.34	199.30	203.01		203.02	0.000074	0.50	216.99	254.44	0.09
Reach-1	56	2-Year	4.28	198.90	199.55	199.36	199.67	0.002418	1.53	2.79	6.26	0.61
Reach-1	56	5-Year	6.06	198.90	199.70	199.48	199.86	0.002359	1.75	3.46	6.73	0.62
Reach-1	56	10-Year	7.23	198.90	199.80	199.56	199.98	0.002356	1.88	3.85	7.01	0.63
Reach-1	56	25-Year	8.36	198.90	199.88	199.63	200.08	0.002346	1.99	4.21	7.26	0.64
Reach-1	56	50-Year	9.81	198.90	199.98	199.71	200.20	0.002353	2.12	4.62	8.14	0.65
Reach-1	56	100-Year	10.90	198.90	200.04	199.77	200.29	0.002394	2.22	4.90	9.02	0.67
Reach-1	56	Regional	62.34	198.90	202.96	201.68	203.00	0.000171	1.39	163.59	192.91	0.22
Reach-1	55.5		Bridge									
Reach-1	55	2-Year	4.28	198.68	199.51	199.14	199.58	0.001059	1.20	3.57	6.81	0.42
Reach-1	55	5-Year	6.06	198.68	199.66	199.27	199.77	0.001207	1.43	4.23	7.28	0.46
Reach-1	55	10-Year	7.23	198.68	199.75	199.34	199.88	0.001294	1.57	4.61	8.09	0.48
Reach-1	55	25-Year	8.36	198.68	199.83	199.41	199.98	0.001360	1.69	4.95	9.19	0.50
Reach-1	55	50-Year	9.81	198.68	199.93	199.49	200.10	0.001443	1.83	5.35	10.47	0.52
Reach-1	55	100-Year	10.90	198.68	199.99	199.55	200.18	0.001509	1.94	5.63	11.34	0.54
Reach-1	55	Regional	62.34	198.68	202.95	201.40	202.97	0.000101	1.10	208.83	234.17	0.17
Reach-1	54	2-Year	4.28	198.50	199.47		199.50	0.002662	0.85	5.05	9.22	0.37
Reach-1	54	5-Year	6.06	198.50	199.63		199.67	0.002543	0.91	6.65	10.52	0.37
Reach-1	54	10-Year	7.23	198.50	199.72		199.77	0.002459	0.94	7.68	11.27	0.36
Reach-1	54	25-Year	8.36	198.50	199.81		199.86	0.002343	0.96	8.71	11.99	0.36
Reach-1	54	50-Year	9.81	198.50	199.92		199.96	0.002223	0.98	10.01	12.82	0.35
Reach-1	54	100-Year	10.90	198.50	199.99		200.04	0.002154	0.99	10.96	13.40	0.35
Reach-1	54	Regional	62.34	198.50	202.96		202.96	0.000080	0.53	185.79	117.36	0.09
Reach-1	53	2-Year	4.28	198.20	199.16		199.23	0.005767	1.18	3.62	7.05	0.53
Reach-1	53	5-Year	6.06	198.20	199.36		199.43	0.004669	1.16	5.22	8.95	0.49
Reach-1	53	10-Year	7.23	198.20	199.48		199.55	0.004051	1.14	6.35	10.07	0.46
Reach-1	53	25-Year	8.36	198.20	199.60		199.66	0.003432	1.10	7.58	11.18	0.43

HEC-RAS Plan: P02   River: RIVER-2   Reach: Reach-1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	53	50-Year	9.81	198.20	199.73		199.78	0.002957	1.08	9.09	12.39	0.40
Reach-1	53	100-Year	10.90	198.20	199.81		199.87	0.002730	1.07	10.16	13.19	0.39
Reach-1	53	Regional	62.34	198.20	202.96		202.96	0.000034	0.33	321.16	229.39	0.06
Reach-1	52	2-Year	4.28	197.50	199.07		199.09	0.000809	0.64	6.71	9.09	0.21
Reach-1	52	5-Year	6.06	197.50	199.28		199.31	0.000767	0.72	9.20	14.98	0.21
Reach-1	52	10-Year	7.23	197.50	199.41		199.43	0.000680	0.72	11.40	18.70	0.20
Reach-1	52	25-Year	8.36	197.50	199.54		199.56	0.000565	0.70	14.10	22.45	0.19
Reach-1	52	50-Year	9.81	197.50	199.68		199.70	0.000472	0.68	17.55	26.46	0.18
Reach-1	52	100-Year	10.90	197.50	199.77		199.79	0.000426	0.68	20.07	29.04	0.17
Reach-1	52	Regional	62.34	197.50	202.96		202.96	0.000018	0.29	331.36	238.88	0.04

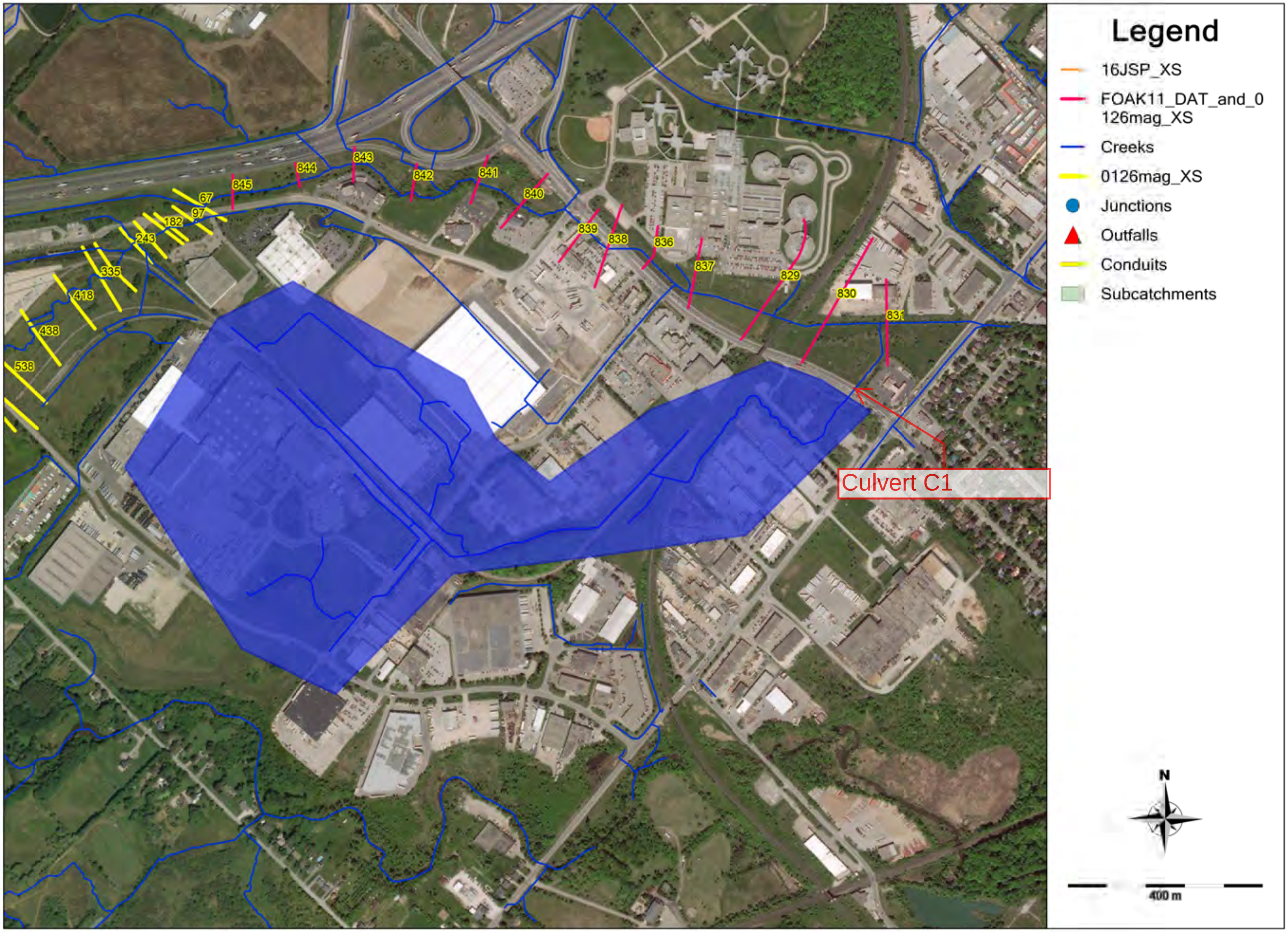

FOAK11 Plan: Proposed Conditions 6/19/2019
RIVER-2 Reach-1
Legend
WS Regional
WS 100-Year
WS 50-Year
WS 25-Year
WS 10-Year
WS 5-Year
WS 2-Year
Ground
Elevation (m)
Main Channel Distance (m)
212
210
208
206
204
202
200
198
196
0
500
1000
1500
2000

Bridge #11 CNR STRUCTURE 102 (CNR Culvert BR02)



Culvert C1 Analysis

Culvert C1 Subcatchment



Culvert C1 Flows
VO Model

```
********************************
** SIMULATION:Run 01          **
********************************

--------------------
|    READ STORM    |     Filename: C:\Users\mmukhtar\AppD
|                  |               ata\Local\Temp\
|                  |               3b804f83-154a-424b-8808-bb13a43efaa2\7b308811
| Ptotal=212.00 mm |     Comments:
--------------------
                 TIME     RAIN |  TIME     RAIN |'  TIME     RAIN |  TIME     RAIN
                  hrs    mm/hr |   hrs    mm/hr |'   hrs    mm/hr |   hrs    mm/hr
                 1.00     6.00 |  4.00    13.00 |  7.00    23.00 | 10.00    53.00
                 2.00     4.00 |  5.00    17.00 |  8.00    13.00 | 11.00    38.00
                 3.00     6.00 |  6.00    13.00 |  9.00    13.00 | 12.00    13.00

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (  0003)|    Area     (ha)=  58.90   Curve Number    (CN)= 80.0
|ID= 1 DT=10.0 min |    Ia       (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------    U.H. Tp(hrs)=   0.50

         NOTE:  RAINFALL WAS TRANSFORMED TO  10.0 MIN. TIME STEP.


                                 ---- TRANSFORMED HYETOGRAPH ----
                 TIME     RAIN |  TIME     RAIN |'  TIME     RAIN |  TIME     RAIN
                  hrs    mm/hr |   hrs    mm/hr |'   hrs    mm/hr |   hrs    mm/hr
                0.167     6.00 | 3.167    13.00 | 6.167    23.00 |  9.17    53.00
                0.333     6.00 | 3.333    13.00 | 6.333    23.00 |  9.33    53.00
                0.500     6.00 | 3.500    13.00 | 6.500    23.00 |  9.50    53.00
                0.667     6.00 | 3.667    13.00 | 6.667    23.00 |  9.67    53.00
                0.833     6.00 | 3.833    13.00 | 6.833    23.00 |  9.83    53.00
                1.000     6.00 | 4.000    13.00 | 7.000    23.00 | 10.00    53.00
                1.167     4.00 | 4.167    17.00 | 7.167    13.00 | 10.17    38.00
                1.333     4.00 | 4.333    17.00 | 7.333    13.00 | 10.33    38.00
                1.500     4.00 | 4.500    17.00 | 7.500    13.00 | 10.50    38.00
                1.667     4.00 | 4.667    17.00 | 7.667    13.00 | 10.67    38.00
                1.833     4.00 | 4.833    17.00 | 7.833    13.00 | 10.83    38.00
                2.000     4.00 | 5.000    17.00 | 8.000    13.00 | 11.00    38.00
                2.167     6.00 | 5.167    13.00 | 8.167    13.00 | 11.17    13.00
                2.333     6.00 | 5.333    13.00 | 8.333    13.00 | 11.33    13.00
                2.500     6.00 | 5.500    13.00 | 8.500    13.00 | 11.50    13.00
                2.667     6.00 | 5.667    13.00 | 8.667    13.00 | 11.67    13.00
                2.833     6.00 | 5.833    13.00 | 8.833    13.00 | 11.83    13.00
                3.000     6.00 | 6.000    13.00 | 9.000    13.00 | 12.00    13.00

     Unit Hyd Qpeak  (cms)=   4.499

     PEAK FLOW       (cms)=   6.858 (i)
     TIME TO PEAK    (hrs)=  10.167
     RUNOFF VOLUME    (mm)= 158.281
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =   0.747

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
********************************
** SIMULATION:Run 02          **
********************************

--------------------
|    READ STORM    |     Filename: C:\Users\mmukhtar\AppD
|                  |               ata\Local\Temp\
|                  |               3b804f83-154a-424b-8808-bb13a43efaa2\ad98bdde
| Ptotal= 80.66 mm |     Comments:
--------------------
                 TIME     RAIN |  TIME     RAIN |'  TIME     RAIN |  TIME     RAIN
                  hrs    mm/hr |   hrs    mm/hr |'   hrs    mm/hr |   hrs    mm/hr
                 0.17     5.55 |  1.17    41.69 |  2.17    12.86 |  3.17     6.58
                 0.33     6.34 |  1.33   174.10 |  2.33    10.98 |  3.33     6.12
                 0.50     7.44 |  1.50    54.37 |  2.50     9.62 |  3.50     5.73
                 0.67     9.10 |  1.67    29.07 |  2.67     8.59 |  3.67     5.39
                 0.83    11.90 |  1.83    20.18 |  2.83     7.78 |  3.83     5.09
                 1.00    17.89 |  2.00    15.63 |  3.00     7.12 |  4.00     4.83

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| NASHYD    (  0003)|    Area     (ha)=  58.90   Curve Number    (CN)= 80.0
```

Regional

```
|ID= 1 DT=10.0 min |    Ia       (mm)=    5.00    # of Linear Res.(N)= 3.00
--------------------    U.H. Tp(hrs)=    0.50

     Unit Hyd Qpeak  (cms)=   4.499

     PEAK FLOW       (cms)=   4.253 (i)
     TIME TO PEAK    (hrs)=   1.833
     RUNOFF VOLUME    (mm)=  41.101
     TOTAL RAINFALL   (mm)=  80.657
     RUNOFF COEFFICIENT   =   0.510

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

100-year

```
--------------------------------------------------------------------------------
********************************
** SIMULATION:Run 03          **
********************************

--------------------
|    READ STORM     |     Filename: C:\Users\mmukhtar\AppD
|                   |               ata\Local\Temp\
|                   |               3b804f83-154a-424b-8808-bb13a43efaa2\db3ea11f
| Ptotal= 72.92 mm |     Comments:
--------------------
                  TIME     RAIN |  TIME     RAIN |'  TIME     RAIN |  TIME     RAIN
                   hrs    mm/hr |   hrs    mm/hr |'   hrs    mm/hr |   hrs    mm/hr
                  0.17     4.96 |  1.17    37.84 |  2.17    11.56 |  3.17     5.88
                  0.33     5.67 |  1.33   158.18 |  2.33     9.86 |  3.33     5.47
                  0.50     6.66 |  1.50    49.42 |  2.50     8.63 |  3.50     5.12
                  0.67     8.15 |  1.67    26.31 |  2.67     7.70 |  3.67     4.81
                  0.83    10.70 |  1.83    18.21 |  2.83     6.96 |  3.83     4.55
                  1.00    16.13 |  2.00    14.08 |  3.00     6.37 |  4.00     4.31

--------------------------------------------------------------------------------

--------------------
| CALIB             |
| NASHYD   (  0003)|    Area     (ha)=   58.90    Curve Number   (CN)= 80.0
|ID= 1 DT=10.0 min |    Ia       (mm)=    5.00    # of Linear Res.(N)= 3.00
--------------------    U.H. Tp(hrs)=    0.50

     Unit Hyd Qpeak  (cms)=   4.499

     PEAK FLOW       (cms)=   3.612 (i)
     TIME TO PEAK    (hrs)=   1.833
     RUNOFF VOLUME    (mm)=  35.075
     TOTAL RAINFALL   (mm)=  72.921
     RUNOFF COEFFICIENT   =   0.481

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

50-Year

```
--------------------------------------------------------------------------------
********************************
** SIMULATION:Run 04          **
********************************

--------------------
|    READ STORM     |     Filename: C:\Users\mmukhtar\AppD
|                   |               ata\Local\Temp\
|                   |               3b804f83-154a-424b-8808-bb13a43efaa2\8b95a9ed
| Ptotal= 46.31 mm |     Comments:
--------------------
                  TIME     RAIN |  TIME     RAIN |'  TIME     RAIN |  TIME     RAIN
                   hrs    mm/hr |   hrs    mm/hr |'   hrs    mm/hr |   hrs    mm/hr
                  0.17     2.88 |  1.17    24.45 |  2.17     7.00 |  3.17     3.44
                  0.33     3.31 |  1.33   105.25 |  2.33     5.92 |  3.33     3.19
                  0.50     3.92 |  1.50    32.26 |  2.50     5.14 |  3.50     2.97
                  0.67     4.85 |  1.67    16.67 |  2.67     4.56 |  3.67     2.79
                  0.83     6.45 |  1.83    11.31 |  2.83     4.11 |  3.83     2.63
                  1.00     9.95 |  2.00     8.62 |  3.00     3.74 |  4.00     2.48

--------------------------------------------------------------------------------

--------------------
| CALIB             |
| NASHYD   (  0003)|    Area     (ha)=   58.90    Curve Number   (CN)= 80.0
|ID= 1 DT=10.0 min |    Ia       (mm)=    5.00    # of Linear Res.(N)= 3.00
--------------------    U.H. Tp(hrs)=    0.50

     Unit Hyd Qpeak  (cms)=   4.499

     PEAK FLOW       (cms)=   1.652 (i)
     TIME TO PEAK    (hrs)=   1.833
     RUNOFF VOLUME    (mm)=  16.269
```

5-Year

```
     TOTAL RAINFALL   (mm)=  46.310
     RUNOFF COEFFICIENT   =   0.351

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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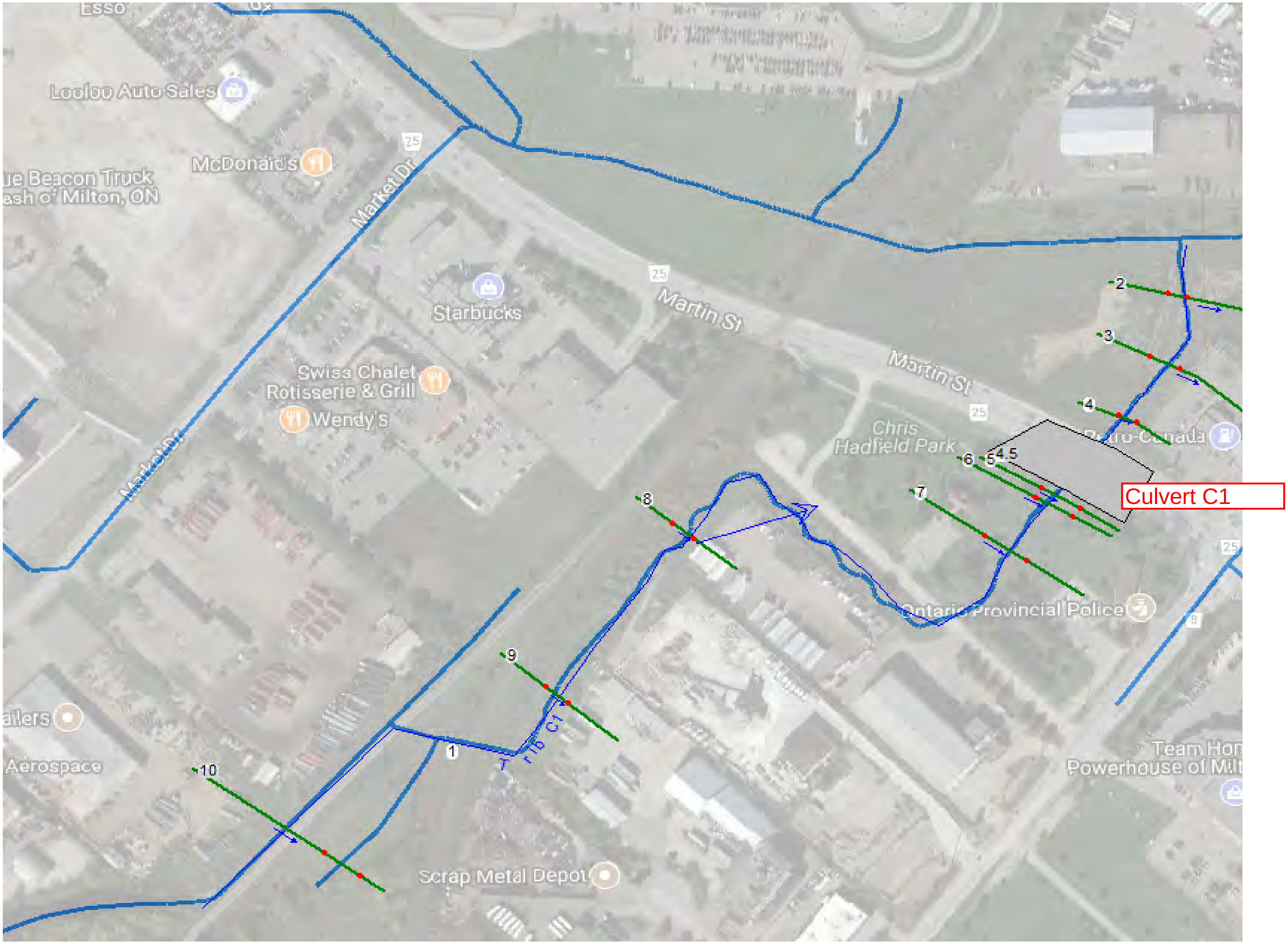
```



Esso
Looloo Auto Sales
McDonald's
ue Beacon Truck
ash of Milton, ON
Market Dr
Starbucks
Martin St
Martin St
Swiss Chalet
Rotisserie & Grill
Wendy's
Chris
Hadfield Park
Petro-Canada
Culvert C1
Ontario Provincial Police
Market Dr
ailers
Aerospace
Scrap Metal Depot
Team Hor
Powerhouse of Milt
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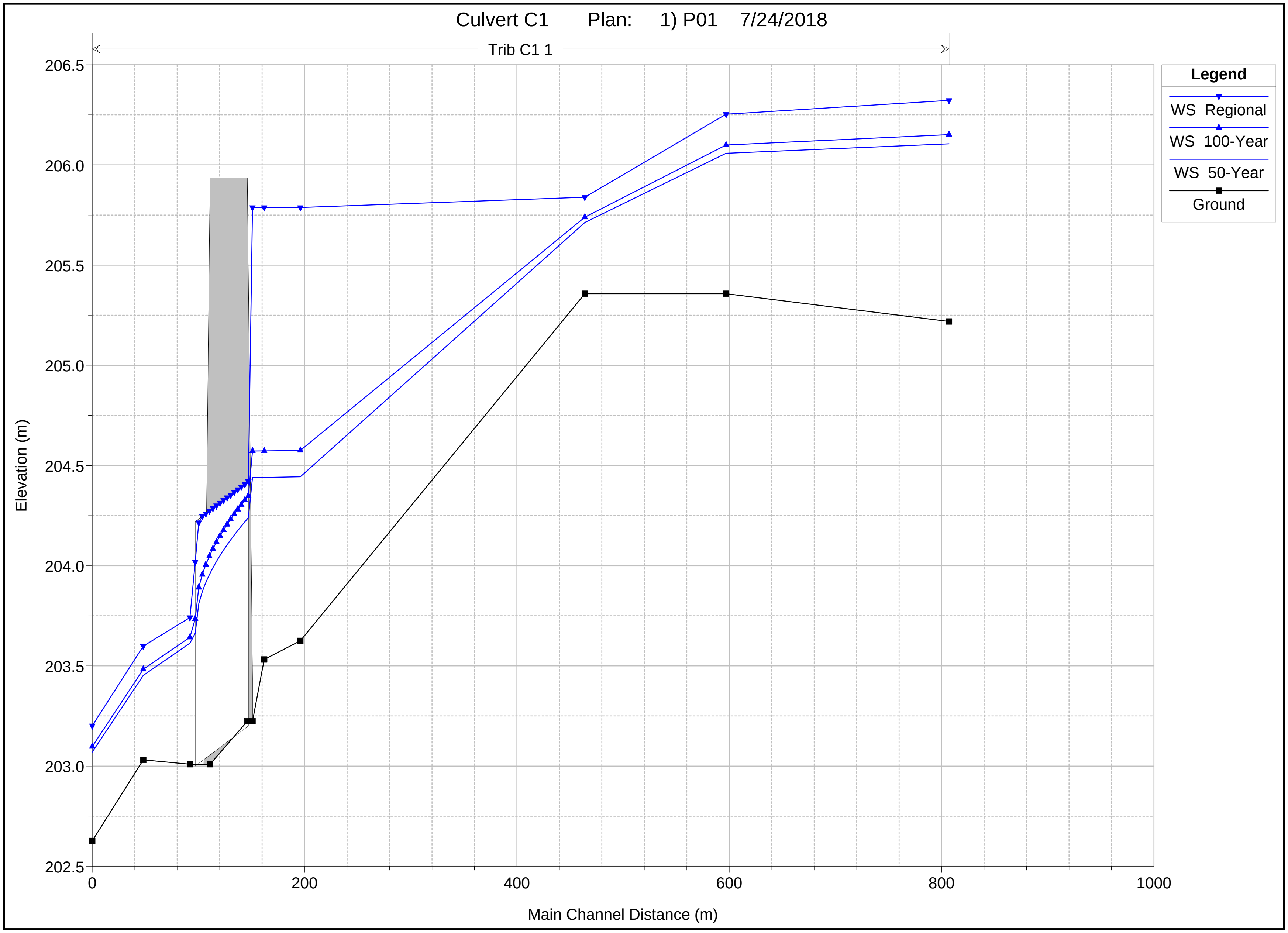
7
8
9
10
1



Culvert C1 Plan: 1) P01 7/24/2018
Trib C1 1
Legend
WS Regional
WS 100-Year
WS 50-Year
Ground
206.5
206.0
205.5
205.0
204.5
204.0
203.5
203.0
202.5
Elevation (m)
0
200
400
600
800
1000
Main Channel Distance (m)

HEC-RAS Model
Culvert C1

HEC-RAS Plan: P01 River: Trib C1 Reach: 1

Reach	River Sta	Profile	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)	
1	10	50-Year	3.60	205.22	206.11		206.11	0.000075	0.22	16.54	25.52	0.09
1	10	100-Year	4.20	205.22	206.15		206.15	0.000081	0.24	17.73	26.12	0.09
1	10	Regional	6.86	205.22	206.32		206.33	0.000105	0.31	22.38	28.31	0.11
1	9	50-Year	3.60	205.36	206.06		206.07	0.000647	0.52	6.97	14.70	0.24
1	9	100-Year	4.20	205.36	206.10		206.12	0.000675	0.55	7.59	14.95	0.25
1	9	Regional	6.86	205.36	206.25	205.84	206.28	0.000781	0.69	9.96	15.91	0.28
1	8	50-Year	3.60	205.36	205.71	205.71	205.83	0.014892	1.49	2.42	10.91	1.01
1	8	100-Year	4.20	205.36	205.74	205.74	205.86	0.014587	1.55	2.72	11.39	1.01
1	8	Regional	6.86	205.36	205.84	205.84	205.99	0.013425	1.75	3.92	12.82	1.01
1	7	50-Year	3.60	203.63	204.44		204.45	0.000076	0.20	18.29	35.29	0.08
1	7	100-Year	4.20	203.63	204.58		204.58	0.000052	0.19	23.18	39.11	0.07
1	7	Regional	6.86	203.63	205.79		205.79	0.000004	0.10	101.35	107.37	0.02
1	6	50-Year	3.60	203.53	204.44		204.44	0.000093	0.23	16.11	30.79	0.09
1	6	100-Year	4.20	203.53	204.57		204.57	0.000064	0.22	20.49	35.39	0.08
1	6	Regional	6.86	203.53	205.79		205.79	0.000005	0.11	100.31	98.34	0.03
1	5	50-Year	3.60	203.22	204.44	203.63	204.44	0.000079	0.22	16.43	25.66	0.09
1	5	100-Year	4.20	203.22	204.57	203.66	204.57	0.000059	0.21	20.17	31.16	0.08
1	5	Regional	6.86	203.22	205.79	203.78	205.79	0.000004	0.11	102.09	88.46	0.02
1	4.5		Culvert									
1	4	50-Year	3.60	203.01	203.61		203.67	0.005185	1.05	3.44	11.93	0.62
1	4	100-Year	4.20	203.01	203.64		203.71	0.005166	1.11	3.79	12.09	0.63
1	4	Regional	6.86	203.01	203.74	203.64	203.84	0.005624	1.38	5.23	20.22	0.68
1	3	50-Year	3.60	203.03	203.45		203.48	0.003227	0.80	4.52	16.50	0.49
1	3	100-Year	4.20	203.03	203.48		203.52	0.003232	0.83	5.03	17.18	0.49
1	3	Regional	6.86	203.03	203.60		203.65	0.003019	0.96	7.16	19.78	0.50
1	2	50-Year	3.60	202.63	203.07	203.07	203.19	0.014453	1.53	2.36	9.95	1.00
1	2	100-Year	4.20	202.63	203.10	203.10	203.23	0.014229	1.59	2.64	10.37	1.01
1	2	Regional	6.86	202.63	203.20	203.20	203.37	0.013091	1.82	3.80	12.08	1.01

Plan: P01 Trib C1 1 RS: 4.5 Culv Group: Culvert #1 Profile: 50-Year

Q Culv Group (m3/s)	3.60	Culv Full Len (m)	
# Barrels	1	Culv Vel US (m/s)	1.63
Q Barrel (m3/s)	3.60	Culv Vel DS (m/s)	2.55
E.G. US. (m)	204.44	Culv Inv El Up (m)	203.20
W.S. US. (m)	204.44	Culv Inv El Dn (m)	203.00
E.G. DS (m)	203.67	Culv Frctn Ls (m)	0.00
W.S. DS (m)	203.61	Culv Exit Loss (m)	0.32
Delta EG (m)	0.77	Culv Entr Loss (m)	0.07
Delta WS (m)	0.83	Q Weir (m3/s)	
E.G. IC (m)	204.26	Weir Sta Lft (m)	
E.G. OC (m)	204.44	Weir Sta Rgt (m)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (m)	204.24	Weir Max Depth (m)	
Culv WS Outlet (m)	203.66	Weir Avg Depth (m)	
Culv Nml Depth (m)	1.18	Weir Flow Area (m2)	
Culv Crt Depth (m)	0.66	Min El Weir Flow (m)	205.94

Plan: P01 Trib C1 1 RS: 4.5 Culv Group: Culvert #1 Profile: 100-Year

Q Culv Group (m3/s)	4.20	Culv Full Len (m)	
# Barrels	1	Culv Vel US (m/s)	1.72
Q Barrel (m3/s)	4.20	Culv Vel DS (m/s)	2.68
E.G. US. (m)	204.57	Culv Inv El Up (m)	203.20
W.S. US. (m)	204.57	Culv Inv El Dn (m)	203.00
E.G. DS (m)	203.71	Culv Frctn Ls (m)	0.00
W.S. DS (m)	203.64	Culv Exit Loss (m)	0.40
Delta EG (m)	0.87	Culv Entr Loss (m)	0.08
Delta WS (m)	0.93	Q Weir (m3/s)	
E.G. IC (m)	204.38	Weir Sta Lft (m)	
E.G. OC (m)	204.57	Weir Sta Rgt (m)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (m)	204.35	Weir Max Depth (m)	
Culv WS Outlet (m)	203.73	Weir Avg Depth (m)	
Culv Nml Depth (m)	1.22	Weir Flow Area (m2)	
Culv Crt Depth (m)	0.73	Min El Weir Flow (m)	205.94

Plan: P01 Trib C1 1 RS: 4.5 Culv Group: Culvert #1 Profile: Regional

Q Culv Group (m3/s)	6.86	Culv Full Len (m)	45.90
# Barrels	1	Culv Vel US (m/s)	2.64
Q Barrel (m3/s)	6.86	Culv Vel DS (m/s)	3.16
E.G. US. (m)	205.79	Culv Inv El Up (m)	203.20
W.S. US. (m)	205.79	Culv Inv El Dn (m)	203.00
E.G. DS (m)	203.84	Culv Frctn Ls (m)	1.02
W.S. DS (m)	203.74	Culv Exit Loss (m)	0.69
Delta EG (m)	1.95	Culv Entr Loss (m)	0.18
Delta WS (m)	2.05	Q Weir (m3/s)	
E.G. IC (m)	205.04	Weir Sta Lft (m)	
E.G. OC (m)	205.79	Weir Sta Rgt (m)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (m)	204.42	Weir Max Depth (m)	
Culv WS Outlet (m)	204.02	Weir Avg Depth (m)	
Culv Nml Depth (m)	1.22	Weir Flow Area (m2)	
Culv Crt Depth (m)	1.02	Min El Weir Flow (m)	205.94

CN Bridge and Road

Overland Flow

CN Bridge Overland Flow

VO4 Model Report

Culvert Master Model Report

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=====================================================================================
=======================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

Developed and Distributed by Civica Infrastructure

***** D E T A I L E D   O U T P U T *****

Input filename: C:\Program Files (x86)\VH Suite 4.0\VO2\voin.dat

Output filename:
C:\Users\mmukhtar\AppData\Local\Civica\VH4\4b140b82-cdff-41d8-b3bc-a4dfdd24d1ac\b48ce46c-96e0-482b-87d2-cda7c504b541\sce
Summary filename:
C:\Users\mmukhtar\AppData\Local\Civica\VH4\4b140b82-cdff-41d8-b3bc-a4dfdd24d1ac\b48ce46c-96e0-482b-87d2-cda7c504b541\sce

DATE: 10/18/2017   TIME: 11:16:52

USER:

COMMENTS: ____

```
-------------------------------------------------------------------------------------
-----------------------
  ************************************
  ** Run 02                         **
  ************************************


--------------------
|    READ STORM    |    Filename: C:\Users\mmukhtar\AppD
|                  |              ata\Local\Temp\
|                  |              162f8712-705a-4cdf-adaa-90c60850aa03\ad98bdde
| Ptotal= 80.66 mm |    Comments:
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	5.55	1.17	41.69	2.17	12.86	3.17	6.58
0.33	6.34	1.33	174.10	2.33	10.98	3.33	6.12
0.50	7.44	1.50	54.37	2.50	9.62	3.50	5.73
0.67	9.10	1.67	29.07	2.67	8.59	3.67	5.39
0.83	11.90	1.83	20.18	2.83	7.78	3.83	5.09
1.00	17.89	2.00	15.63	3.00	7.12	4.00	4.83

```
 --------------------
 | CALIB              |
 | STANDHYD (  0001)|   Area    (ha)=      3.00
 |ID= 1 DT= 5.0 min |   Total Imp(%)=     90.00   Dir. Conn.(%)=  70.00
 --------------------
                                  IMPERVIOUS      PERVIOUS (i)
      Surface Area     (ha)=          2.70            0.30
      Dep. Storage     (mm)=          1.00            1.50
      Average Slope     (%)=          1.00            2.00
      Length            (m)=        141.42           40.00
      Mannings n           =         0.013           0.250

          NOTE:  RAINFALL WAS TRANSFORMED TO      5.0 MIN. TIME STEP.


                                 ---- TRANSFORMED HYETOGRAPH ----
                  TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 0.083    5.55 | 1.083   41.69 | 2.083   12.86 |  3.08    6.58
                 0.167    5.55 | 1.167   41.69 | 2.167   12.86 |  3.17    6.58
                 0.250    6.34 | 1.250  174.10 | 2.250   10.98 |  3.25    6.12
                 0.333    6.34 | 1.333  174.10 | 2.333   10.98 |  3.33    6.12
                 0.417    7.44 | 1.417   54.37 | 2.417    9.62 |  3.42    5.73
                 0.500    7.44 | 1.500   54.37 | 2.500    9.62 |  3.50    5.73
                 0.583    9.10 | 1.583   29.07 | 2.583    8.59 |  3.58    5.39
                 0.667    9.10 | 1.667   29.07 | 2.667    8.59 |  3.67    5.39
                 0.750   11.90 | 1.750   20.18 | 2.750    7.78 |  3.75    5.09
                 0.833   11.90 | 1.833   20.18 | 2.833    7.78 |  3.83    5.09
                 0.917   17.89 | 1.917   15.63 | 2.917    7.12 |  3.92    4.83
                 1.000   17.89 | 2.000   15.63 | 3.000    7.12 |  4.00    4.83

      Max.Eff.Inten.(mm/hr)=       174.10      NaN
                 over (min)          5.00           10.00
      Storage Coeff.  (min)=         2.52 (ii)      5.12 (ii)
      Unit Hyd. Tpeak (min)=         5.00           10.00
      Unit Hyd. peak  (cms)=         0.29            0.16
                                                                *TOTALS*
      PEAK FLOW       (cms)=         1.00            0.29          1.290 (iii)
      TIME TO PEAK    (hrs)=         1.33            1.42           1.33
      RUNOFF VOLUME    (mm)=        79.66           67.56          76.03
      TOTAL RAINFALL   (mm)=        80.66           80.66          80.66
      RUNOFF COEFFICIENT   =         0.99            0.84           0.94

 ***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

        (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
             CN*  =  85.0    Ia = Dep. Storage  (Above)
       (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
      (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------------
 --------------------
 | DUHYD    (  0002)|
 | Inlet Cap.= 0.730|
 | #of Inlets=     1|
 | Total(cms)=   0.7|         AREA     QPEAK     TPEAK    R.V.
 --------------------         (ha)     (cms)     (hrs)    (mm)
      TOTAL HYD.(ID= 1):      3.00      1.29      1.33   76.03
      ========================================================
      MAJOR SYS.(ID= 2):      0.35      0.56      1.33   76.03
      MINOR SYS.(ID= 3):      2.65      0.73      1.25   76.03
```

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

Bridbge BR01(CNR) RRD25

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.014	
Channel Slope	0.00500	m/m
Normal Depth	0.053	m
Bottom Width	15.00	m

Results

Discharge	0.564	m^3/s
Flow Area	0.80	m^2
Wetted Perimeter	15.11	m
Hydraulic Radius	0.053	m
Top Width	15.00	m
Critical Depth	0.05	m
Critical Slope	0.00518	m/m
Velocity	0.71	m/s
Velocity Head	0.03	m
Specific Energy	0.08	m
Froude Number	0.98	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.000	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.053	m
Critical Depth	0.05	m
Channel Slope	0.00500	m/m
Critical Slope	0.00518	m/m

Road Overland Flow

Quantity Control Calculations
Overland Flow

Project No. : 165010570

Project Name : Regional Road 25

Road Sections

Section	Station	Area (ha)	Drainage Area	
			From	To
1	26+520	10.890	28+120	26+520
2	25+190	3.920	25+020	25+860

Major Flow Calculation

Section	5yr			100-YEAR			Major Flow Q_{100-5} (m^3/s)
	C	Rainfall Intensity (mm/hr)	Peak Flow Q_{10} (m^3/s)	C	Rainfall Intensity (mm/hr)	Peak Flow Q_{100} (m^3/s)	
1	0.63	61.00	1.16	0.8	103.00	2.456	1.29
2	0.83	77.30	0.70	1.0	129.80	1.415	0.72

Road Max. Water Elevations

Section		Overland Flow (m^3/s)	Max. W.L.[(1)]	Max. W.Depth[(2)]	Spread	Unflooded Width
ID	Station					
1	26+520	1.29	212.36	0.14	14.00	7
2	25+190	0.72	205.83	0.13	13.00	8

[(1)] *Maximum water elevation at each cross section is calculated using FlowMaster Software*
Refer to the attached FlowMaster Reports

[(2)] *Maximum Depth = Max. Water level - Road eelev.*

Overalnd Flows Section 1

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01000	m/m
Normal Depth	0.141	m

Section Definitions

Station (m)	Elevation (m)
0+00	212.52
0+00	212.22
0+11	212.43
0+21	212.22
0+21	212.52

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 212.52)	(0+21, 212.52)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	1.290	m³/s
Elevation Range	212.22 to 212.52 m	
Flow Area	1.00	m²
Wetted Perimeter	14.40	m
Hydraulic Radius	0.069	m
Top Width	14.11	m
Normal Depth	0.141	m
Critical Depth	0.17	m

Overalnd Flows Section 1

Results

Critical Slope		0.00388	m/m
Velocity		1.30	m/s
Velocity Head		0.09	m
Specific Energy		0.23	m
Froude Number		1.56	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.000	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.141	m
Critical Depth	0.17	m
Channel Slope	0.01000	m/m
Critical Slope	0.00388	m/m

Cross Section for Overalnd Flows Section 1

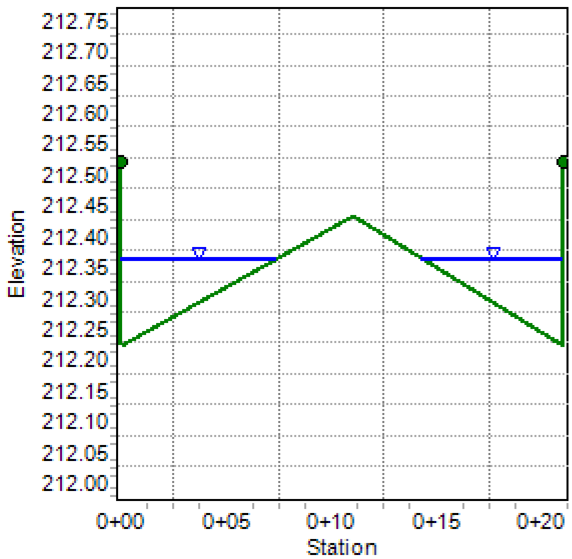
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01000	m/m
Normal Depth	0.141	m
Discharge	1.290	m³/s

Cross Section Image



Overalnd Flows Section 1

Results

Critical Slope	0.00388	m/m
Velocity	1.30	m/s
Velocity Head	0.09	m
Specific Energy	0.23	m
Froude Number	1.56	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.000	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.141	m
Critical Depth	0.17	m
Channel Slope	0.01000	m/m
Critical Slope	0.00388	m/m

Overalnd Flows Section 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00500	m/m
Normal Depth	0.129	m
Section Definitions		

Station (m)	Elevation (m)
0+00	206.00
0+00	205.70
0+11	205.91
0+21	205.70
0+21	206.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 206.00)	(0+21, 206.00)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	0.718	m³/s
Elevation Range	205.70 to 206.00 m	
Flow Area	0.83	m²
Wetted Perimeter	13.16	m
Hydraulic Radius	0.063	m
Top Width	12.90	m
Normal Depth	0.129	m
Critical Depth	0.13	m

Overalnd Flows Section 2

Results

Critical Slope		0.00420	m/m
Velocity		0.86	m/s
Velocity Head		0.04	m
Specific Energy		0.17	m
Froude Number		1.09	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.000	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.000	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.129	m
Critical Depth	0.13	m
Channel Slope	0.00500	m/m
Critical Slope	0.00420	m/m

Cross Section for Overalnd Flows Section 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.00500	m/m
Normal Depth	0.129	m
Discharge	0.718	m^3/s

Cross Section Image