Regional Municipality of Halton

Trafalgar Road Corridor Improvements EA, Cornwall Road to Highway 407

Stormwater Management Report

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Statement of Qualifications and Limitations

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01	Janelle Weppler	July 31, 2014	Report edits as per comments from Halton Region to incorporate SWM impacts from additional adjacent development.
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Appendices

1. Introduction

AECOM Canada Limited was retained by the Regional Municipality of Halton (Region) to complete an Environmental Assessment (EA) for Trafalgar Road from the north limit at Highway 407 to the south limit at Cornwall Road. This Stormwater Management (SWM) Report has been prepared in support of the EA to examine existing drainage conditions, evaluate the impact of the preferred roadway improvements on stormwater quality, quantity and flooding, and recommend measures to mitigate any impacts associated with the preferred road design alternative.

The Study Area is located within the Town of Oakville (Town) and falls entirely within the jurisdiction of Conservation Halton (CH) with portions of the site draining to Joshua's Creek, East Morrison Creek, West Morrison Creek, and the Morrison-Wedgewood Diversion, as illustrated on Figure 1.1.

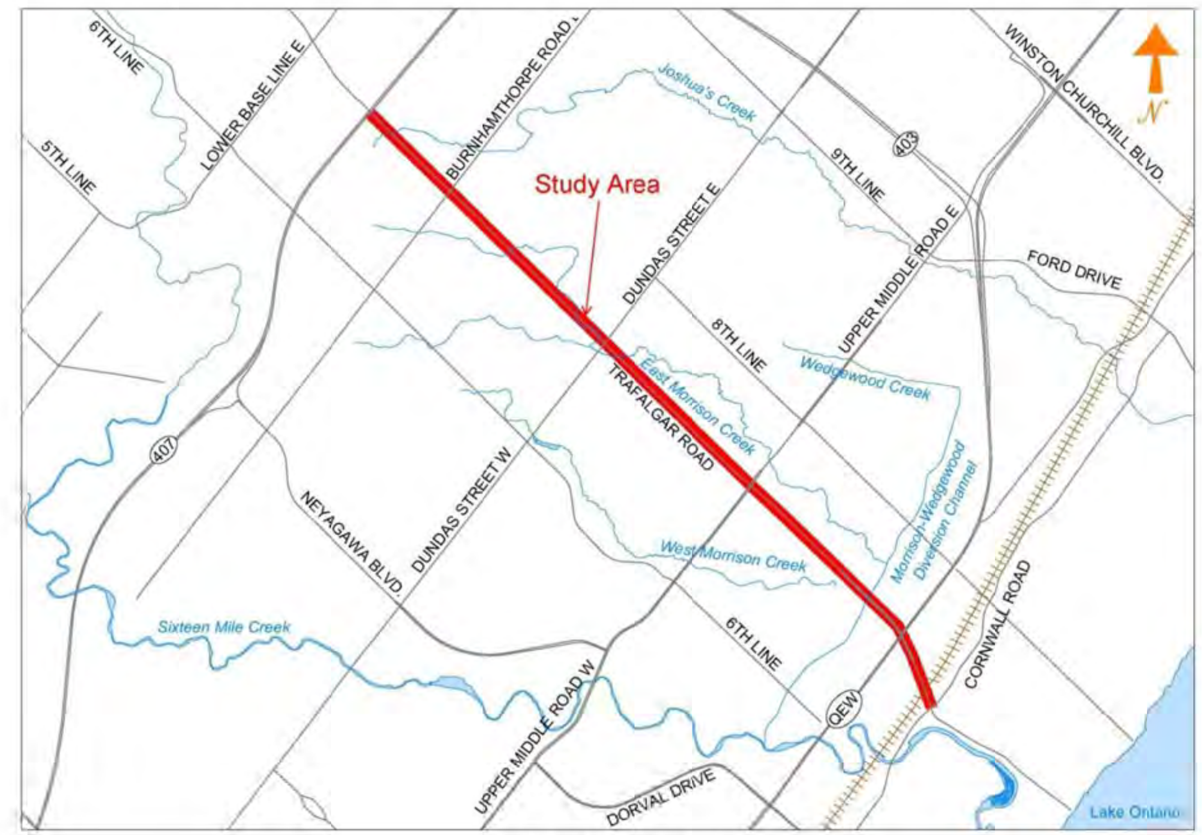

Figure 1.1 Study Area

1.1 Background Information

Numerous relevant studies and reports regarding drainage within and adjacent to the Study Area were reviewed during the preparation of this report, including the following:

- East Morrison Creek Subwatershed Study (EMCSS) prepared by Cosburn Patterson Wardman Limited, April 1995
- Master Drainage Study for West Morrison Creek prepared by Marshall Macklin Monaghan, October 1990 (Addendum March 1994)
- Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan Study prepared by R.V. Anderson Associates Limited, January 1993
- North Oakville Creeks Subwatershed Study (NOCSS) prepared by TSH, August 2006 (Addendum September 2007)

Several other studies and reports have been completed to support the preliminary design for subdivision development adjacent to Trafalgar Road and the detailed design for reconstructing Dundas Street, including the following:

- Environmental Implementation Report & Functional Servicing Study (EIR/FSS) for East Morrison Creek Subcatchment EM4 prepared by Stonybrook Consulting et. al on behalf of Dundas-Trafalgar Inc. & Shieldbay Inc., December 2012 (hereafter referred to as the East Branch EIR/FSS)
- EIR/FSS Update and Response Document EIR/FSS Dundas-Trafalgar Inc., North Oakville prepared by Stonybrook, January, 2014
- EIR/FSS Update and Response Document EIR/FSS Dundas-Trafalgar Inc., North Oakville prepared by Stonybrook, April, 2014
- Response to Agency Comments Dundas-Trafalgar Inc./Shieldbay Developments EIR/FSS prepared by Stonybrook, June, 2014
- Dundas-Trafalgar Inc. & Shieldbay Inc. East Morrison Creek Subcatchment EM4 EIR/FSS Update and Response Document prepared by Town of Oakville, March, 2014
- Email comments from Town to Urbantech regarding Minto site modeling prepared by Town of Oakville, May, 2014
- Highlight of Town comments from Matt Krusto prepared by Town of Oakville, May, 2014
- Supplementary Drawings and Figures for the Settlement Proposal for Draft Plan of Subdivision and Zoning By-law Amendment Application prepared by Urbantech, April, 2014-07-24
- Email response to Town and CH comments prepared by Urbantech, May, 2014
- Green Ginger Developments Inc. North Oakville Main-East Morrison Creek EIR/FSS prepared by Sernas, May, 2012
- Green Ginger Developments Inc. North Oakville Main-East Morrison Creek EIR/FSS prepared by Sernas, February, 2013
- EIR/FSS for North Oakville Main-East Morrison Creek prepared by Sernas Associates on behalf of Green Ginger Developments, May 2012 (hereafter referred to as the Main Branch EIR/FSS), including subsequent submissions dated February 2013 and July 19, 2013.
- Final Submission East Morrison Creek EMI EIR/FSS prepared by GHD, January 2014
- Drainage and SWM Report for the Detailed Design of the Reconstruction of Dundas Street (Regional Road 5) from Oak Park Boulevard to Highway 403 prepared by McCormick Rankin, December 2011
- Stormwater Management Report for the Stan Vine Subdivision prepared by Dillon, October, 1988
- FSR and SWM, Residential Development River Oaks Boulevard & Trafalgar Road prepared by Anton Kikas, August, 2006
- SWM Report for the Stan Vine Subdivision prepared by Dillon, October 1988

- Letter from Jim Stewart (Stantec Consulting Ltd.), addressed to Anton Kikas regarding provision of Stormwater Management Controls for the proposed Kilbarry site located north of River Oaks Boulevard prepared by Stantec, January, 2008
- Letter from Jim Stewart (Stantec Consulting Ltd.), addressed to Kilbarry Holding Corporation regarding Addendum to Functional Servicing Report and Stormwater Management Report prepared by Stantec, October, 2010
- Stormwater Management Conformance Letter of Kilbarry site prepared by Stantec, December, 2011
- Second Engineering Submission for Biddington Homes (formerly Kilbarry) prepared by Stantec, May, 2012
- Dunpar Developments Inc. Proposed Townhouse Development 2158, 2168, 2180 and 2192 Trafalgar Road Oakville, Ontario prepared by JSW and Associates, August 2012
- Dunpar Developments Inc. Proposed Townhouse Development 2158, 2168, 2180, and 2192 Trafalgar Road SWM Report prepared by JSW & Associates, January, 2014

The above background information was augmented with the following additional information to gain a comprehensive understanding of drainage and stormwater management (SWM) within the Study Area:

- Available soils mapping;
- Aerial photography;
- Topographical data, including survey data provided by the Region and contour data provided by the Town;
- Site visit completed on December 8, 2011 to investigate the existing conditions of mainline culverts crossing Trafalgar Road within the Study Area.

1.2 Objectives

The objective of this report is to provide preliminary recommendations for managing storm runoff for the preferred Trafalgar Road improvement alternative in compliance with design criteria defined by the Town, CH, and Ministry of Transportation Ontario (MTO). The criteria applied for managing stormwater and the hydraulic performance of culverts in the Study Area are described in the following sections.

1.2.1 Stormwater Management Criteria

The SWM criteria applicable to the Study Area were obtained from the *North Oakville Creeks Subwatershed Study* (NOCSS) (August, 2006), NOCSS Addendum (September, 2007), MOE guidelines, and the Town's *Development Engineering Procedures and Guidelines Manual (January 2011).*

The criteria from the NOCSS are applicable within the portion of the Study Area located north of Dundas Street and include the following:

Water Quality: The NOCSS defines water quality targets in Table 6.2.2, including targets for phosphorus, suspended solids, chloride, dissolved oxygen, and temperature as follows:

- Total phosphorus (TP) in loadings must not increase after development.
- Level 1 (enhanced protection) is required in the Morrison Creeks to achieve 80% total suspended solids (TSS) removal whereas Level 2 (normal protection, 70% TSS removal) is required for Joshua's Creek. The NOCSS further details that Level 1 protection is required for Joshua's Creek to achieve the TP removal criterion.
- No specific chloride target is provided in the NOCSS however it is recommended in Table 6.2.2 that the Town review the Federal Code of Practice (April, 2004), to identify areas that are vulnerable to road salt, and update the *Salt Management Plan*.

- A dissolved oxygen level of 6 mg/L is required in the Morrison Creeks while 5 mg/L is required for Joshua's Creek.
- A daily maximum mid-summer water temperature of 18°C is recommended for the Morrison Creeks. No water temperature recommendations are provided for Joshua's Creek within the Study Area.

Peak Flow Control: Post-development peak flows are to be controlled to rates based on target unit area peak flows (m^3/s/ha) published in Table 7.4.1 in the NOCSS Addendum (September 5, 2007) for the 2- to 100-year design storm events and the Regional storm. The target unit area peak flows documented within the NOCSS Table 7.4.1 (at Dundas Street) are based on existing conditions and are to be used to calculate target peak flows for new development projects at the EIR/FSS stage by applying updated subcatchment boundaries using more detailed topography.

Fluvial Geomorphology: The NOCSS requires that erosion rates in receiving watercourses be maintained at existing levels. Preliminary threshold flows for erosion were established in the NOCSS and continuous simulation modelling is required to demonstrate that the existing frequency and duration of exceedance of this threshold is not increased following development. Surrounding development has verified the erosion threshold locations and has carried out the associate modelling for development (including Trafalgar Road) north of Dundas Street only. It is recommended that erosion threshold flow rates be verified and established during the detailed design phase with application of updated and more detailed modeling, currently being prepared by the proposed developments adjacent to Trafalgar Road; assumptions made by others may need to be confirmed and / or updated by the Region at detailed design.

Hydrogeology: The NOCSS specifies that infiltration should be maximized to the extent feasible.

Post-development peak flows from Trafalgar Road located south of Dundas Street must be controlled to existing peak flows, up to the 100-year design storm event in accordance with the Town's guidelines and SWM facilities must provide Enhanced Level of treatment (i.e., 80% TSS removal) as per CH requirements.

The EMCSS provided recommended locations and sizing for extended detention ponds beyond the extents of this Study Area and therefore does not provide criteria applicable to the Study Area.

1.2.2 Hydraulic Criteria

The mainline culverts crossing Trafalgar Road must be in accordance with the hydraulic requirements of the MTO *Highway Drainage Design Standards* (HDDS), CH, and the Town.

Return Periods: The HDDS defines the design flow return period for culverts based on functional road classification and culvert span. Within the Study Area, Trafalgar Road is classified as a major arterial according to the *Livable Oakville*, Schedule C Transportation Plan (September, 2012) and is assumed to be the equivalent classification to an urban arterial in the HDDS. All ten (10) existing culverts in the Study Area are therefore considered as crossing an urban arterial road. Standard WC-1 (Sections 1.1.1) of the HDDS states for culverts crossing an urban arterial with a span less than 6 m, the 50-year return period design flow should be applied. The check flood return period for all culverts crossing an urban arterial is defined in Standard WC-1 (Section 1.1.1) and Standard WC-7 (Section 3.6) as 130% of the 100-year flood. Additional analysis is required during detailed design using the Regional storm due to the availability of floodline mapping and the potential for impact to adjacent properties, as per Standard WC-1 (Section 1.1.2).

Freeboard: For culverts crossing an urban arterial on a defined watercourse, the minimum freeboard from the lowest edge of the travelled lane to the high water level for the design flood is 1.0 m as per Standard

WC-7, Section 3.2. Standard WC-7 (Section 3.6) requires that the water level generated by the check flood (130% of the 100-year) shall not exceed the elevation of the travelling lanes. Conservation Halton's *Policies, Procedures and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document* (April 2006) does not specifically require that Regional roads be flood-free under Regional storm conditions. However, this is the current standard recommended by Conservation Halton for all major roads within Conservation Halton jurisdiction that may serve an emergency route purpose and has become a standard requirement for all roadways that will be experiencing an increase in use due to development.

Clearance: Open-bottom culverts with an erodible bottom must allow for a minimum clearance of 0.3 m from the high water level during the design storm (50-year) to the soffit of the culvert in accordance with Standard WC-7, Section 3.4.2.

Headwater to Depth Ratio: Open- and closed-footing culverts with a non-erodible bottom up to 3 m in diameter are subject to HDDS Standard WC-7 (Section 3.5) which limits the headwater-to-depth ratio (HW/D) to 1.5:1 during the design storm event.

The Town's *Development Engineering Procedures and Guidelines Manual* (January 2011) defines additional criteria for culvert capacity in Section 3.1.3.16. The manual states that, as a minimum requirement, arterial road crossings of watercourses shall be designed to provide capacity for 100-year to Regional flood frequencies with allowance for overtopping of roads and road crossings shall not result in an increase in upstream Regional flood levels.

The hydraulic requirements of watercourse crossings in the Study Area are summarized in Table 1.1.

Table 1.1 Summary of Hydraulic Design Criteria

Parameter	50-yr	100-yr	130% of 100-yr	Regional
Freeboard (m)	≥ 1 *		≥ 0 *	≥ 0 ***
HW/D	≤ 1.5 *	< 1 **		
Clearance (m)	≥ 0.3 *			
Water Level (Upstream)				No Increase****

Notes: *As per MTO HDDS
**As per Town's *Development Engineering Procedures and Guidelines Manual (January 2011)*
***As per CH requirements
****As per Town's *Development Engineering Procedures and Guidelines Manual (January 2011) and CH Requirements*

1.2.3 Target Unit Area Peak Flows

A conservative approach was taken to provide SWM storage volume and culvert size estimates in this study. The storage volume required to control peak flows were estimated using the lowest targets whereas the culvert size required to provide appropriate conveyance capacity was estimated using the highest targets. Both methods use the results of the NOCSS modelling and were confirmed verbally by Janette Brenner of CH on July 29, 2013 as being appropriate design criteria.

As summarized in Table 1.2, the low target unit area peak flows occur at the Dundas Street crossings. The targets were provided in NOCSS Table 7.4.1 (Targets at Dundas Street). The lower target peak flows require larger storage volumes for quantity control and their use is therefore conservative for SWM calculations.

Higher targets are found by looking at the culvert crossings located upstream of Dundas Street in the existing conditions modelling completed as part of the NOCSS (Table 5.4.1, existing flows at upstream culverts). For example, the culvert ME-T1 is located immediately upstream of the East Morrison Creek crossing at Dundas Street

(ME-D2) and has a target unit area peak flow of 0.020 m^3/s/ha for the 100-year storm. This is higher than the target unit area peak flow at ME-D2 of 0.016 m^3/s/ha for the 100-year storm. The high targets were calculated using the area draining to each culvert and peak flows generated by the NOCSS hydrologic model. Further discussion and detailed calculations for additional storms are provided in this study and are summarized for the 100-year storm in Table 1.2. The High Unit Area Peak Flow Rates shown in Table 1.2 should be revisited in detailed design.

Table 1.2 Target Unit Area Peak Flows for 100-Year Design Storm

Culvert Station	NOCSS Culvert ID	Low Targets Used for SWM Sizing (at Dundas St.) Source: NOCSS Table 7.4.1		High Targets Used for Culvert Sizing (upstream of Dundas St.) Source: Calculated using NOCSS Model Results	
		Culvert ID	Unit Area Peak Flow (m^3/s/ha)	Culvert ID[1]	Unit Area Peak Flow (m^3/s/ha)
n/a	ME-D2	ME-D2	0.016	ME-D2	0.016
5+500[2]	ME-T1	ME-D2	0.016	ME-T1	0.020
5+665	ME-T2	ME-D2	0.016	*ME-T1*	0.020
5+820	ME-T3	ME-D2	0.016	*ME-T1*	0.020
6+200	ME-T4	ME-D2	0.016	*ME-T1*	0.020
6+725	ME-T5	ME-D2	0.016	ME-T5	0.029
7+315	n/a	JC-D1	0.021	*JC-D1*	0.021
7+750	n/a	JC-D1	0.021	*JC-B10*	0.023
8+080	n/a	JC-D1	0.021	*JC-B10*	0.023
8+385	n/a	JC-D1	0.021	*JC-B10*	0.023

1 – Seven (7) of the culverts in the Study Area were not in the NOCSS models. In these cases, the results at the nearest downstream culvert included in the model was used to calculate a target unit area peak flow. The ID of the downstream culvert is provided in italics.

2 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station.

Culvert naming conventions varied between reports. Table 1.3 cross-references the culvert naming conventions between the Trafalgar Road EA Environmental Study Report (ESR) Appendices, i.e., the Natural Environment, Fluvial Geomorphology, and Stormwater Management (including structural) Assessment Reports.

Table 1.3 Cross-Reference Table for Culvert Naming Conventions

Station*	Structure ID	NOCSS ID#	Fluvial Geomorphology Crossing ID #
18+385			C1
18+080			CA
17+750			C2
17+315			CB
16+725		ME-T5	C3
16+200		ME-T4	CC
15+820		ME-T3	C4
15+665	03-1182530 CU01	ME-T2	C5
15+500	03-1182530 CU02	ME-T1	C6
15+228	03-1182510 CU01		C7
11+820	03-1182340 CU01		C8
11+775	03-1182340 BR01		C9

**Note that for the SWM report, all station numbers do not indicate the 10km placeholder, i.e. station 15+820 is identified in the SWM report as station 5+820.*

2. Existing Conditions

2.1 Existing Environment

In addition to field reconnaissance, several sources of information were used to characterize the Study Area including the following:

- North Oakville Creeks Subwatershed Study (2006) and Addendum (2007)
- 1:10,000 scale Ontario Base Maps (OBM)
- Elevation contours and other GIS data provided by the Town
- Aerial photography provided by the Region
- Soils of Halton County (Report 43 of the Ontario Soil Survey)
- Physiographic Maps (Chapman & Putnam)
- Utility mapping prepared by T2UE (2013)

2.1.1 Roadway Configuration

Between Highway 407 and Dundas Street, Trafalgar Road is primarily a rural, undivided four-lane roadway with gravel shoulders, small local areas of urbanization, and a posted speed limit of 80 km/hr.

From Dundas Street to the southern limits of the Study Area at Cornwall Road, Trafalgar Road is primarily an urban roadway with a short rural section located adjacent to Sheridan College. This length of Trafalgar Road has a mix of undivided and divided sections that include paved or grassed medians and, in some locations, a centre turning lane. Trafalgar Road is a four-lane roadway from Dundas Street East to Ceremonial Road at Sheridan College. The northbound lanes widen from two to three lanes at Ceremonial Road followed by a lane increase in the southbound lanes further south at White Oaks Boulevard where Trafalgar Road becomes a six-lane roadway that continues to the south limits of the Study Area at Cornwall Road.

2.1.2 Land Use

There is a wide range of land uses through the Study Area. North of Dundas Street, land use is primarily agricultural, with limited commercial activity at the intersection with Burnhamthorpe Road. However, this area north of Dundas Street is within the North Oakville East Secondary Plan area and is anticipated to be developed as the Trafalgar Road Urban Core Area. This designation allows for mixed use development in a 'main street' format, with retail and service commercial development oriented to the roadway.

The majority of the Study Area south of Dundas Street has already been developed as commercial, residential and institutional development. There are several large commercial developments between Dundas Street and Oak Park Boulevard. South of Oak Park Boulevard, the land use transitions to low and medium density residential.

Sheridan College is a large institutional development on the west side of Trafalgar Road, south of Upper Middle Road. Further south, parks and a woodlot are located adjacent to the road with the Town's offices southeast of the intersection with White Oaks Boulevard South.

Large commercial centres are present along Trafalgar Road both north and south of the Queen Elizabeth Way Highway (QEW), including Oakville Place Mall at the northwest corner of the interchange.

2.1.3 Soils

The predominant soils through the Study Area are Chinguacousy Clay Loam and Oneida Clay Loam. Both soils are typical of the Halton Till and have very limited infiltration capacity. Chinguacousy Clay Loam is classified as Hydrologic Soil Group (HSG) C in the US Soil Conservation Service (SCS) system while Oneida Clay Loam falls under HSG D.

2.1.4 Physiography and Topography

The majority of the Study Area lies within the South Slope Physiographic Region which is an area of glacial till deposited in a variety of landforms generally related to moraines (Chapman and Putnam, 1984). The Trafalgar Moraine is located north of Highway 407. The moraine loses definition east of Sixteen Mile Creek, and by Trafalgar Road is characterized as a broad, low undulation in the landscape. The Study Area generally slopes southward toward Lake Ontario.

2.1.5 Aquatic Resources

An important aquatic constraint for the Study Area from a national and provincial perspective is the presence of Redside Dace in the Morrison Creeks as reported in the NOCSS. Nationally, Redside Dace has been identified as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) according to the assessment completed in 2007 while the species is being considered for listing under the federal Species at Risk Act (SARA). Urban development is identified by the Recovery Strategy for Redside Dace in Ontario (2010) as one of nine potential threats to the remaining population. The strategy also relates the decline in the population directly to siltation and removal of bank cover in urban headwater areas. To protect the remaining population, the NOCSS follows the recommendations of the recovery strategy by requiring 'enhanced' level of SWM protection (80% TSS removal) for all reaches of streams supporting resident Redside Dace populations, including Fourteen Mile, East Morrison, and West Morrison Creeks.

2.2 Roadway Drainage System

The existing road drainage system is illustrated on Drawings 1 to 5 of Appendix A with further discussion in the following sections.

2.2.1 Highway 407 to Dundas Street

Between Highway 407 and Dundas Street, Trafalgar Road drains to roadside ditches that lead to the mainline crossing culverts. There are localized storm sewer systems providing drainage along short urban sections where Trafalgar Road intersects Burnhamthorpe Road and Dundas Street. Runoff from the Trafalgar Road Catchment Areas 10 to 14 is then directed in an easterly direction along rural ditches that discharge to a tributary of Joshua's Creek. This tributary of Joshua's Creek is classified by the NOCSS as a low constraint stream corridor just north of the William Halton Parkway crossing and as a medium constraint stream corridor to the south. The remaining Trafalgar Road Catchment Areas in this section (Catchment Areas 5 to 9) drain to East Morrison Creek, which is classified as a high constraint stream by the NOCSS downstream of the crossing at station 6+725 (ME-T5) of Trafalgar Road and then changes to a medium constraint reach before crossing Trafalgar Road again at station 5+820 (ME-T3).

2.2.2 Dundas Street to Cornwall Road

South of Dundas Street, Trafalgar Road has an urban cross section that includes curbs and gutters with some sections that also have roadside ditches that appear to partially collect external drainage areas.

<u>Dundas Street to Hays Boulevard</u>

Trafalgar Road has an urban section between Dundas Street and Hays Boulevard with two storm sewer outlets north and south of Culvert 5+225 discharging to East Morrison Creek. As shown on Drawing 2 of Appendix A, a ditch is also located on the west side of Trafalgar Road and directs external drainage to the upstream side of Culvert 5+225.

<u>Hays Boulevard to Upper Middle Road</u>

The majority of this length of Trafalgar Road has an urban section with curbs and gutters and a single storm sewer system that collects drainage from both the east and west sides of the road. This storm sewer system terminates at Upper Middle Road where it outlets to another storm sewer flowing east to East Morrison Creek, as shown on Drawings 3 and 4 of Appendix A.

There is an intermittent roadside ditch on the west side of Trafalgar Road that starts at Hays Boulevard and ends north of River Oaks Boulevard East. Ditch inlet catchbasins (DICBs) convey drainage to the main storm sewer system on Trafalgar Road.

An intermittent roadside ditch also runs along the east side of Trafalgar Road from Oak Park Boulevard/Postridge Drive to Glenashton Drive. Storm drainage from this ditch is collected in DICBs that convey flow to the Trafalgar Road storm sewer system.

Trafalgar Road has a short (250 m) rural section on both the east and west sides of the roadway from Oak Park Boulevard/Postridge Drive to approximately 75 m south of Rosegate Way.

<u>Upper Middle Road to Ceremonial Drive</u>

Trafalgar Road has an urban section from Upper Middle Road to approximately midway to White Oaks Boulevard North/Sheridan College. This section conveys roadway drainage through curbs and gutters into two parallel storm sewer systems that service the east and west sides of the roadway. Both parallel storm sewers terminate at the end of the urban section where the west side outlets to a roadside ditch through a 300 mm diameter round concrete pipe as shown in Figure 2.1. This storm sewer outlet was found to be largely filled with sediment and submerged.

Figure 2.1 Trafalgar Road West Side Storm Sewer Outlet to Ditch

The storm sewer on the east side of Trafalgar Road outlets to a roadside ditch that is conveyed across Trafalgar Road through a 600 mm diameter CSP and outlets to the west roadside ditch as shown in Figure 2.2. This crossing culvert was found to be largely buried and submerged as shown.

Figure 2.2 Culvert Conveying Runoff from East Roadside Ditch to West Roadside Ditch, Across Trafalgar Road

As shown on Drawing 4 of Appendix A, this west roadside ditch continues past Sheridan College, under Ceremonial Drive, and then departs due south through a woodlot towards West Morrison Creek. The east roadside ditch continues to collect runoff along the rural section of Trafalgar Road from White Oaks Boulevard North to approximately 75 m north of the plaza across from Ceremonial Drive. The east roadside ditch terminates at a DICB with an unknown connection to be further investigated at detailed design. For the purposes on this study, the ditch inlet is assumed to connect to the west roadside ditch and ultimately drain to West Morrison Creek.

Trafalgar Road has a rural section adjacent to Sheridan College that starts at the termination of the storm sewer system (midway between Upper Middle Road and White Oaks Boulevard North/Sheridan College access road) to approximately 75 m north of Ceremonial Drive. Roadway drainage throughout this rural section is conveyed by the previously described roadside ditches draining to West Morrison Creek.

Ceremonial Drive to Morrison-Wedgewood Diversion Channel

Trafalgar Road has an urban section throughout this length of roadway and includes curbs and gutters for roadway drainage conveyance with a storm sewer system for most of its length. Approximately midway between McCraney Street East and the Morrison-Wedgewood Diversion Channel, West Morrison Creek discharges into the Trafalgar Road storm sewer. As shown on Drawing 4 of Appendix A, the storm sewer system continues south and outlets at the Morrison-Wedgewood Diversion Channel.

Morrison-Wedgewood Diversion Channel to Cross Avenue/South Service Road

As-built drawings were not available for this length of Trafalgar Road. However, based on field reconnaissance, GIS data from the Town, and the utility mapping completed by T2UE, this urban section includes curbs and gutters with catchbasins collecting storm drainage into a storm sewer system that drains in the easterly direction along North Service Road, crosses the QEW in the southerly direction, and then drains westerly across Trafalgar Road to outlet to Lower Morrison Creek, as shown on Drawing 5 of Appendix A.

Cross Avenue/South Service Road to Cornwall Road

As-built drawings indicate that stormwater from this urban roadway with curbs and gutters is collected by catchbasins and conveyed through a storm sewer system that outlets to Sixteen Mile Creek, directly south of Cornwall Road, as shown on Drawing 5 of Appendix A.

2.3 Stormwater Management

There are no existing SWM controls to manage runoff from Trafalgar Road between Highway 407 and Cornwall Road except for the Morrison-Wedgewood Diversion Channel. The Morrison-Wedgewood Diversion Channel is a concrete flood control channel that crosses under Trafalgar Road north of the QEW. As described in the Lower Morrison/Wedgewood Creeks Master Drainage Plan Study, the channel was designed to convey flows from the East Morrison, West Morrison, and Wedgewood Creeks westward to Sixteen Mile Creek to prevent flooding downstream of the QEW (Town of Oakville, 1993).

The existing conditions peak flows from the Study Area during the 100-year storm were estimated and compared to peak flows during the Regional storm. The 100-year storm was found to have a higher peak intensity. Detailed design of Trafalgar Road should confirm the critical storm and include a full analysis for the 2- to 100-year and Regional storms. The existing peak flows from the Trafalgar Road corridor were calculated north and south of Dundas Street based on the NOCSS unit area peak flows and the Rational Method, respectively. The ROW corridor was divided into 14 catchments based on high and low points in the existing road profile and drainage outlets. The catchments are illustrated on Drawing 6 of Appendix A.

North of Dundas Street (hereafter referred to as the north corridor), peak flows were estimated based on the delineated ROW drainage area and the unit area peak flows obtained from Table 7.4.1 of the NOCSS Addendum. Relevant information from the NOCSS is provided in Appendix E. The unit area peak flows calculated using the detailed NOCSS model results are generally lower at Dundas Street and higher at the culverts located farthest upstream. Existing peak flows for the north corridor drainage areas were determined using the unit area peak flow rates at Dundas Street at ME-D2 and JC-D1 where the flows at each culvert crossing Trafalgar Road were determined using the NOCSS model results at each crossing. These two different approaches that apply a conservative approach for estimating existing flows were confirmed by Janette Brenner of CH on July 29, 2013.

The existing conditions 100-year storm peak flows are summarized in Table 2.1 and detailed calculations are provided in Appendix B.

Table 2.1 North Corridor Existing Peak Flows (100-Year Storm Event)

Catchment No.	Drainage Area (ha)	Nearest NOCSS Culvert No.	Unit Area Peak Flow ($m^3/s/ha$)	100-Year Storm Peak Flow (m^3/s)
5	1.49	ME-D2	0.016	0.025
6	0.76			0.013
7	1.95			0.032
8	1.94			0.032
9	2.66			0.044
10	2.27	JC-D1	0.021	0.048
11	0.84			0.018
12	1.68			0.036
13	0.24			0.005
14	1.94			0.041

In the absence of similar unit area peak flows for the catchments south of Dundas Street East (hereafter referred to as the south corridor), the Rational Method was applied. As defined in the MTO *Drainage Management Manual*, the Rational Method is appropriate for calculating peak flows for catchments less than 100 hectares in size. Weighted runoff coefficients were calculated to represent the impervious paved surfaces and the pervious grassed boulevards along the corridor. As required by the MTO *Drainage Management Manual*, the runoff coefficients of urban areas were increased by 25% for the 100-year return period. The times of concentration was calculated using the Watt & Chow equation and found to be a representative average of other methods applied, as further detailed in Appendix B. The Intensity-Duration-Frequency (IDF) curve parameters for the 100-year design storm were taken from the Town's *Development Engineering Guidelines*. The catchment parameters and resulting 100-year design storm peak flows are summarized in Table 2.2

Table 2.2 South Corridor Existing Peak Flows (100-Year Storm Event)

Catchment No.	Drainage Area (ha)	Runoff Coefficient C x 1.25	Time to Peak (hr)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	100-Year Design Storm Peak Flow (m^3/s)
1	4.23	0.90	**0.267**	22.90	119.83	**1.27**
2	3.48	0.85	**0.392**	33.57	91.19	**0.75**
3	7.97	0.83	**0.686**	58.82	59.47	**1.09**
4	1.33	0.74	**0.183**	15.69	153.89	**0.42**

2.4 Mainline Crossing Culverts

Within the Study Area, Trafalgar Road crosses tributaries of Joshua's creek at four locations and East Morrison Creek at six locations. As shown on Drawing 7 of Appendix A, the culvert named ME-D2 in the NOCSS is outside of the Study Area but is located between two East Morrison Creek crossings within the Study Area.

The following sections summarize the existing properties of the culverts within the Study Area as determined by field investigation and the hydraulic analysis completed to assess the ability of the mainline culverts to safely convey peak flows under existing conditions.

2.4.1 Physical Properties

A site visit was completed on December 8, 2011 to investigate the existing conditions of the ten mainline culverts crossing Trafalgar Road within the Study Area. Interior and exterior photographs were taken at both ends of each culvert in addition to documenting material condition, presence and severity of deformation, water levels, sediment depth, and inlet/outlet configuration. The size and shape of each culvert was also verified. Using the documented observations, each culvert's condition was rated as 'good', 'acceptable', 'poor', or 'very poor'. The following subsections describe the detailed findings of the field investigation.

For reference, Halton Region's structure appraisals / inspection reports are included in Appendix H.

2.4.1.1 Highway 407 to Burnhamthorpe Road

Between Highway 407 and Burnhamthorpe Road, there are three culverts that convey drainage from west to east under Trafalgar Road at stations 8+385, 8+080, and 7+750 as illustrated on Drawing 7 of Appendix A. The three drainage courses lead to a tributary of Joshua's Creek classified as a low to medium constraint stream corridor in the NOCSS. Drainage courses crossing Trafalgar Road in this area do not have assigned constraint ratings in the NOCSS and can be replaced by drainage infrastructure.

Culvert 8+385

The culvert located at station 8+385 is a corrugated steel pipe (CSP) with a diameter of 800 mm and was found to be in good condition overall, as illustrated on Figure 2.3. This culvert appears to be an older culvert with a new extension on the upstream end (west face). The downstream end (east face) was found to be crushed, likely due to recent roadside ditch grading. A small amount of sedimentation was found within this culvert, likely due to the construction and consequential ditch disturbance upstream, as illustrated on Figure 2.3. This culvert was found to have a low flow shallow depth of water throughout its length.

West Face

East Face

Figure 2.3 Culvert 8+385

Culvert 8+080

The existing mainline culvert crossing Trafalgar Road at station 8+080 is a 1000 mm CSP that showed some corrosion and internal buckling with a crushed upstream end. The overall condition of this culvert was determined to be poor. The culvert was found to have a significant amount of sedimentation (300 mm) at the downstream end as well as a significant depth of water throughout. The upstream end had a water depth of 500 mm where the downstream end had a water depth of 300 mm above the sedimentation. The upstream and downstream ends are shown on Figure 2.4. The downstream (east) end of the culvert was found to be largely overgrown with vegetation, as illustrated on Figure 2.4.

West Face

East Face

Figure 2.4 Culvert 8+080

Culvert 7+750

The culvert located at station 7+750 appears to be a relatively new 1400 mm diameter (CSP). Field reconnaissance found little sedimentation at the culvert inlet and 500 mm of sediment has accumulated at the outlet. A water depth of 350 mm was found at the upstream end whereas a water depth of 100 mm was found above the sedimentation at the downstream end. The culvert condition was evaluated as acceptable due to corrosion of the steel and the assessed degree of deformation, as shown on Figure 2.5. Both ends were found to have a significant amount of vegetative growth.

West Face (Inlet)

East Face (Outlet)

Figure 2.5 Culvert 7+750

2.4.1.2 Burnhamthorpe Road to Oak Park Boulevard

Seven mainline culverts crossing Trafalgar Road are located between Burnhamthorpe Road and Oak Park Boulevard, as shown on Drawing 7 of Appendix A. One culvert drains to a tributary of Joshua's Creek while the other six culverts drain to or convey East Morrison Creek.

The first three culverts south of Burnhamthorpe Road are located at stations 7+315, 6+725 (ME-T5), and 6+200 (ME-T4) as illustrated on Drawing 7 of Appendix A. The mainline culvert crossing Trafalgar Road at station 7+315 is located on the south side of the golf centre immediately south of Burnhamthorpe Road and drains to a tributary of Joshua's Creek. This drainage course does not have a constraint rating defined in the NOCSS.

The watershed divide between Joshua's Creek and East Morrison Creek is located approximately a third of the way between culverts 7+315 and 6+725 (ME-T5) as shown on Drawing 7 of Appendix A. Two small drainage courses cross under Trafalgar Road at stations 6+725 (ME-T5) and 6+200 (ME-T4), approximately mid-way between Burnhamthorpe Road and Dundas Street. These drainage courses are within the headwaters of East Morrison Creek and although they do not have a constraint rating in the NOCSS, the watercourse at 6+725 (ME-T5) is located approximately 150 m upstream of a high constraint stream corridor section and the watercourse at 6+200 (ME-T4) is located approximately 85 m upstream of a medium constrain stream corridor section.

Culvert 7+315

Twin corrugated steel pipe arches (CSPA) with a span of 1390 mm and rise of 970 mm are located at station 7+315 of Trafalgar Road. As illustrated on Figure 2.6 and Figure 2.7, both the inlet and outlet are concrete headwalls. The twin CSPAs were both found to have acceptable levels of corrosion and deformation. Field reconnaissance found that sedimentation has accumulated in CSPAs to a depth of 270 mm at the upstream end of both cells. Sedimentation depth at the downstream end of the north cell is 420 mm and is 370 mm in the south cell. Water depths of 100 mm above the sedimentation in both cells upstream and downstream were found. Both upstream and downstream ends of the twin CSPA culverts were found to be overgrown with vegetation.

West Face

East Face

Figure 2.6 Culvert 7+315 (North Cell)

West Face (Inlet)

East Face (Outlet)

Figure 2.7 Culvert 7+315 (South Cell)

Culvert 6+725 (ME-T5)

A single CSPA culvert crosses Trafalgar Road at station 6+725 (ME-T5) with a span of 1880 mm and rise of 1260 mm. Physical assessment of this culvert determined that the material was in good condition with some corrosion and the degree of deformation was found to be acceptable due to the internal buckling located two thirds from the upstream end. An accumulation of sediment was found within the culvert that measured 210 mm at the upstream end and 460 mm at the downstream end. As shown on Figure 2.8, Water depths of 300mm upstream and 200 mm downstream above the sedimentation were found. Both upstream and downstream ends of the CSPA culvert were found to be overgrown with vegetation. The presence of watercress was detected indicating the surfacing of groundwater in the vicinity of this culvert crossing.

West Face

East Face

Figure 2.8 Culvert 6+725 (ME-T5)

Culvert 6+200 (ME-T4)

The culvert crossing Trafalgar Road at station 6+200 (ME-T4) is a 600 mm diameter CSP. Physical assessment of this culvert determined that the material was in poor condition with corrosion along the entire length and at several locations at both ends where perforations had corroded completely through the culvert walls as shown on Figure 2.9. The degree of deformation was found to be good due to minor deformation of the upstream (west) end and compression of the downstream (east) end. As shown on Figure 2.9, an accumulation of sediment was found within the culvert that measured 80 mm at the upstream end and 55 mm at the downstream end. Both upstream and downstream ends of the CSP culvert were found to be overgrown with vegetation.

West Face

East Face

Figure 2.9 Culvert 6+200 (ME-T4)

As illustrated on Drawing 7 of Appendix A, East Morrison Creek crosses Trafalgar Road three times over a short length north of Dundas Street at stations 5+820 (ME-T3), 5+665 (ME-T2) and 5+500 (ME-T1). The creek then crosses Dundas Street west of Trafalgar Road through culvert ME-D2. The reach along these three crossings is considered a medium constraint stream corridor in NOCSS and as such, may be relocated but the form and function must be maintained.

East Morrison Creek crosses back to the east side of Trafalgar Road a short distance south of Dundas Street at station 5+225. East Morrison Creek remains on the east side of Trafalgar Road flowing in a south-easterly direction and crosses Postridge Drive, Glenashton Drive, and Upper Middle Road before ultimately draining to the Morrison-Wedgewood Diversion Channel. West Morrison Creek also flows in a south-easterly direction and comes close to the west side of Trafalgar Road south of Upper Middle Road but does not cross Trafalgar Road. West Morrison Creek is conveyed by storm sewers from McCraney Street East to the Morrison-Wedgewood Diversion Channel.

Culvert 5+820 (ME-T3)

The mainline culvert crossing Trafalgar Road at station 5+820 (ME-T3) is a twin 1000 mm CSP with a concrete headwall at both ends that conveys flow from east to west. The north cell showed some corrosion and minor deformation deeming it to have an overall condition of good. The south cell also showed some corrosion however it was found to be buckled approximately one third from the downstream end and the overall condition was determined to be acceptable, according to MTO guidelines. Both the upstream and downstream ends of each CSP cell are shown on Figure 2.10 and Figure 2.11.

Sedimentation was found at both ends of each cell. Both cells had 100 mm of sediment accumulated at the upstream end while the downstream ends had 200 mm and 250 mm in the north and south cells, respectively. A depth of water above the sedimentation was found throughout the length each CSP. At the upstream end, 150 mm of water was observed in the north cell and 200 mm in the south cell. The water depth at the downstream ends reached 200 mm in the north cell and 100 mm in the south. Both upstream and downstream ends of each CSP culvert were found to be overgrown with vegetation. The presence of watercress was detected indicating the surfacing of groundwater in the vicinity of this culvert crossing.

East Face

West Face

Figure 2.10 Culvert 5+820 (ME-T3) (North Cell)

West Face (Inlet)

East Face (Outlet)

Figure 2.11 Culvert 5+820 (ME-T3) (South Cell)

AECOM Regional Municipality of Halton Trafalgar Road Corridor Improvements EA, Cornwall Road to Highway 407 Stormwater Management Report

Culvert 5+665 (ME-T2)

The mainline culvert crossing Trafalgar Road at station 5+665 (ME-T2) is a concrete box with a span of 1800 mm, a rise of 1050 mm, and an open footing that conveys flow from west to east. The culvert appeared to have an extension previously installed however both the original and extension portions of the culvert appeared to be in good condition as shown on Figure 2.12. An accumulation of sediment was found only at the downstream end and measured 150 mm. Water depths above the invert upstream and above the accumulated sediment downstream were found to be 250 mm and 200 mm, respectively. Both ends of the culvert were found to be overgrown with vegetation. The presence of watercress was detected indicating the surfacing of groundwater in the vicinity of this culvert crossing.

West Face (Inlet)

East Face (Outlet)

Figure 2.12 Culvert 5+665 (ME-T2)

Culvert 5+500 (ME-T1)

The mainline culvert crossing Trafalgar Road at station 5+500 (ME-T1) is a concrete box with a span of 2440 mm and rise of 1520 mm that conveys flow from east to west. This box culvert appeared to be an older culvert with a recently installed extension. Both the original and extension portions of the culvert appeared to be in good condition as shown on Figure 2.13. An accumulation of sediment was found at both the upstream and downstream end measuring 420 mm and 270 mm, respectively. Water was steadily flowing with a depth above the sediment at the upstream end of 100 mm and 250 mm at the downstream end. The presence of watercress was detected indicating the surfacing of groundwater in the vicinity of this culvert crossing.

East Face (Inlet)

West Face (Outlet)

Figure 2.13 Culvert 5+500 (ME-T1)

Culvert 5+225

A large CSPA culvert with a span of 3480 mm and rise of 2210 mm conveys East Morrison Creek from west to east under Trafalgar Road at station 5+225, south of Dundas Street. This culvert was found to be severely corroded with perforations completely through the culvert walls as shown on Figure 2.14. The degree of deformation was found to be minimal however the overall condition of this culvert was determined to be very poor due to the severity of corrosion. There was no sediment accumulation on either the upstream or downstream ends, as shown on Figure 2.15. A water depth of 150 mm was found throughout the culvert and watercress was present indicating the surfacing of groundwater.

Figure 2.14 Corrosion at Culvert 5+225

West Face

East Face

Figure 2.15 Culvert 5+225

2.4.1.3 *Summary of Culvert Inspection Results*

The results of the culvert inspection and existing properties of each culvert are summarized in Table 2.3. The properties of the Dundas Street culvert (ME-D2) are the proposed conditions from the *Drainage and SWM Final Report* for the reconstruction of Dundas Street (McCormick Rankin, 2011).

Table 2.3 Culvert Crossing Condition Summary

Station	NOCSS ID	Size	Overall AECOM Condition Rating (2013)
5+225[1]	n/a	3480 x 2210 mm CSP arch	Very Poor
n/a	ME-D2	4270 x 2000 mm CONC. box	n/a
5+500	ME-T1	2440 x 1520 mm CONC. box	Good
5+665	ME-T2	1800 x 1050 mm CONC. Box (open footing)	Good
5+820 (North Cell)	ME-T3	1000 mm diameter CSP	Good
5+820 (South Cell)	ME-T3	1000 mm diameter CSP	Acceptable
6+200	ME-T4	600 mm diameter CSP	Poor
6+725	ME-T5	1880 x 1260 mm CSP arch	Acceptable
7+315 (North Cell)	n/a	1390 x 970 mm CSP arch	Acceptable
7+315 (South Cell)	n/a	1390 x 970 mm CSP arch	Acceptable
7+750	n/a	1400 mm diameter CSP	Acceptable
8+080	n/a	1000 mm diameter CSP	Poor
8+385	n/a	800 mm diameter CSP	Good

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station .

2.4.2 Hydraulic Analysis

A hydraulic analysis was completed to assess the ability of the existing culverts crossing Trafalgar Road within the Study Area to safely convey the applicable peak flow under existing conditions. The performance of each culvert was evaluated based on the MTO and Town drainage criteria outlined in Section 1.2. Two previously developed HEC-RAS hydraulic models of East Morrison Creek including culvert crossings at five (5) stations 5+225, 5+500 (ME-T1), 5+665 (ME-T2), 5+820 (ME-T3), and 6+725 (ME-T5) were updated to evaluate the existing level of service, as highlighted in yellow on Figure 2.16 and Figure 2.17. The remaining culvert crossings at stations 6+200 (ME-T4), 7+315, 7+750, 8+080, and 8+385 were modelled using CulvertMaster, as highlighted in cyan on Figure 2.16 and Figure 2.17. A detailed discussion of the process of developing the HEC-RAS models based on the HEC-2 model from the EMCSS and the NOCSS HEC-RAS model is provided in Appendix C. The appropriate methodology for this hydraulic analysis was determined through communications with CH.

During field inspection, significant sediment accumulation was recorded in several of the crossing culverts in addition to deformation of the original barrel. The analysis of the existing conditions in both HEC-RAS and CulvertMaster assumed that the accumulated sediment would be removed and the full capacity of each culvert was considered.

Several other hydraulic models of the East Morrison Creek crossings of Dundas Street and Trafalgar Road are being prepared simultaneous to the Trafalgar Road Corridor Improvements EA. These models are in support of the subdivision developments adjacent to Trafalgar Road and the reconstruction of Dundas Street. All of the above hydraulic models should be coordinated during detailed design, and include the resulting floodline mapping. Recommendations made in this report will need to be reviewed during detailed design to evaluate the impacts on the results and recommendations documented within this report.

The following sections describe the hydraulic models and summarize the hydraulic performance of each existing culvert in the Study Area.

2.4.2.1 South Hydraulic Model

The mainline culvert crossing Trafalgar Road at station 5+225 was evaluated using the EMCSS HEC-2 model (converted to HEC-RAS), of East Morrison Creek extending from the Morrison-Wedgewood Diversion Channel to Dundas Street, as shown on Figure 2.16. The model is hereafter referred to as the south hydraulic model with its extents highlighted in red on Figure 2.16.

Observations were made while reviewing the original model from the EMCSS regarding the representation of East Morrison Creek downstream of the Study Area. Additional field reconnaissance, clarification by the regulatory authorities, and modifications may be required in the future to address the following observations:

- Manning's n values applied throughout the model not referenced in the EMCSS
- Revisions were made to the model after publication of the EMCSS (i.e. cross sections added)
- Insufficient expansion and contraction coefficients
- Inconsistencies between reach lengths in model and drawing (i.e. RS 5265.41)
- Inconsistencies between reported and modelled culvert properties
- Inconsistencies in applied flow data and flow change locations (i.e. Glenashton Drive)

These inconsistencies are noted for further review and possible revision during detailed design. The south hydraulic model results are subject to change due to future updates from more detailed information representing existing conditions.

Figure 2.16 South Hydraulic Model

The flow profiles in the south hydraulic model are summarized in Table 2.4.

Table 2.4 South Hydraulic Model Flow Profiles (HEC-RAS)

Flow Change Location				Profile Names and Flow Rates (m^3/s)							
River	Reach	RS	Description	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	1.3 x 100 YR	Regional
RIVER-1	Reach-1	5565.71	U/S of Dundas (HWY 5)	1.66	2.63	3.22	4.10	4.69	5.31	6.90	14.00
RIVER-1	Reach-1	5466.84	D/S of Dundas (HWY 5)	7.5	11.6	14.3	17.8	20.4	22.9	29.77	37.7
RIVER-1	Reach-1	5320.74	U/S of Trafalgar Road*	9.3	14.4	17.9	22.2	25.6	28.7	37.31	48.9
RIVER-1	Reach-1	3226.50	@ Glenashton Drive	9.2	15.5	19.4	24.3	28.1	31.6	41.08	59.8
RIVER-1	Reach-1	1909.57	@ Upper Middle Road	9.6	16.5	20.8	26.1	30.3	34.0	44.20	67.7

* – Flow change location not included with provided EMCSS HEC-RAS model; flows extracted from Table 7 of EMCSS Report and appended to model

The updated south hydraulic model was run using subcritical, supercritical, and mixed regimes. The comparison of the resulting water surface elevations and energy grade lines computed during the Regional storm under the three regimes is provided in Appendix C and indicates that the subcritical flow regime resulted in the highest energy gradeline at the upstream end of the model. Therefore, the subcritical flow regime was conservatively used for hydraulic analysis in this report. A summary of the culvert performance compared to MTO and Town standards is provided in Section 2.4.2.4.

2.4.2.2 North Hydraulic Model

Four of the mainline culverts crossing Trafalgar Road north of Dundas Street were evaluated using the NOCSS HEC-RAS model of East Morrison Creek extending from the headwaters of the creek to Dundas Street, as highlighted in green on Figure 2.17. All four culverts convey the east branch of East Morrison Creek. The updated model is hereafter referred to as the north hydraulic model with its extents highlighted in green on Figure 2.17.

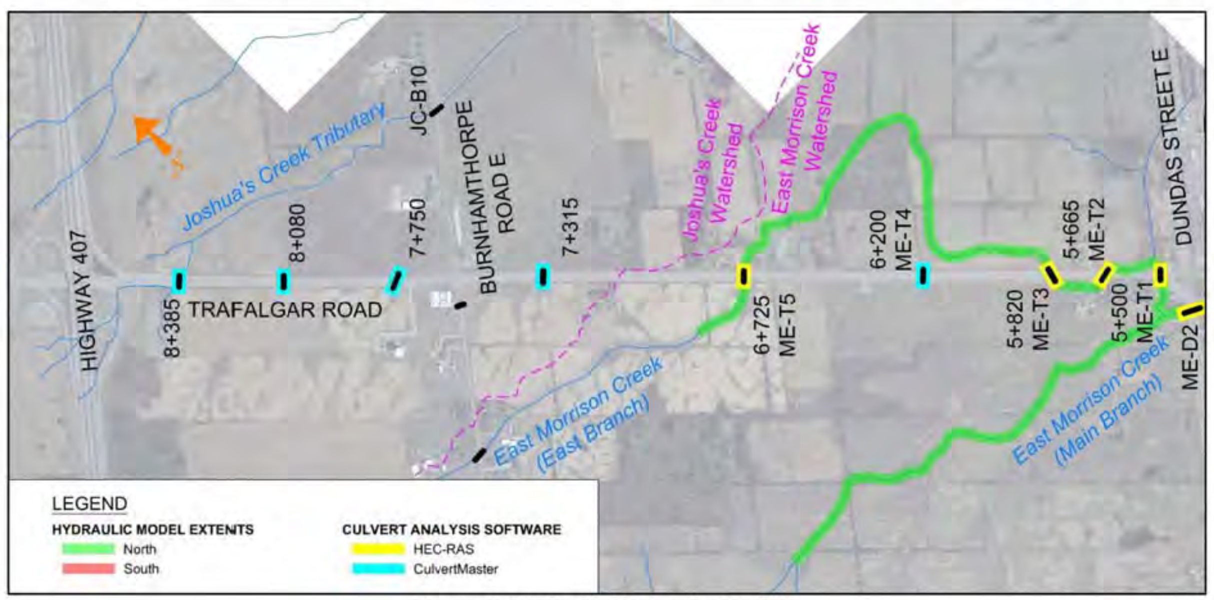

Figure 2.17 North Hydraulic Models

The flow profiles in the north hydraulic model are summarized in Table 2.5 with the applied flow change locations within HEC-RAS shown on Drawing 8 of Appendix A. Detailed discussion and calculations of updated peak flows are provided in Appendix C. The north and south models are connected using the known water surface elevation at

the upstream end of the south model as the downstream boundary condition of the north model. The areas draining to each culvert are illustrated on Drawing 8 of Appendix A. Different unit area peak flows were used for culvert and SWM storage analysis in order to attain conservative estimates from preliminary calculations. The conservative approach for culvert sizing uses high flows whereas controlling discharge to low flows is conservative for sizing SWM facilities. Overall, the NOCSS unit area peak flows are lowest at the Dundas Street crossings and highest at the crossings farther north. Therefore, the low unit area peak flows from the Dundas Street crossings were used for SWM storage estimates whereas the specific unit area peak flows were calculated for each culvert in order to evaluate hydraulic performance.

Table 2.5 North Hydraulic Model Flow Profiles

Flow Change Location					Profile Names and Flow Rates (m^3/s)							
River	Reach	RS	Drainage Area (ha)	Calculation Description	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	1.3 x 100-Year	Regional
RIVER-1	Reach-1	40	43.80 *	ME-T5	0.42	0.65	0.78	0.99	1.13	1.27	1.65	2.72
RIVER-1	Reach-1	35	43.80 *	ME-T5	0.42	0.65	0.78	0.99	1.13	1.27	1.65	2.72
RIVER-1	Reach-1	30	63.53	Transposition	0.53	0.83	1.01	1.28	1.46	1.65	2.14	4.05
RIVER-1	Reach-1	26	96.10	ME-T3	0.63	0.99	1.20	1.52	1.74	1.96	2.55	4.83
RIVER-1	Reach-1	23	105.20	ME-T2	0.69	1.08	1.32	1.67	1.91	2.15	2.80	5.29
RIVER-1	Reach-1	21	150.20	ME-T1	0.98	1.54	1.88	2.38	2.72	3.07	3.99	7.55
RIVER-2	Reach-1	16	26.94	Prorated ME-D2	0.14	0.22	0.27	0.34	0.39	0.44	0.58	1.17
RIVER-2	Reach-1	8	118.73	Prorated ME-D2	0.61	0.97	1.19	1.51	1.73	1.96	2.55	5.17
RIVER-2	Reach-2	4	321.60	ME-D2	1.66	2.63	3.22	4.10	4.69	5.31	6.90	14.00

* – The same peak flows were used at cross section 40 and 35 as directed by CH on May 2, 2013.

The north hydraulic model results are summarized in Section 2.4.2.4.

2.4.2.3 CulvertMaster Models

The five (5) remaining Trafalgar Road crossings north of Dundas Street not included in either the NOCSS or EMCSS HEC-RAS hydraulic models were evaluated using CulvertMaster. CulvertMaster analyzes culverts under both inlet control and outlet control conditions. The inlet control headwater is based on the inlet control nomograph equations provided in the *Hydraulic Design of Highway Culverts* (HDS-5) by the US Federal Highway Administration. The outlet control analysis uses standard methods for determining entrance, exit, friction losses through a culvert and tailwater elevations measures during field reconnaissance.

One of the five (5) remaining culverts drains to the east branch of East Morrison Creek whereas the other four (4) drain to a tributary of Joshua's Creek, as highlighted in blue on Figure 2.17.

The areas draining to each culvert are illustrated on Drawing 8 of Appendix A and were delineated using a combination of the following:

- LiDAR from East Branch EIR/FSS
- Survey data provided by the Region
- Contour data provided by the Town
- Drainage area drawings from the NOCSS and East and Main Branch EIR/FSS reports

The peak flows for each culvert were calculated using the drainage areas described above and unit area peak flows for the nearest downstream culvert modelled in NOCSS. The peak flows for each culvert modelled in CulvertMaster are summarized in Table 2.6.

Table 2.6 Peak Flows Used in CulvertMaster Models

Station	ID	NOCSS Culvert No. *(Nearest Downstream Culvert)*	Watershed / Tributary	Drainage Area (ha)	Peak Flow (m^3/s)		
					50-Year	100-Year	Regional
6+200[1] (ME-T4)	6	*(ME-T1)*	East Morrison Creek (EM4)	1.58	0.029	0.032	0.080
7+315	8	*(JC-D1)*	Joshua's Creek (JC9)	24.26	0.46	0.52	1.26
7+750	9	*(JC-B10)*	Joshua's Creek (JC7)	26.93	0.54	0.61	1.45
8+080	10	*(JC-B10)*	Joshua's Creek (JC7)	7.99	0.16	0.18	0.43
8+385	11	*(JC-B10)*	Joshua's Creek (JC7)	11.27	0.23	0.26	0.61

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The results of the CulvertMaster analysis are summarized with the other existing hydraulic analysis results in Section 2.4.2.4 and further details are provided in Appendix C.

2.4.2.4 Summary of Results

The results of the existing conditions hydraulic models using HEC-RAS and CulvertMaster are summarized in Table 2.7 through Table 2.10 in comparison to the design criteria summarized in Section 1.2.2 and Table 1.1. As can be seen from Table 2.7, the hydraulic modelling of the 50-year design storm event indicates that four (4) culverts (5+225, 5+500/ME-T1, 5+665/ME-T2 and 5+820/ME-T3) could be overtopped while the culvert at 6+725 (ME-T5) does not overtop but does not meet the minimum 1.0 m freeboard requirement. Five (5) of the ten (10) culvert crossings achieve both of the HDDS requirements for freeboard and headwater-to-depth ratio or clearance during the 50-year design storm event.

Table 2.7 Existing Culvert Performance Summary – 50-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Headwater to Depth Ratio(HW/D)	Clearance (m)	Freeboard (m)
5+225[1]	25.60	168.63	OVERTOPPING		
5+500 (ME-T1)	2.72	168.72	OVERTOPPING		
5+665 (ME-T2)	1.91	168.85	OVERTOPPING		
5+820 (ME-T3) – South Cell	1.74	170.03	OVERTOPPING		
5+820 (ME-T3) – North Cell					
6+200 (ME-T4)	0.029	174.79	0.30	n/a	1.90
6+725 (ME-T5)	1.13	180.05	0.62	n/a	0.85
7+315 – South Cell	0.46	180.88	0.29	n/a	1.42
7+315 – North Cell			0.31	n/a	1.42
7+750	0.54	182.78	0.44	n/a	1.98
8+080	0.16	184.68	0.36	n/a	1.72
8+385	0.23	184.85	0.59	n/a	1.56
MTO Highway Drainage Design Standards			≤ 1.5	≥ 0.3 m	≥ 1.0 m
PASS	FAIL	N/A			

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The hydraulic modelling results summarized in Table 2.8 indicates that four (4) of the ten (10) culvert crossings do not achieve the headwater-to-depth ratio during the 100-year storm event as per the Town's requirements.

Table 2.8 Existing Culvert Performance Summary – 100-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Headwater to Depth Ratio(HW/D)
5+225[1]	28.70	168.67	1.93
5+500 (ME-T1)	3.07	168.80	1.77
5+665 (ME-T2)	2.15	168.97	1.65
5+820 (ME-T3) – South Cell	1.96	170.12	1.01
5+820 (ME-T3) – North Cell			1.18
6+200 (ME-T4)	0.032	174.80	0.32
6+725 (ME-T5)	1.27	180.05	0.62
7+315 – South Cell	0.52	180.90	0.31
7+315 – North Cell			0.33
7+750	0.61	182.82	0.47
8+080	0.18	184.70	0.38
8+385	0.26	184.89	0.64
Town Development Engineering Requirements			≤ 1
PASS	FAIL	N/A	

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The headwater elevation generated by the check flows (130% of the 100-year storm event peak flows) could overtop the road at four (4) of the ten (10) culvert crossings while the other six (6) culvert crossings achieve the MTO HDDS freeboard requirement, as summarized in Table 2.9.

Table 2.9 Existing Culvert Performance Summary – 130% of 100-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Freeboard (m)
5+225[1]	37.31	168.76	OVERTOPPING
5+500 (ME-T1)	3.99	168.96	OVERTOPPING
5+665 (ME-T2)	2.80	169.24	OVERTOPPING
5+820 (ME-T3) – South Cell	2.55	170.41	OVERTOPPING
5+820 (ME-T3) – North Cell			
6+200 (ME-T4)	0.042	174.82	1.87
6+725 (ME-T5)	1.65	180.14	0.76
7+315 – South Cell	0.67	180.95	1.35
7+315 – North Cell			1.35
7+750	0.79	182.92	1.84
8+080	0.24	184.76	1.64
8+385	0.33	184.96	1.45
MTO Highway Drainage Design Standards			≥ 0
PASS	FAIL	N/A	

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

Regional roads must be free of flooding during the Regional storm event as per CH requirements, however the results summarized in Table 2.10 indicate that four (4) of the ten (10) culvert crossings will overtop while the other six (6) achieve the freeboard requirement.

Table 2.10 Existing Culvert Performance Summary – Regional Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Freeboard (m)
5+225[1]	48.90	168.85	OVERTOPPING
5+500 (ME-T1)	7.55	169.17	OVERTOPPING
5+665 (ME-T2)	5.29	169.50	OVERTOPPING
5+820 (ME-T3) – South Cell	4.83	170.86	OVERTOPPING
5+820 (ME-T3) – North Cell			
6+200 (ME-T4)	0.08	174.91	1.78
6+725 (ME-T5)	2.72	180.50	0.40
7+315 – South Cell	1.26	181.11	1.19
7+315 – North Cell			1.19
7+750	1.45	183.21	1.55
8+080	0.43	184.92	1.48
8+385	0.61	185.23	1.18
CH Requirements			≥ 0
PASS	FAIL	N/A	

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

Overall, the mainline culvert crossings at stations 5+225, 5+500 (ME-T1), 5+665 (ME-T2), and 5+820 (ME-T3) fail to meet the hydraulic requirements during the 50-year, 100-year, check storm (130% of the 100-year storm event), and Regional storm events. Culvert 6+725 (ME-T5) achieves all of the standards except for the freeboard requirement during the 50-year design storm (achieves 0.85 m rather than the required 1.0 m). The remaining five (5) of ten (10) culverts in the Study Area meet all of the hydraulic requirements under existing conditions.

The results of the hydraulic models are subject to changes in future phases of the Trafalgar Road Improvements project due to coordination with hydraulic modeling of adjacent development and reconstruction projects and should be confirmed during detailed design.

3. Proposed Conditions

3.1 Proposed Environment

3.1.1 Proposed Roadway Improvements

The development and evaluation of alternative design concepts for the improvements to Trafalgar Road are documented in the *Trafalgar Road Corridor Improvements Environmental Study Report* (ESR). The preferred design alternative for improvements to Trafalgar Road includes roadway widening to accommodate four general purpose with provision for two curbside High Occupancy Vehicle/Bus Rapid Transit (HOV/BRT) lanes, along with other intersection improvements. These proposed recommendations apply to the portion of the Study Area from the Morrison-Wedgewood Diversion Channel to Highway 407, for a total distance of approximately 7 km. No roadway improvements are proposed south of the Diversion Channel and as such, the SWM recommendations in this study are limited to north of the Diversion Channel. The improvements will generally maintain the existing profile of Trafalgar Road, with some potential changes in elevation in the vicinity of the New North Oakville Transportation Corridor (as determined by detailed design for that corridor, undertaken by others). More information on the preferred roadway alternative and a summary of the anticipated impacts and mitigation measures can be found in the ESR.

The proposed widening of Trafalgar Road has the potential to impact drainage through the Study Area. Widening of the roadway platform will require extensions and / or replacement of the existing culverts. The widened roadway will also generate more runoff from storm events, potentially impacting the quantity and quality of runoff delivered to the receiving drainage systems. The following sections quantify the potential impacts of roadway improvements, develop alternative mitigation measures, and evaluate the alternatives in order to satisfy Phase 3 of the Class EA process.

3.1.2 Proposed Adjacent Developments

Several proposed development projects located adjacent to Trafalgar Road are underway simultaneous to the completion of this EA study, including the following:

- Dunpar Developments Inc. townhouse subdivision southwest of Glenashton Drive and Trafalgar Road
- Green Ginger Inc., Mattamy, and Argo subdivisions northwest of Dundas Street and Trafalgar Road (West Branch EIR/FSS)
- Dundas-Trafalgar Inc. (Minto) and Shieldbay Inc. subdivision northeast of Dundas Street and Trafalgar Road (East Branch EIR/FSS)
- Reconstruction of Dundas Street between Oak Park Boulevard to Highway 403
- New North Oakville Transportation Corridor and Crossing of Sixteen Mile Creek Class EA Study

Multiple reports and assessments by other parties, and a series of potential options were reviewed during the preparation of this study to identify opportunities to proceed with and without integration and/or coordination of the management of runoff with adjacent development (refer to list of reports in Section 1.2). Opportunities included the SWM ponds proposed in the East and Main Branch EIR/FSS reports which were evaluated to identify surplus storage and the feasibility of using it to control runoff from the ROW. The feasibility of these options are further discussed in Section 3.4 and in the technical memos provided in Appendix G.

The realignment of the east branch of East Morrison Creek was an opportunity proposed by Minto subsequent to the initial assessment undertaken within this report. The realignment of the east branch of East Morrison Creek was proposed by Minto as a means to accommodate runoff and maintain the form and function of the East Morrison Creek watercourse north of Dundas Street as required by NOCSS. The EIR/FSS reports documenting Minto's proposed creek realignment design and associated impacts were reviewed in relation to the Trafalgar Road ROW, and included as part of this assessment.

Regulatory authorities are currently working towards coordinating the hydrologic and hydraulic models of East Morrison Creek prepared for the EIR/FSS and Dundas Street reconstruction reports. Relevant excerpts from the reports are provided in Appendices D, E, and F.

3.1.3 Timing of Adjacent Development and Potential Options

Two general options were considered, referenced as the Combination Option and the Solo Option and are described as follows:

1. Combination Option: The Combination Option is the realignment of the east branch of East Morrison Creek, as proposed by Minto. The east branch of East Morrison Creek will be directed to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3). The creek will remain on the west side of Trafalgar Road until south of Dundas Street, eliminating the need for the culvert at Station 5+665 (ME-T2) and for the watercourse to pass through the 900 mm CSP upstream of ME-T2 and through the culvert at Station 5+500 (ME-T1). The Combination Option is further documented in Section 3.2
2. Solo Option: In the unlikely event that development of the adjacent properties does not proceed, East Morrison Creek would be realigned on the east side of Trafalgar Road from ME-T3 southerly to ME-T1, eliminating the need for the crossing culverts at ME-T3 and ME-T2. A meandering creek form would be provided from upstream of the culvert at ME-T3 to upstream of the culvert at ME-T1 to mitigate channel length loss as well as improve aquatic habitat and channel morphology. Further, the realigned channel would be positioned to ensure the road is not located within the erosion and flooding hazard limits and associated regulated allowances. The Solo Option is further documented in Section 3.3, including the stormwater requirements section from Dundas Street southerly to the Morrison-Wedgewood Diversion Channel.

Two conditions for the solo option are assessed in this report with consideration for their implications on drainage and stormwater management as follows:

1. The "undeveloped" conditions scenario considers the proposed Trafalgar Road improvements as constructed while the adjacent land north of Dundas Street and the William Halton Parkway remain undeveloped.
2. The 'developed" conditions scenario considers the development of all adjacent lands, completed construction of William Halton Parkway, and completion of Trafalgar Road improvements.

Further consideration for the realignment of East Morrison Creek during detailed design must ensure that riparian flood storage is maintained.

3.2 Combination Option

A review of Minto EIR/FSS updates, reports and response documents was carried out as part of this SWM assessment to identify impacts of the design proposed by Minto on stormwater management for the Trafalgar Road ROW.

The area proposed for development by Minto is located at the northeast corner of Trafalgar Road and Dundas Street East/Highway 5. The Minto EIR/FSS (October 30, 2014) proposes a SWM pond (Pond 32) and realignment of the east tributary of East Morrison Creek downstream of culvert ME-T3 (5+820) towards the west, where it would join the main branch of East Morrison Creek on the west side of Trafalgar Road, and upstream of the existing confluence.

The following details identify potential impacts either within the vicinity of, or within the Trafalgar Road ROW.

A comparison of peak flows in the tributaries upstream of Dundas Street should be provided in detailed design to illustrate impacts of the proposed drainage plan and demonstrate compliance with the North Oakville Creeks Subwatershed Study (NOCSS). This comparison of flows should illustrate the ability of watercourse conveyance infrastructure crossing Trafalgar Road (existing or proposed Trafalgar Road infrastructure, depending on construction timing) such as that located at 5+500 (ME-T1), 5+665 (ME-T2), 5+820 (ME-T3), 6+200 (ME-T4) (if still required) and 6+725 (ME-T5).

The proposed drainage plan included with the Minto EIR/FSS identifies a storm sewer within the Trafalgar Road ROW that will convey the 2-year to Regional storm flows that discharge from SWM Pond 29 southerly to ME-T3. It will need to be determined during detailed design if the proposed storm sewer by Star Oaks is intended to accommodate both the roadway drainage and the pond drainage, or only the pond drainage (consideration will also need to be given to the design storms for these features). In addition, an evaluation should be completed during detailed design to document the impacts on form and function of the high constraint receiving watercourse (as defined in NOCSS), downstream on the east side of Trafalgar Road, as this diversion of flow will reduce flows from existing conditions. Any changes from existing peak flows crossing Trafalgar Road will require review on associated watercourse conveyance infrastructure crossing Trafalgar Road. Interim solutions may be required if the timing of construction between the outlet from Pond 29 precedes Trafalgar Road improvements. In addition, further co-ordination during detailed design will be required with Halton Region for the construction of the Pond 29 outfall and associated storm sewer system within the Trafalgar Road ROW. This co-ordination will require reviewing the feasibility of the proposed infrastructure with consideration for other subsurface utilities within the Trafalgar Road ROW, while ensuring gravity flow.

Potential connection/integration of Trafalgar Road SWM measures should be considered in detailed design to evaluate potential connection to Pond 32 or overcontrol of Pond 32 to account for stormwater management within the Trafalgar Road ROW that cannot connect to Pond 32. Some controls within the Trafalgar Road ROW may also be required.

Detailed design for all flows, including emergency flows from Pond 32, needs to consider the capacity of the receiving downstream infrastructure that crosses Trafalgar Road for proposed conditions with respect to overtopping of the roadway and potentially erosive velocities. In addition, the consideration of resulting flows during proposed conditions needs to review updated floodplain mapping and identify potential spills upstream due to limited receiving infrastructure capacity.

Further details can be found in Appendix G.

It is noted that proposed watercourse crossing upgrades detailed in the Trafalgar Road EA are based on meeting requirements dictated within the NOCSS and any changes to these flows will impact the capacity and level of service of proposed water crossing infrastructure improvements.

3.3 Solo Option

Storm sewer system design for flow conveyance within the Trafalgar Road right-of-way (ROW) will be considered during detailed design. Determining the capacity and level of service of the existing storm sewer systems within the Trafalgar Road ROW under existing and proposed conditions will require an understanding of both local flows from Trafalgar Road as well as external flows contributing to the Trafalgar Road storm sewer system. Detailed design should also consider if the existing storm sewer network within Trafalgar Road has capacity and can adequately accommodate potential additional flows resulting from increased runoff generated from the preferred roadway design concept identified during this EA phase.

Preliminary SWM alternatives considered in this study for the Trafalgar Road ROW include review of potential outlets of the future storm sewer system and associated impacts on the receiving watercourses, as well as consideration of any future requirements for the existing mainline crossing culverts.

3.3.1 Highway 407 to Dundas Street

The roadway drainage system for the Study Area north of Dundas Street requires consideration for integration with future development adjacent to Trafalgar Road and requirements based on the receiving watercourses defined in the NOCSS. The NOCSS classified several sections of the East Morrison Creek and Joshua's Creek that receive runoff from Trafalgar Road as low, medium, or high constraint riparian corridors as shown on Drawings 1 and 2 of Appendix A. The NOCSS defines the management requirements for each constraint category within the *Management Report,* Section 6.3.4.5 and is summarized as follows:

1. High Constraint Streams where current form and function are to be preserved (red streams) and must be protected (and/or enhanced) in their current location;
2. Medium Constraint Streams where the current function is to be preserved (blue streams) but can be relocated or deepened if their function can still be preserved, subject to acquiring relevant agency approvals (DFO, CH, MNR, and Town of Oakville);
3. Low Constraint Streams (green streams) can be replaced through infrastructure or SWM.

The NOCSS requirements for high and medium constraint streams are further defined within the NOCSS *Management Report*, (Section 6.3.4.5) where drainage of flows within these corridors must be maintained and conveyance of flows outside the stream corridors must be maintained for both frequent and infrequent events.

The following sections discuss the potential stormwater outlets and receiving watercourses with consideration for the previously discussed NOCSS requirements. Alternative management measures for stormwater quality and quantity are discussed in Section 3.4.

3.3.1.1 Highway 407 to Joshua's Creek and East Morrison Creek Watershed Divide

Stormwater drainage from Trafalgar Road ROW Catchment Areas 10 to 14 shown on Drawing 6 of Appendix A, flows in an easterly direction along rural ditches that discharge to a tributary of Joshua's Creek. This tributary of Joshua's Creek is classified by the NOCSS as a low constraint stream corridor just north of the William Halton Parkway crossing and as a medium constraint stream corridor to the south. The NOCSS stream corridor constraint classification requires maintaining the form and function of medium constraint reaches (blue on Drawing 6 of Appendix A), whereas sections with low or no constraint classification (green or not highlighted on Drawing 6 of Appendix A) do not have to be maintained as open systems and can be replaced with drainage infrastructure. The roadside and rural ditches currently conveying runoff from the Trafalgar Road ROW Catchment Areas 10 to 14 easterly may be replaced with drainage infrastructure under developed conditions as they have no constraint ranking under the NOCSS.

<u>*Catchment Areas 13 and 14*</u>

The William Halton Parkway is undergoing detailed design concurrent with the study. Through communications with Halton Region (meeting at Halton Region on October 24, 2013), it was confirmed that part of the detailed design of the William Halton Parkway includes the detailed design of Trafalgar Road improvements from the future intersection at the William Halton Parkway to Highway 407, inclusive. The William Halton Parkway design assignment includes a

review of SWM measures for the noted section of Trafalgar Road, assuming that improvements to Trafalgar Road precede adjacent development.

The SWM measures for Trafalgar Road will consider super pipe storage with oil and grit separators at each proposed outlet, subject to further analysis during detailed design, with the understanding that SWM measures will be connected and integrated into future adjacent development SWM measures. The SWM and roadway drainage system can replace the tributaries of Joshua's Creek with no or low (green) constraint ranking with underground drainage infrastructure but the existing flow contributions to the medium constraint stream corridor (blue) must be maintained as per the previously discussed NOCSS requirements. A temporary drainage swale may be required to convey runoff from the roadway and SWM measures to the tributary of Joshua's Creek.

<u>*Catchment Areas 11 and 12*</u>

Runoff from Catchment Areas 11 and 12 of the Trafalgar Road ROW currently flows southerly towards Burnhamthorpe Road. Catchment Area 12 drains into roadside ditches adjacent to Trafalgar Road, then discharges to a rural ditch near station 7+750 directing runoff to the roadside ditch along Burnhamthorpe Road that also collects runoff from the localized storm sewer system along Catchment Area 11. The roadside ditch along Burnhamthorpe Road then directs drainage in an easterly direction and discharges to the medium constraint stream corridor of Joshua's Creek Tributary (blue) at culvert JC-B10. The NOCSS requires flow contributions to the medium constraint tributary at culvert JC-B10 to be maintained. To do so, it is recommended to maintain the use of the Burnhamthorpe Road roadside ditch to convey runoff from Trafalgar Road to the tributary of Joshua's Creek. The rural ditch conveying runoff from Catchment Area 12 to Burnhamthorpe Road will likely be replaced by underground drainage infrastructure when the adjacent land is developed as allowed by the NOCSS requirements for stream corridors with no constraint ranking.

<u>*Catchment Area 10*</u>

Runoff from Trafalgar Road ROW Catchment Area 10 currently drains to adjacent roadside ditches and is directed to a low point at the culvert located at station 7+315. Flow then drains to a rural ditch and outlets to the medium constraint stream corridor of Joshua's Creek Tributary, where existing flow contributions must be maintained as per NOCSS. This drainage pathway is to be maintained under undeveloped conditions and will likely be integrated into the development of adjacent land under ultimate conditions by replacing the ditch with drainage infrastructure as allowed by the NOCSS requirements for stream corridors with no constraint ranking.

3.3.1.2 Joshua's Creek and East Morrison Creek Watershed Divide to Dundas Street

The remaining Trafalgar Road Catchment Areas in this section (Catchment Areas 5 to 9) drain to the east branch of East Morrison Creek, which is classified as a high constraint stream by NOCSS downstream of the crossing at station 6+725 (ME-T5) of Trafalgar Road and then changes to a medium constraint reach before crossing Trafalgar Road again at station 5+820 (ME-T3).

<u>*Catchment Areas 5 to 7 and 9*</u>

Catchment Areas 5, 6, 7 and 9 currently drain into adjacent roadside ditches that outlet directly into East Morrison Creek at the mainline crossing culverts, as shown on Drawing 6 of Appendix A. To maintain flow contributions as per NOCSS requirements, it is recommended that the existing drainage direction is maintained under undeveloped and developed conditions.

Catchment Area 8

Catchment Area 8 currently drains into adjacent roadside ditches that flow in a southerly direction to the mainline crossing culvert at station 6+200 (ME-T4) that is located on a rural drainage ditch with no NOCSS constraint classification. The rural ditch conveys drainage from Trafalgar Road a short distance to East Morrison Creek. It is recommended to convey runoff along the existing rural ditch to maintain flows to the medium constraint stream corridor of East Morrison Creek as required by NOCSS in the unlikely event the roadway construction precedes the development of the adjacent lands. Under developed conditions, drainage can be integrated into adjacent development by replacing the ditch with underground drainage infrastructure as allowed by NOCSS for streams with no constraint ranking.

3.3.2 Dundas Street to the Morrison-Wedgewood Diversion Channel

As previously discussed, the roadway drainage system in the Study Area south of Dundas Street includes a combination of intermittent roadside ditches and storm sewers. The existing outlets of these systems are to be maintained under proposed conditions to utilize existing drainage infrastructure and maintain existing flows to the receiving watercourses, including the following existing outlets shown on Drawings 3 and 4 of Appendix A:

- Outlet 1: Storm sewer outfall to the Morrison Wedgewood Diversion Channel
- Outlet 2: Roadside drainage swale discharging to a tributary of West Morrison Creek
- Outlet 3: Storm sewer connection to the Upper Middle Road storm sewer draining easterly to East Morrison Creek
- Outlet 4: Storm sewer, culvert, and roadside ditches discharging to East Morrison Creek

Evaluating the capacity of existing contributing and receiving drainage infrastructure should be included during detailed design to identify any limiting factors for peak flow control.

3.4 Stormwater Management

The potential impact of transportation infrastructure on the quality and quantity of runoff delivered to the receiving water bodies is well documented (MTO, 1997). Relative to natural ground cover, the paved surfaces of highways and roadways generate significantly greater volumes of runoff from the same storm event. Associated drainage infrastructure such as ditches and storm sewers have the potential to deliver the runoff to the receiving system much earlier relative to natural, sheet flow conditions. The above have the potential to increase the peak flow delivered to the receiving water body and can lead to increased flooding and erosion in the receiving watercourse.

Vehicular traffic deposits materials such as oil, grease, trace organics, trace metals, and other pollutants on roadway surfaces, which can be washed off during storm events and delivered to the receiving water body. In addition, water bodies also receive sand, salt, and other de-icing agents applied to roads during winter months but washed off by snowmelt and rainfall events. These pollutants have the potential to impair water quality in the receiving systems, with associated impacts to aquatic habitat and other water users.

The proposed improvements to Trafalgar Road are expected to impact quality and quantity of runoff delivered to the receiving watercourses. The total area of asphalt and concrete through the Study Area will increase due to widening and the roadway drainage systems will be altered. Therefore, the volume, rate, and timing of delivery of runoff to the receiving watercourses will be impacted by the proposed improvements. As the paved area and the rate and volume of runoff generated by the road are expected to increase, a corresponding increase in pollutant loadings delivered to the receiving watercourses is also expected.

The following sections provide preliminary calculations of the storage required to control runoff, evaluate potential SWM measures, and recommend SWM measures for each section of the Trafalgar Road Study Area. Detailed calculations are provided in Appendix B.

3.4.1 Storage Requirement Calculations

In accordance with the stormwater management requirements outlined in Section 1.2.1, the proposed SWM measures must control peak flows from the ROW under proposed conditions to existing levels, as per NOCSS and the Town's guidelines, and provide an enhanced level (i.e. 80% TSS removal) of water quality treatment of all runoff from the ROW as per NOCSS and CH requirements. The change in impervious area along Trafalgar Road is summarized in Table 3.1 for each catchment within the ROW.

Table 3.1 Change in Impervious Area within ROW

Catchment No.	Watershed / Tributary	Constraint Ranking	Drainage Area (ha)	Impervious Area		
				Existing (%)	Proposed (%)	Increase (ha)
1	East Morrison Creek		4.23	68%	78%	0.42
2			3.48	63%	79%	0.58
3			7.97	60%	81%	1.61
4			1.33	51%	78%	0.35
5	East Morrison Creek (EM4)	Medium	1.49	55%	84%	0.43
6		Medium	0.76	39%	80%	0.32
7		Medium	1.95	34%	85%	0.99
8			1.94	40%	73%	0.64
9	East Morrison Creek (EM3)		2.66	38%	83%	1.21
10	Joshua's Creek (JC9)		2.27	45%	78%	0.76
11	Joshua's Creek (JC7)		0.84	57%	84%	0.22
12			1.68	36%	80%	0.75
13			0.24	35%	90%	0.13
14			1.94	42%	71%	0.57

3.4.1.2 *Quality Control*

The north and south Trafalgar Road corridors of the Study Area divided by Dundas Street have different opportunities for managing runoff quality. The south corridor has very limited open space due to existing adjacent developments and, as such, oil-grit separators (OGS) will likely be required to treat the majority of runoff from this area. In contrast, SWM measures of future developments adjacent to the north corridor have the potential to be designed to accommodate road runoff quality from Trafalgar Road. Alternative SWM measures are further discussed in Sections 3 and 3.4.3. This section estimates the storage volume required to provide appropriate treatment of runoff from the ROW.

The active and permanent pool volumes required to provide enhanced treatment of runoff from the ROW were calculated using Table 3.2 of the MOE *SWM Planning and Design Manual*. The results are summarized in Table 3.2 of this report. The active storage required is the larger of the water quality and erosion control volumes. The water quality volume is calculated using the MOE *SWM Planning and Design Manual* ratio of 40 m^3/ha whereas the erosion control volume is the runoff produced by the 25 mm storm. As shown in Table 3.2 below, the required erosion control volume is larger than the water quality volume for every catchment. The permanent pool is calculated as the difference between the total storage required for enhanced protection as defined by the MOE and the active storage-water quality volume. Detailed calculations are provided in Appendix C.

Table 3.2 Storage Required to Control North Corridor Runoff Quality

Catchment No.[5]	Drainage Area (ha)	Proposed Impervious Area (%)	MOE Quality Control Storage Volume Requirements		Active Storage (m^3)			Permanent Pool (m^3)
			Unit Storage (m^3/ha)	Total Storage (m^3)	Water Quality[1]	Erosion Control[2]	Maximum[3]	
5	1.49	84%	248	370	60	372	372	310
6	0.76	80%	242	184	30	190	190	154
7	1.95	85%	250	486	78	486	486	409
8	1.94	73%	230	446	78	485	485	369
9	2.66	83%	247	657	106	664	664	550
10	2.27	78%	239	542	91	566	566	451
11	0.84	84%	248	208	34	210	210	174
12	1.68	80%	242	406	67	419	419	339
13	0.24	90%	258	63	10	61	61	53
14	1.94	71%	227	439	77	484	484	362

Notes:

1 – Calculated using 40 m^3/ha as per MOE *SWM Planning and Design Manual*

2 – Volume of runoff produced by 25 mm storm

3 – The total active storage required is the larger of the erosion control and the water quality volumes as per the MOE *SWM Planning and Design Manual*

4 – The permanent pool required to provide enhanced treatment of runoff from the ROW under proposed conditions calculated as the difference between the total MOE required quality control volume and the active storage-water quality control volume.

5 – Catchments 1 to 4 have insufficient space within or adjacent to the ROW for SWM ponds and therefore were not included in these estimates. An alternative SWM measure providing quality control but requiring minimal open space, such as an OGS, will be required.

3.4.1.3 *Quantity Control*

Runoff from the ROW under proposed conditions must also be controlled to the existing conditions peak flows calculated in Section 2.3. As discussed in Section 1.2.1, the NOCSS requires the north corridor peak flows to be

controlled to existing conditions up to the Regional storm whereas the Town's guidelines require the south corridor peak flows to be controlled to existing up to the 100-year storm. The 100-year design storm event typically has a higher peak intensity than the Regional storm for small urban catchments and would result in a larger required storage volume to control flows to existing conditions, like those for the Trafalgar Road ROW. A test file was created to represent a typical Trafalgar Road ROW catchment area using comparable and representative catchment parameters. This test file confirmed that the 100-year design storm was critical in determining the required storage volume for quantity control. Notwithstanding, this concept should be further detailed and confirmed for Trafalgar Road during detailed design.

To estimate the storage required for quantity control, an analysis was performed for a number of different duration storms by increasing the time of concentration. The time of concentration was increased by five minute time steps. At each time step, the rainfall intensity was calculated using the 100-year storm IDF curve parameters from the Town's *Development Engineering Guidelines*. The Rational Method was then applied to calculate the proposed flow for each time step using weighted runoff coefficients representing proposed conditions. The proposed flow at each time step was then compared to the existing peak flow to calculate the storage required to control the runoff. The existing peak flow was kept constant throughout the varying durations. The maximum storage calculated over the varying time of concentration is the estimated required quantity control storage volume. Detailed calculations for each catchment are provided in Appendix B and summarized in Table 3.3.

Table 3.3 Storage Required to Control Peak Flows (100-Year Storm Event)

Catchment No.	Drainage Area (ha)	Length of Roadway (m)	Existing Conditions Peak Flow (m^3/s)	Proposed Runoff Coefficient C x 1.25	Required Storage (m^3)
1	4.23	860	1.266	0.99	643
2	3.48	720	0.747	1.00	717
3	7.97	1689	1.088	1.00	2186
4	1.33	275	0.425	0.99	186
5	1.49	268	0.025	1.00	821
6	0.76	152	0.013	1.00	420
7	1.95	397	0.032	1.00	1073
8	1.94	388	0.032	0.94	995
9	2.66	531	0.044	1.00	1465
10	2.27	453	0.048	0.99	1167
11	0.84	164	0.018	1.00	437
12	1.68	339	0.036	1.00	873
13	0.24	49	0.005	1.00	127
14	1.94	388	0.041	0.92	913

3.4.1.4 *Overall Storage Requirements*

The results of the quality and quantity control storage requirement calculations are summarized in Table 3.4. The summary shows that the active storage volumes required for quantity control are larger than the volumes required for quality control. Therefore, the active storage required if SWM ponds are utilized is the quantity control volume. The total pond volume was used to estimate the land area required for the pond based on MOE guidelines.

Table 3.4 Summary of Storage Requirements

Catchment No.	Drainage Area (ha)	Proposed Impervious Area (ha)	Active Storage (m^3)			Permanent Pool Volume (m^3)	Total Storage Volume (m^3)
			Quality Control	Quantity Control	Maximum	Quality Control	Maximum Active Storage + Permanent Pool
1	4.23	3.31	n/a	643	643	n/a	643
2	3.48	2.76	n/a	717	717	n/a	717
3	7.97	6.43	n/a	2186	2186	n/a	2186
4	1.33	1.04	n/a	186	186	n/a	186
5	1.49	1.25	372	821	821	310	1132
6	0.76	0.61	190	420	420	154	573
7	1.95	1.65	486	1073	1073	409	1482
8	1.94	1.42	485	995	995	369	1364
9	2.66	2.21	664	1465	1465	550	2015
10	2.27	1.78	566	1167	1167	451	1618
11	0.84	0.70	210	437	437	174	611
12	1.68	1.35	419	873	873	339	1212
13	0.24	0.22	61	127	127	53	180
14	1.94	1.38	484	913	913	362	1275

n/a – Catchments 1 to 4 have insufficient space within or adjacent to the ROW for SWM ponds and therefore were not included in these estimates. An alternative SWM measure providing quality control but requiring minimal open space, such as an OGS, will be required.

The sizes of the potential SWM measures that could provide the required storage volumes are estimated in Table 3.5. The land area required for potential SWM ponds was based on the formulas provided in Section 7.6.1 of the MOE SWM Planning and Design Manual (2003). The calculations assumed a rectangular shape, a length-to-width ratio of 3:1, 4:1 side slopes in the permanent pool, and 5:1 side slopes in the extended detention portion of the pond. The specific guidelines provided by the Town of Oakville must be followed during detailed design and may revise the land area required for the ponds. To obtain a conceptual understanding of the potential super pipe storage required, the quantity control volume provided in Table 3.3 and total length of roadway in each catchment were then used to calculate the minimum diameter of an oversized storm sewer or super pipe to provide sufficient quantity control. The length, diameter and configuration of the super pipes should be confirmed during detailed design with consideration for frost depth, required cover, conflicts with subsurface utilities, connectivity and grading. Pre-treatment is recommended to prevent sediment accumulation in super pipes.

Table 3.5 Potential Sizes of SWM Facilities

Catchment No.	Pond Footprint[1] (m^2)	Super Pipe Diameter[2] (mm)
1	n/a	975
2	n/a	1200
3	n/a	1350
4	n/a	975
5	1198	2100
6	757	1950
7	1443	1950
8	1364	1950
9	1792	1950
10	1534	1950
11	782	1950
12	1253	1950
13	344	1950
14	1297	1800

1 – Pond footprint calculated using typical design parameters for wet ponds with the formulas provided in Section 7.6.1 of the MOE SWM Planning and Design Manual (2003).

2 – For north corridor, super pipes were sized as an alternative to integrating SWM measures with adjacent development.

n/a – Catchments 1 to 4 have insufficient space within or adjacent to the ROW for SWM ponds and therefore were not included in these estimates. An alternative SWM measure providing quality control but requiring minimal open space, such as an OGS, will be required.

3.4.2 Alternative Mitigation Measures

A wide range of best management practices are available to mitigate the impacts of road runoff on receiving watercourses. These are generally classified into source, conveyance, and end-of-pipe treatment alternatives. The alternatives considered in this section are based on detailed descriptions and design criteria published in the following documents:

- *SWM Planning and Design Manual* (MOE, 2003)
- *Low Impact Development SWM Planning and Design Guide* (Credit Valley Conservation Authority (CVC) and the Toronto and Region Conservation Authority (TRCA), 2010)
- *Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters* (United States Environmental Protection Agency (US EPA), 1993)

The available soils information indicates the soils throughout the Study Area have a low infiltration capacity that could limit the application of infiltration measures. However, the culvert inspection identified watercress at five (5) of the mainline culvert crossings along East Morrison Creek, indicating potential groundwater discharge or upwelling. In accordance with the NOCSS, detailed consideration of the feasibility of infiltration facilities, such as Low Impact Development (LID) measures, should be made during detailed design using site specific information, best-management practices from current guidelines, and recognition that modifications to facilities may be required to account for the low infiltration capacity of soils within the Study Area.

<u>*Source Controls*</u>

Source control measures address precipitation where it falls to maintain the pre-development hydrologic character of watersheds. Before land is developed, rain has multiple hydraulic and hydrologic pathways, such as infiltration, interflow, evapotranspiration, surface runoff, and streamflow. These pathways provide storage and treatment of stormwater before it reaches rivers and water bodies. Natural drainage characteristics can be mimicked using small-scale, distributed controls that provide storage, detention, and treatment instead of a central end-of-pipe stormwater facility. Runoff volume can be reduced by encouraging groundwater recharge through infiltration galleries, retaining pools of water to allow for evaporation, and maintaining as much vegetative cover as possible to enable plant transpiration. Quantity control can also be provided by storage cisterns, swales with shallow slopes, and the void space in filter media. Pollutant reduction is achieved by allowing suspended solids to settle in standing water, microbial soil processes, using plant species that can remove pollutants from runoff, and filtration. Other examples of source control measures include rooftop storage, parking lot storage, cisterns for rainwater harvesting, infiltration trenches, soak-away pits, and permeable pavement.

Using multiple SWM measures in sequence is called a treatment train approach. Pre-treatment may be required for certain source control measures to prevent premature clogging of filters and to ensure the facility functions as intended. In addition to pre-treatment controls, source pollution prevention measures such as amendments to the Region's *Road Salt Management Plan* (2011) could lead to further water quality improvements.

Potential source control SWM alternatives include the following:

Infiltration Trenches

Trenches with a subsurface component consisting of clean granular stone lined with a geotextile fabric. They can be implemented at ground level to intercept overland flows or underground to connect to a storm sewer. Infiltration trenches can achieve an average removal rate of 75% TSS and 60% TP (US EPA, 1993). Pre-treatment, such as a grassed swales or OGS, is required to prevent clogging and can help reach the water quality criteria for this project. Infiltration trenches also reduce runoff volume through groundwater recharge. The maximum storage volume recommended to be provided in the storage media is the 4 hour, 15 mm storm (MOE, 2003). Recommended application include small drainage areas (less than 2 ha) with primarily residential land use but not commercial land use areas due to the high potential for dry weather spills that could contaminate groundwater. An example is shown on Figure 3.1. **Infiltration trenches are not recommended for the Study Area due to the limited infiltration capacity of the predominant clay soils throughout.**

Figure 3.1 Cross Section of an Infiltration Trench System below a Laneway

Source: *Low Impact Development SWM Planning and Design Guide*, Credit Valley Conservation Authority and Toronto and Region Conservation Authority

Soakaway Pits

Soakaway pits are similar to infiltration trenches but are smaller in scale. They typically receive roof and walkway runoff or overflow from rainwater harvesting systems on single lots, as illustrated on Figure 3.2. The water quantity improvements offered by soakaway pits are dependent on the infiltration capacity of the native soils since the recommended drawdown time is 24 hours (MOE, 2003). Water quality improvements may be similar to infiltration trenches; however the quality of runoff may be very good from roof water leaders. Runoff from a busy road should be treated before discharging to a soakaway pit. Similar to infiltration trenches, the minimum acceptable infiltration rate is not met by the Study Area soils for soakaway pits to be feasible. **Soakaway pits are not recommended for the Study Area.**

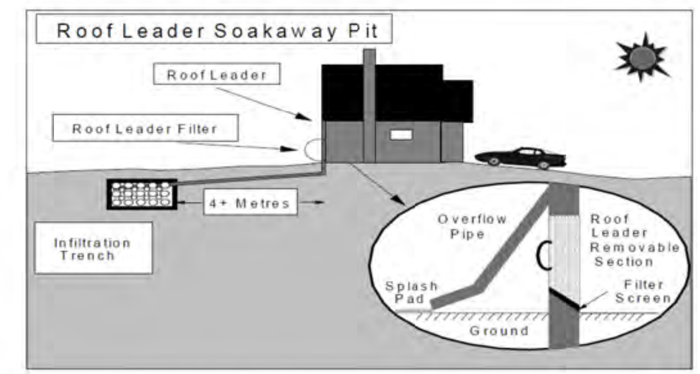

Figure 3.2 Roof Leader Discharge to Soakaway Pit

Source: *SWM Planning and Design Manual*, Ontario Ministry of Environment

Vegetated Filter Strips:

Also referred to as buffer strips and grassed filter strips, vegetated filter strips are densely vegetated areas that have been graded to treat sheet flow runoff from impervious areas. Sheet flow is achieved using a level spreader, such as a shallow trench or a pea gravel diaphragm, as shown on Figure 3.3. Vegetated filter strips can achieve an average removal rate of 65% TSS and 40% TP (US EPA, 1993). The level spreader should be sized for the 4 hour Chicago 10 mm storm (MOE, 2003). Stormwater infiltration measures such as vegetated filter strips should not receive runoff from high traffic areas where large amount of de-icing salts are applied (CVC and TRCA, 2010). Although vegetated filter strips are not recommended for runoff from Trafalgar Road, there are multiple other applications such as treating overland flow from the proposed multiuse pathways throughout the Study Area. **Vegetated filter strips have been carried forward as a potential measure to manage storm runoff from the Study Area with the exception of runoff from high traffic roads.**

Figure 3.3 Pea Gravel Diaphragm Applied as Level Spreader for Parking Lot Runoff

Source: Low Impact Development SWM Planning and Design Guide, *Credit Valley Conservation Authority and Toronto and Region Conservation Authority*

Sand Filters

Sand filters are commonly used at the bottom of infiltration galleries, such as soakaway pits and infiltration trenches. However, as previously discussed, these SWM practices are not recommended for the Study Area. As illustrated on Figure 3.4, sand filters can also be used at the bottom of swales to provide treatment and attenuation before draining through underdrains to the storm sewer system. Sand filters do not provide storage but they can attenuate peak flows through infiltration. They can achieve an average removal rate of 80% TSS and 50% TP (US EPA, 1993). Additional treatment can be achieved by adding layers of other materials such as peat (MOE, 2003). Sand filters can also be added to bioretention cells and underground cisterns, although pre-treatment to remove suspended sediment would be necessary to prevent clogging. **The application of sand filters to bioswales and cisterns has been carried forward as a potential SWM measure for the Study Area.**

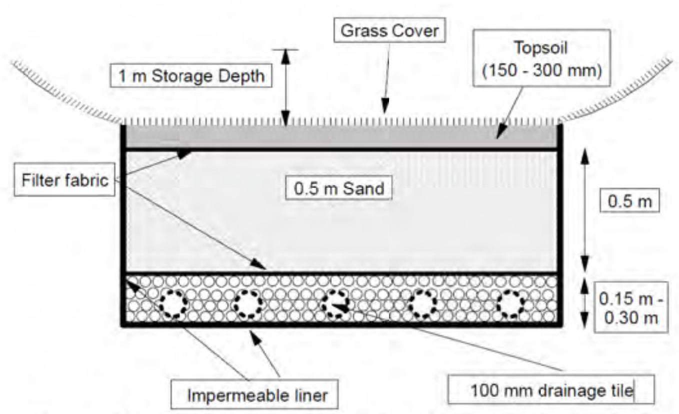

Figure 3.4 Sand Filter Cross Section with Underdrain

Source: *SWM Planning and Design Manual*, Ontario Ministry of Environment

AECOM Regional Municipality of Halton Trafalgar Road Corridor Improvements EA, Cornwall Road to Highway 407
Stormwater Management Report

Pervious Catchbasins

Pervious catchbasins are catchbasins with a deep sump and a connection to a soakaway pit or exfiltration system, as illustrated on Figure 3.5. They reduce runoff volumes through groundwater recharge and have the same potential water quality improvements as infiltration trenches. Similar to the other infiltration practices previously discussed, the limited capacity for infiltration in the Study Area pre-empt the application of pervious catchbasins. **Pervious catchbasins are not recommended for the Trafalgar Study Area.**

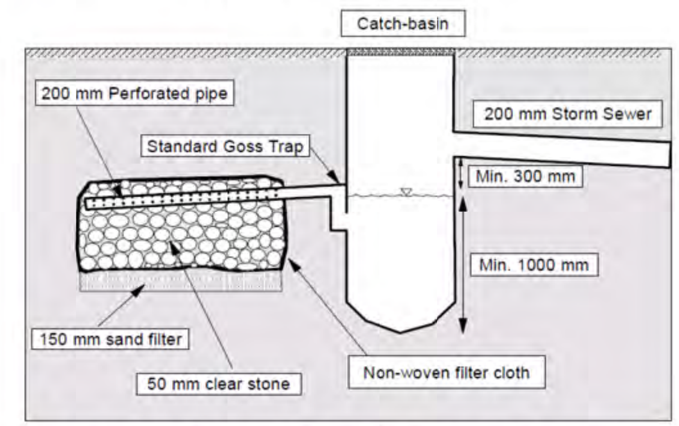

Figure 3.5 Sand Filter Cross Section with Underdrain

Adopted from 'SWM Planning and Design Manual', Ontario Ministry of Environment

Cisterns

Cisterns provide underground storage and, unlike SWM ponds, allow space above ground to be used for landscaping, pedestrian traffic, and parking. Cisterns can benefit water quality by settling suspended solids, but pre-treatment is recommended. Pre-treatment options include leaf screens, in-ground filters, and vegetated filter strips. As previously mentioned, a sand filter can be used in a cistern to increase water quality benefits. Due to the limited space for storage in the ROW, **cisterns have been carried forward as a potential SWM measure for the Study Area.**

Permeable Pavement

Compared to traditional impervious pavement, permeable pavement drains water through the pavement, into a stone reservoir, and then is either infiltrated or temporarily detained. As previously discussed, infiltration practices are not recommended for this Study Area due to the predominance of clay soils throughout. Therefore, an impermeable liner and underdrain system is recommended as illustrated by the Partial Infiltration with Flow Restrictor scenario on Figure 3.6. This will limit the water quantity benefits to reducing stormwater runoff volumes through evaporation (CVC and TRCA, 2010). With these considerations, permeable pavement could be applied to sidewalks that meet the minimum building setback requirement of 4 m (MOE, 2003) and lay-by parking spaces. Examples of permeable pavers, permeable asphalt parking, and permeable concrete along a sidewalk are provided on Figure 3.7, Figure 3.8, and Figure 3.9, respectively. Pre-treatment is not required for permeable pavement but periodic vacuum sweeping and preventing clogging from sand application during the winter is recommended. Winter operations, such as plowing and salt management, may need to be revised to maintain the performance of permeable lay-by parking spaces (CVC and TRCA, 2010). Permeable pavement can achieve an average removal rate of 90% TSS and 65% TP (US EPA, 1993). **Permeable pavement has been carried forward as a potential SWM measure for the Study Area.**

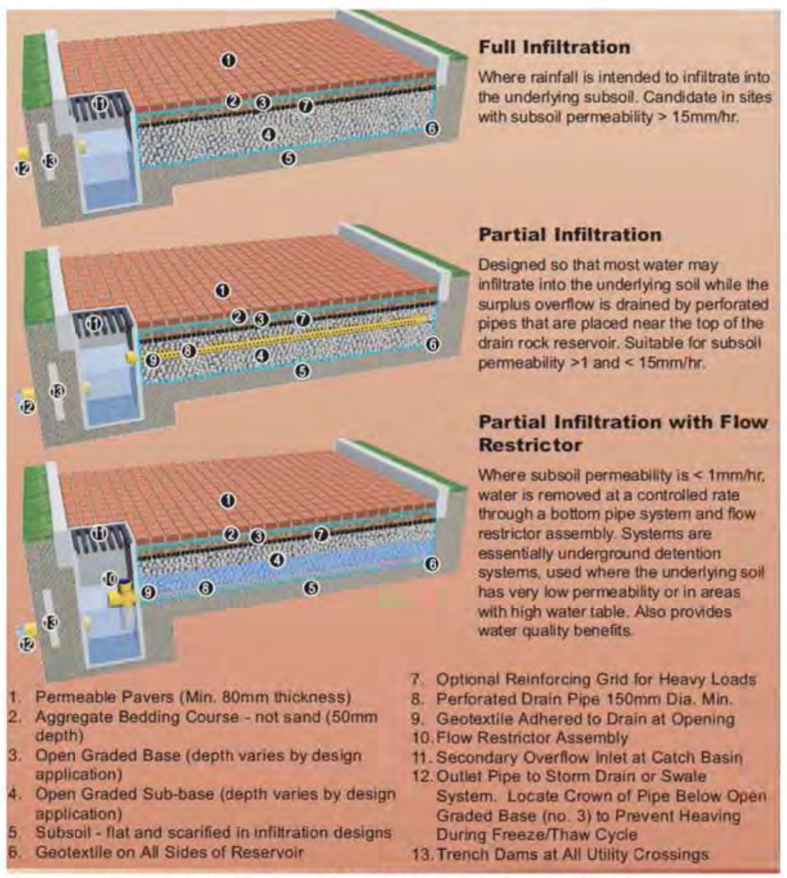

Figure 3.6 Permeable Pavement Cross Sections

Source: *Low Impact Development SWM Planning and Design Guide*, Credit Valley Conservation Authority and Toronto and Region Conservation Authority

AECOM
Regional Municipality of Halton
Trafalgar Road Corridor Improvements EA, Cornwall Road to Highway 407
Stormwater Management Report

Figure 3.7 Permeable Pavers

Source: *Beautifying City Streets with LID*, City of Toronto

Figure 3.8 Permeable Asphalt Parking

Source: *Beautifying City Streets with LID*, City of Toronto

Figure 3.9 Permeable Concrete

Source: *Beautifying City Streets with LID*, City of Toronto

Goss Traps and Sumps

Catchbasins or ditch inlets can provide preliminary sediment removal using Goss traps and sumps. The Goss trap forces sediment to settle to the bottom of the catchbasin sump, as shown on Figure 3.10. Additional maintenance is required for these structures in order to regularly remove the sediments collected in the sump. The sump will provide limited water quantity improvements through evaporation. Pre-treatment is not required. **Goss traps and sumps have been carried forward as a potential SWM for the Study Area.**

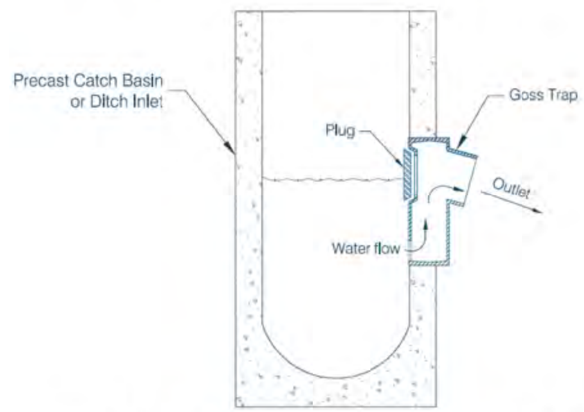

Figure 3.10 Catchbasin with Goss Trap and Sump

Source: *Goss Trap Design Specification*, Hanson

Enhanced Depth and Quality of Topsoil

Application of high quality topsoil in landscaped areas can enhance infiltration capacity despite the limiting clay soils throughout the Study Area (Green Ginger Developments Inc., 2012). Partial water quality benefits may be achieved through microbial soil processes. Pre-treatment is not required. **Enhanced depth and quality of topsoil has been carried forward as a potential SWM measure for the Study Area.**

In summary, the following source control alternatives have been carried forward as potential SWM measures for the Study Area:

- Vegetated filter strips, with the exception of runoff from high traffic roads
- Sand filters applied to bio-swales and cisterns
- Cisterns
- Permeable pavement
- Goss traps and sumps
- Enhanced depth and quality of topsoil

<u>Conveyance Controls</u>

Conveyance control measures manage the quality and quantity of runoff through the municipal SWM system to the outlet. There are several conveyance control measures applicable to transportation infrastructure, given the relatively long, narrow configuration of transportation corridors. Potential conveyance control SWM alternatives for the Study Area include the following:

Enhanced Vegetated Swales

Where property is available, enhanced vegetated swales can be constructed along one or both sides of the roadway. The swales are typically constructed with a wide, flat base to reduce flow velocity and maximize infiltration, filtration through vegetation, and nutrient uptake by vegetation. As illustrated on Figure 3.11, stormwater treatment can be further enhanced by adding rock check dams to slow and pond water in the swales, soil amendments to improve growing conditions and hold water for infiltration/evapotranspiration, and granular trenches below the swale to promote infiltration and cooling before it is released to the receiving drainage course. This SWM measure should only be applied where groundwater levels are deeper than 1 m year-round. The geotechnical investigation for this EA found groundwater levels ranging from approximately 3.7 to 4.6 m below grade throughout the Study Area although the measurements may not represent possible fluctuations due to changing seasons or following rainfall events (Terraprobe, 2013). Enhanced vegetated swales can achieve an average removal rate of 76% TSS and 55% TP (CVC and TRCA, 2010). Pre-treatment is recommended for road runoff and alternatives include a pea gravel diaphragm, vegetated filter strips, and sedimentation forebays. Enhanced vegetated swales can also provide partial water quantity improvements through evaporation and infiltration. **Enhanced vegetated swales have been carried forward as a potential SWM measure for the Study Area where sufficient open space is available and groundwater levels are at acceptable depths.**

Figure 3.11 Enhanced Grass Swales Featuring Check Dams to Temporarily Pond Runoff

Source: *Low Impact Development SWM Planning and Design Guide*, Credit Valley Conservation Authority and Toronto and Region Conservation Authority

Bioretention Swales

Bioretention swales are specifically designed to filter stormwater and promote infiltration and evaporation. A typical cross-section through a bioretention swale is shown below on Figure 3.12. It generally consists of a surface swale to accept runoff from adjacent paved areas, which is underlain by a layer of planting soil. Stormwater passing through the planting soil will drain down through a layer of sandy soil, and a sub-drain is generally provided at the base of the trench to collect the filtered runoff and prevent ponding. For the Study Area, these facilities should include an impermeable liner to prevent infiltration of road runoff with potentially high chloride levels. A separation barrier may be required to prevent saturation of the road's subbase. In addition, vegetation must be salt tolerant. With these design considerations, a bioretention swale can provide water quality improvements if sized for water quality storage requirements and partial volume reduction through evapotranspiration. Pre-treatment of road runoff is recommended to prevent clogging. A two-cell design can be used to settle sediment in a pre-treatment chamber. Two types of bioretention facilities are stormwater planters and extended tree pits, as illustrated on Figure 3.13 and Figure 3.14, respectively. Stormwater planters differ from traditional landscaped areas because they receive runoff from other surfaces and are typically applied in dense urban areas. Runoff from the sidewalk or streets can be directed to extended tree pits through curb cuts (CVC and TRCA, 2010). **Bioretention swales have been carried forward as a potential SWM measure for the Study Area with the appropriate design considerations made for site specific constraints.**

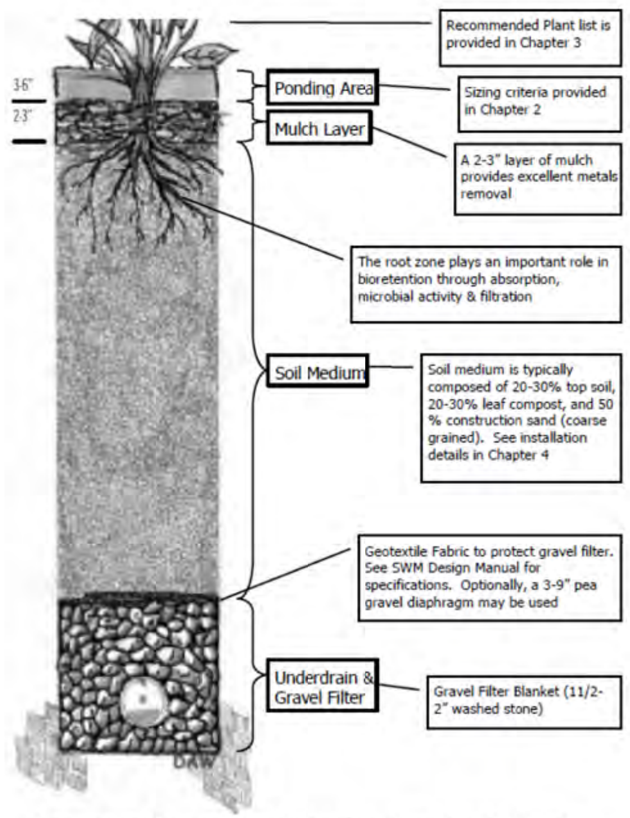

Figure 3.12 Typical Bioretention Swale Section

Source: *The Bioretention Manual*, Prince George's County, Maryland

Figure 3.13 Stormwater Planter

Source: *Low Impact Development SWM Planning and Design Guide*, Credit Valley Conservation Authority and Toronto and Region Conservation Authority

Figure 3.14 Extended Tree Pit

Source: *Low Impact Development SWM Planning and Design Guide*, Credit Valley Conservation Authority and Toronto and Region Conservation Authority

Silva Cells are an alternative low impact development measure similar to a tree pit for managing runoff from high traffic roads. As illustrated on Figure 3.15, the Silva Cell is a modular system of underground frames that can support loadings from parked cars or pedestrian traffic while also providing uncompacted soil within the frames for large tree growth and runoff management. The system provides quantity control through absorption, evapotranspiration, and interception and achieves similar nutrient removal rates to a bioretention cell. Silva Cell systems can be located under sidewalks, parking lay-bys, or landscaped medians, but the frames cannot be positioned under travel lanes since they do not support lateral loads, as described in brochures by Deep Root Canada Corporation (2013). Further consideration is required during detailed design to determine if salt application to the roadway is an applicable restriction to Silva Cells. The modular nature of Silva Cells also provides flexibility in meeting site-specific requirements. For example, the cells allow easy navigation around existing and proposed utilities, as shown on Figure 3.16. **Silva Cells have been carried forward as a potential SWM measure for the Study Area.**

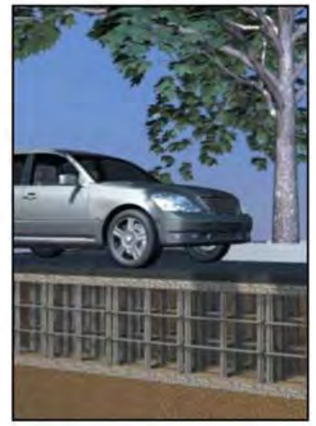

Figure 3.15 Silva Cell

Source: Deep Root Canada Corporation, 2013

Figure 3.16 Running Utilities Through Silva Cells (Left) and External Utility Corridors (Right)

Source: Deep Root Canada Corporation, 2013

Pervious Pipe (Exfiltration) Systems

These systems are constructed in place of or in addition to a traditional storm sewer system and consist of a perforated pipe within a stone trench under the roadway. As shown on Figure 3.17, catchbasins are connected to the perforated pipe, and road runoff infiltrates into the soil surrounding the trench during and following rainfall events. A relief storm sewer conveys runoff from larger storm events to the outlet once the exfiltration trench is full. Exfiltration systems are generally not appropriate for heavily travelled urban arterials. Extensive pre-treatment is required to prevent clogging and there is an increased risk of contamination from polluted runoff. Similar to infiltration trenches and soakaway pits, the Study Area soils do not meet the Ontario Ministry of Environment's minimum infiltration rate. Pervious pipe systems provide similar water quality and quantity benefits as infiltration trenches. **Pervious pipe systems are not recommended for the Study Area due to the limited infiltration capacity of the predominant clay soils throughout.**

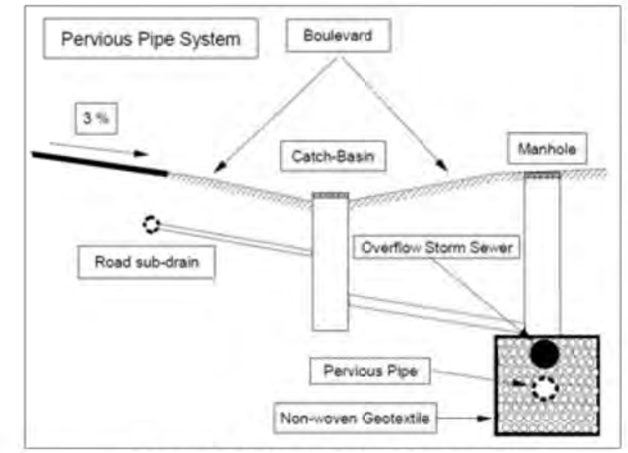

Figure 3.17 Pervious Pipe System

Source: *SWM Planning and Design Manual*, Ontario Ministry of Environment

In summary, the following conveyance control alternatives have been carried forward as a potential SWM measures for the Study Area:

- Enhanced vegetated swales
- Bioretention swales, including tree pits (i.e., Silva Cells)

<u>*End-of-Pipe Controls*</u>

The final alternatives explored for the Study Area are end-of-pipe measures, such as SWM ponds and OGSs. Due to the limited space available for SWM within the ROW, the possibility of using storage on adjacent development land is considered in addition to stand-alone measures.

Potential stand-alone end-of-pipe SWM alternatives within the Study Area include the following:

Super Pipes (Trunk Sewers)

Super pipes are oversized storm sewers that provide underground storage based on a downstream restriction of a small outlet pipe or orifice plate. Although they do not provide water quality improvements, they are very useful when land for above-ground detention facilities is not available. **Super pipes have been carried forward as a potential SWM measure for the Study Area.**

Oil-Grit Separators (OGS)

These treatment devices are often installed to remove both sediments and floatables such as oil from runoff where space is not available for a SWM pond. They can be used in combination with other treatment measures to make up a treatment train approach and can be installed on-line on the storm sewer system. However, OGSs do not have a significant storage volume and are unable to reduce flow rates to mitigate potential flooding and erosion impacts. Oil-grit separators can achieve greater than the required enhanced level of water quality treatment (80% TSS removal) according to the Imbrium technical manual for Stormceptors (Date Unknown), but their performance varies based on design. Similar to CVC and TRCA guidelines, Conservation Halton considers that OGS units are only capable of 50% TSS removal at their original design capacity and recommend the use of a multi-component or treatment train approach in conjunction with the use OGS units. **Oil-grit separators used in conjunction with a treatment train approach, have been carried forward as a potential SWM measure for the Study Area.**

Stormwater Management Ponds

Stormwater management ponds are a commonly applied end-of-pipe measure to manage runoff from new development areas. These detention pools include a permanent pool of water to slowly settle out fine sediments and an active storage zone above the permanent pool to slowly release runoff from moderate to large storm events. The active storage zone typically includes an extended detention zone that slowly discharges runoff from small storm events over a period of 24 to 48 hours to improve water quality and reduce erosion in the receiving watercourse. The remainder of the active storage zone attenuates peak flows from large storm events and controls the discharge from the pond to prevent downstream flooding. Stormwater management ponds can achieve 80% TSS and 65% TP removal (US EPA, 1993). Pre-treatment in a sediment forebay is recommended.

Stormwater management ponds can provide full treatment of storm runoff from roadways, but require a drainage area large enough to support a permanent pool of water (typically greater than 5 ha) and considerable land area beyond a standard road ROW. Open spaces south of Dundas Street are under development or are too small to be used for ponds. Opportunities for using surplus storage in the ponds proposed as part of development plans north of Dundas Street are discussed later in this report. **Stormwater management ponds have been carried forward as a potential SWM measure for the north corridor of the Study Area in conjunction with adjacent development ponds.**

Infiltration Basins

Infiltration basins are ponds constructed with a subsurface infiltration gallery draining into the natural soil or through perforated pipes to the downstream storm sewer network. Infiltration basins can achieve an average removal rate of 75% TSS and 65% TP (US EPA, 1993) and provide quantity control similar to a SWM pond. Pre-treatment in a sediment forebay is recommended. Similar to other infiltration practices, limited infiltration capacity of the soils in the Study Area are not suitable for infiltration basins. **Infiltration basins are not recommended for the Study Area.**

In summary, the following end-of-pipe alternatives have been carried forward as a potential SWM measures for the Study Area:

- Super Pipes
- Oil-grit separators (OGS)
- Stormwater management ponds in conjunction with adjacent development ponds

3.4.3 Proposed Stormwater Management Plan

Drainage from Trafalgar Road is directed to a number of receiving systems throughout the Study Area. To better evaluate SWM measures for Trafalgar Road, the corridor has been divided into smaller drainage catchment areas, as illustrated on Drawing 6 of Appendix A. As previously discussed, an “undeveloped” development scenario is considered north of Dundas Street to represent construction of the Trafalgar Road Corridor Improvements prior to the development of adjacent land. The source, conveyance and end-of-pipe controls identified below should be considered at the detailed design stage for all of the catchment areas.

A restriction along the entire Study Area is the low infiltration rate of the local soils. This limits the application of LID measures dependent on infiltration but alternative measures may become feasible when considering site specific

information, best-management practices, and potential design modifications during detailed design. For example, partial functionality of bioretention swales depends on infiltration into soils. Soils within the Study Area have low infiltration rates, however, bioretention swales may still be feasible in the form of tree pits and rain gardens along the boulevards and landscaped areas. Despite the low infiltration rates of soils in the study area, bioretention units will still function with an underdrain to capture any additional water that does not infiltrate into the surrounding soils. As such, this type of LID infrastructure will be carried forward for consideration with respect to feasibility at the Detailed Design stage.

Source controls such as vegetated filter strips, cisterns, permeable pavement, and enhanced topsoil can reduce the required size of conveyance controls and end-of-pipe facilities (i.e. super pipes, OGSs or SWM ponds). A potential application of permeable pavement would be along the multi-use pathways. These alternatives are further detailed in the following sections as possible options to be evaluated during detailed design.

3.4.3.1 Highway 407 to Joshua’s Creek and East Morrison Creek Watershed Divide

The proposed improvements to this section of Trafalgar Road involve roadway widening and new multiuse pathways. The total ROW area subject to improvements in this section is approximately 7.0 ha, of which 5.4 ha will be impervious. The existing roadside ditch drainage system will be replaced by curb and gutters directing runoff to the proposed storm sewer system. An intersection with the William Halton Parkway is proposed immediately south of the culvert crossing at 8+080.

As previously discussed in Section 3.3.1.1, the preliminary recommendation for runoff generated from the Trafalgar Road ROW is to be collected in a curb and gutter system within the proposed urban cross section and conveyed in a storm sewer system within the Trafalgar Road ROW. This runoff will ultimately outlet to the medium constraint stream corridor of the Joshua’s Creek tributary to maintain flow contributions relative to existing conditions.

Although space within the ROW will be limited, proposed development of adjacent lands could include surplus storage in SWM ponds that could be used to control runoff from Trafalgar Road. The timing of proposed development on adjacent lands will impact the feasibility of SWM ponds and must be considered during detailed design.

Developed Conditions

The potential locations of future SWM ponds are illustrated on Drawing 9 of Appendix A, as indicated by the NOCSS Addendum (2007) and North Oakville Master Plan (2008). Future development SWM ponds in North Oakville should be designed with sufficient capacity to treat and control runoff from roadways, such as Trafalgar Road, as indicated on Figure 7.4.6 of the NOCSS. Further coordination of SWM measures will be required during detailed design of Trafalgar Road with adjacent development. The analysis completed in Section 3.4.1 estimated the storage volume required to treat and control peak flows to existing levels as follows:

- Catchment Area 14 = 1275 m^3
- Catchment Area 13 = 180 m^3
- Catchment Area 12 = 1212 m^3
- Catchment Area 11 = 611 m^3
- Catchment Area 10 = 1618 m^3

The total volume of treatment required to treat runoff from Trafalgar Road determined in Section 3.3.1 are the result of the critical 100-year design storm event as these volumes were larger than those required for the Regional storm, as detailed in Section 3.3.1.3. Detailed design of Trafalgar Road and integration with future SWM facilities should confirm the critical storm for determination of conservative SWM storage requirements.

The roadside ditches and swales currently conveying runoff from the Trafalgar Road ROW Catchment Areas 13 and 14 easterly may be replaced with drainage infrastructure under ultimate conditions as they have no constraint ranking under the NOCSS. SWM mitigation for future adjacent development will need to accommodate the 1455 m^3 volume required to treat runoff from Trafalgar Road from Catchment Areas 13 and 14. It is also recommended that runoff generated from Catchments 13 and 14 directed through future development, maintain a similar outlet as in existing conditions, to the medium constraint stream corridor (blue) to maintain flow contributions relative to existing conditions, as required through the NOCSS.

Similarly, treatment of runoff from Trafalgar Road ROW Catchment Area 12 (1212 m^3) could be accommodated by SWM measures for future development such as the potential future pond located on the west side of Trafalgar Road suggested by Appendix 7.3 of the *North Oakville Master Plan* and as shown on Drawing 9 of Appendix A. Alternatively, treatment of runoff from Trafalgar Road ROW Catchment Areas 12 and 11 could be combined (1823 m^3), and accommodated by the future pond located on the east side of Trafalgar Road and north of Burnhamthorpe Road, as approximated on Figure 7.4.6 of the NOCSS and shown on Drawing 9 of Appendix A. Both potential SWM facilities will be required to outlet at the same location as in existing conditions to maintain the form and function via flow contributions into the receiving medium constraint stream, as required by NOCSS.

The remaining runoff from the Trafalgar Road ROW draining to the Joshua's Creek tributary within the Study Area is generated within Catchment Area 10. Treatment of runoff from Catchment Area 10 (1618 m^3) could be accommodated by SWM measures for future adjacent development such as the future pond estimated by Figure 7.4.6 of the NOCSS, located east of Trafalgar Road and as shown in Drawing 9 of Appendix A. Output from this future potential pond would maintain the existing form and function via flow contributions into the receiving medium constraint stream, as required by NOCSS.

Undeveloped Conditions

In the unlikely event that development of the adjacent properties does not proceed, SWM measures for runoff generated from the Trafalgar Road ROW could include super pipe storage within the ROW to control peak flows with OGS units at each outlet for water quality treatment, subject to further analysis during detailed design. Pre-treatment of flows controlled by the super pipe is recommended to prevent sedimentation build-up within the super pipe.

Super pipe storage with OGS units for pre-treatment may be redundant in developed conditions if the proposed Trafalgar Road storm sewer system is connected and runoff leaving the ROW is integrated into SWM measures for adjacent developments. Alternatively, super pipes with OGS units within the Trafalgar Road ROW could be maintained in developed conditions to provide treatment of flows prior to leaving the Trafalgar Road ROW and before they outlet into the drainage infrastructure of adjacent development.

3.4.3.2 Joshua's Creek and East Morrison Creek Watershed Divide to Dundas Street

The proposed road widening along this 8.8 ha section of Trafalgar Road will double the impervious area within the ROW from 3.6 ha to 7.2 ha. The existing ditch drainage system of the existing rural roadway cross section will be replaced by curb and gutters directing runoff to a proposed storm sewer system to accommodate the proposed urban roadway cross section. Further coordination of SWM measures will be required during detailed design of Trafalgar Road with adjacent development. The analysis completed in Section 3.4.1 estimated the storage volume required to treat and control peak flows to existing levels as follows:

- Catchment Area 9 = 2015 m^3
- Catchment Area 8 = 1364 m^3

- Catchment Area 7 = 1482 m^3
- Catchment Area 6 = 573 m^3
- Catchment Area 5 = 1132 m^3

Developed Conditions

As previously discussed in Section 3.3, it is recommended that the direction of runoff directly from Catchment Area 9 into East Morrison Creek at the mainline crossing culverts is maintained under developed and undeveloped conditions to maintain the form and function of the downstream high constraint stream corridor through flow contributions, as required by the NOCSS. Treatment of runoff from Trafalgar Road Catchment Area 9 could be achieved through integration with SWM measures proposed for future development such as Pond 29 shown on Drawing 10 of Appendix A.

A preliminary review of the Main Branch EIR/FSS was prepared by AECOM on November 4, 2013 and is included in Appendix G. This preliminary review indicated that Pond 29 may be a feasible end-of-pipe measure for treatment of runoff from Catchment Area 9 of the Trafalgar Road ROW. Review of the existing Trafalgar Road profile indicates a low point located near the location of proposed Pond 29. The hydrologic model provided in the appendices of the Main Branch EIR/FSS report indicates that the proposed development area contributing drainage to Pond 29 does not include the Trafalgar Road ROW. The Main Branch EIR/FSS indicates that the current pond design provides approximately 10,599 m^3 more storage than is required during the Regional storm as detailed in Table 3.6.

Table 3.6 Total and Regional Storage in Pond 29

Storage Type	Storage Volume (m^3)	Reference[1]
Total Volume of Pond	68,458	Appendix H-1, GAWSER input code
Regional Storm Storage	57,859	Appendix H-1, GAWSER results table
Surplus	10,599	n/a

1 – All references taken from *EIR/FSS for North Oakville Main-East*, Green Ginger Developments

It is recommended that the potential surplus identified in the preliminary design of Pond 29 documented within the Main Branch EIR/FSS be investigated further during detailed design as a potential end-of-pipe SWM measure for the treatment of 2015 m^3 runoff generated from Catchment Area 9 of the Trafalgar Road ROW. Detailed design should also confirm the critical storm for determination of conservative SWM storage requirements.

Similarly and as previously discussed in Section 3.2, it is recommended that runoff from Catchment Area 8 be captured by the proposed curb and gutter system and conveyed through the supporting storm sewer system that would outlet into East Morrison Creek while maintaining existing flows into the receiving medium constraint stream. Ultimate SWM measures for treatment of 1364 m^3 of runoff generated from Catchment Area 8 of the Trafalgar Road ROW could be accommodated by proposed SWM measures for adjacent development through connection of the proposed Trafalgar Road storm sewer system to the drainage infrastructure of the future development. The feasibility of connection and integration of Trafalgar Road SWM measures with adjacent development on the east side of Trafalgar Road may be limited by the existing alignment of the east branch of East Morrison Creek, as shown on Drawing 10 of Appendix A. The creek alignment limitation may require that runoff from Catchment Area 8 of the Trafalgar Road ROW be treated prior to leaving the ROW. Treatment within the ROW could be accomplished through super pipe storage to control peak flows to existing levels and OGS units to treat water quality. Further investigation for optimal treatment of runoff from Catchment Area 8 and outlet requirements to maintain the form and function of the receiving medium constraint stream will be evaluated during detailed design. Detailed design should also confirm the critical storm for determination of conservative SWM storage requirements.

Runoff generated from Trafalgar Road ROW Catchment Area 7 could also be integrated with SWM measures supporting future adjacent development however, the existing alignment of the east branch of East Morrison Creek limits the potential for SWM integration to the west side of Trafalgar Road, as shown in Drawing 10 of Appendix A. The Main Branch EIR/FSS that included a preliminary design for Pond 29 also carried out a preliminary design of Pond 30 located north of Dundas Street and on the west side of Trafalgar Road as shown on Drawing 10 of Appendix A.

A preliminary review of the Main Branch EIR/FSS was prepared by AECOM on November 4, 2013 and is included in Appendix G. This preliminary review indicated that Pond 30 may be a feasible end-of-pipe measure for treatment of the 1482 m^3 runoff from Catchment Area 7 of the Trafalgar Road ROW. Review of the existing Trafalgar Road profile indicates another low point located near the location of proposed Pond 30. Figure 7.2 and the hydrologic model provided in the appendices of the Main Branch EIR/FSS report indicates that the proposed development area contributing drainage to Pond 30 does not include the Trafalgar Road ROW. The Main Branch EIR/FSS indicates that the current pond design provides a range of surplus storage that varies between EIR/FSS report submission as follows and is summarized in Table 3.7 (note: information presented in Table 3.7 based on current information available at the time the analysis was conducted):

- May 2012 Main Branch EIR/FSS submission: 200 m^3 to 1865 m^3 (range of surplus due to discrepancies in reported volumes in text of report compared to volumes documented in modeling files included in appendices provide with report)
- February 2013 Main Branch EIR/FSS submission: 9,960 m^3
- July 19, 2013 Interim submission (memorandum): 3,600 m^3 to 3,700 m^3 (range due to variation in potential options)

Table 3.7 Total and Regional Storage in Pond 30

Storage Type	Storage Volume (m^3)		
	May 2012 EIR/FSS	**February 2013 EIR/FSS**	**July 19, 2013 Interim Submission**
Data Source	Tables 7.13 & 7.15	Tables 7.15 & 7.17	Memo text
Total Volume of Pond	47,000	65,680	46,500-59,500*
Regional Storm Storage	46,800	55,720	42,800-55,900*
Surplus (Calculated)	200	9,960	3,600-3,700*
Data Source	Appendix H-1 GAWSER input code	Appendix H-1 GAWSER input code	n/a
Total Volume of Pond	48,628	59,366	n/a
Regional Storm Storage	46,763	n/a	n/a
Surplus (Calculated)	1,865	n/a	n/a

1 – All references taken from *EIR/FSS for North Oakville Main-East*, Green Ginger Developments

More recent design information suggests that Pond 30 storage volumes may be constrained, and as such the reliance on Pond 30 for over-control of Trafalgar Road drainage will be confirmed through detailed design. SWM controls within the ROW may be required.

Further investigation for optimal treatment of runoff from Catchment Area 7 and outlet requirements to maintain the form and function of the receiving medium constraint stream will be evaluated during detailed design. Detailed design should also confirm the critical storm for determination of conservative SWM storage requirements.

Runoff generated from Trafalgar Road ROW Catchment Area 6 could also be integrated with SWM measures supporting future adjacent development, however, the existing alignment of the east branch of East Morrison Creek limits the potential for SWM integration to the east side of Trafalgar Road, as shown in Drawing 10 of Appendix A. The East Branch EIR/FSS includes a preliminary design for Pond 32 located north of Dundas Street and on the east side of Trafalgar Road as shown on Drawing 10 of Appendix A.

A preliminary review of the East Branch EIR/FSS was prepared by AECOM on July 4, 2013 and is included in Appendix G. This preliminary review indicated that Pond 32 may be a feasible end-of-pipe measure for treatment of the 573 m^3 runoff from Catchment Area 6 of the Trafalgar Road ROW. Review of the existing Trafalgar Road profile indicates a low point located near the location of proposed Pond 32. Figure 7.2b and the hydrologic model provided in the appendices of the East Branch EIR/FSS report indicates that the proposed development area contributing drainage to Pond 32 does not include the Trafalgar Road ROW. The East Branch EIR/FSS indicates that the current pond design provides a surplus of 77 m^3 to 8348 m^3 of storage during the Regional storm as detailed in Table 3.8. The range of surplus is due to discrepancies in reported volumes in text of report compared to volumes documented in modeling files included in appendices provided with report.

Table 3.8 Total and Regional Storage in Pond 32

Storage Type	Storage Volume (m^3)	Reference[1]
Total Volume of Pond		
	89,811	Table 7.10
	81,100	Appendix H-1, Visual OTTHYMO output code
Regional Storm Storage		
	81,463	Table 7.10
	81,023	Appendix H-1, Visual OTTHYMO output code
Surplus Volume		
Min.	77	n/a
Max.	8348	n/a

1 *All references taken from East Morrison Creek Subcatchment EM4, Dundas-Trafalgar Inc. & Shieldbay Inc. North Oakville, EIR/FSS, December, 2012*

Further investigation for optimal treatment of runoff from Catchment Area 6 and outlet requirements to maintain the form and function of the receiving medium constraint stream will be evaluated during detailed design. Detailed design should also confirm the critical storm for determination of conservative SWM storage requirements.

Integration of the 1132 m^3 runoff generated from Trafalgar Road ROW Catchment Area 5 with SWM measures of future development may be possible but limited to the west side of Trafalgar Road, such as the previously discussed Pond 30, as a result of existing alignment of East Morrison Creek, as shown on Drawing 10 of Appendix A. Preliminary investigation of the existing road profile indicates that grading may not permit drainage of Trafalgar Road Catchment Area 5 to Pond 30 and due to spacing limitations within the ROW, this runoff may need to be treated using super pipe storage for peak flow control and OGS units for water quality treatment.

Further review and analyses are recommended during detailed design to confirm details associated with the Trafalgar Road improvements and proposed SWM ponds on adjacent lands. This subsequent review and analyses may include, but is not limited to the following:

- Confirming positive drainage is feasible considering grading constraints
- Verifying feasibility of drainage infrastructure considering design requirements
- Evaluating potential SWM pond design modifications to gain additional surplus storage (i.e., deeper pond depth, increased footprint)
- Calculating the resultant SWM pond performance with the changes to the contributing drainage area from Trafalgar Road.
- Confirmation of critical storm event including the Trafalgar Road ROW for determining SWM facility storage requirements.

Undeveloped Conditions

SWM measures for runoff generated from the Trafalgar Road ROW could include super pipe storage within the ROW to control peak flows with OGS units at each outlet for water quality treatment, subject to further analysis during detailed design. Pre-treatment of flows controlled by the super pipe is recommended to prevent sedimentation build-up within the super pipe.

Super pipe storage with OGS units for treatment may be redundant in developed conditions if the proposed Trafalgar Road storm sewer system is connected and runoff leaving the ROW is integrated into SWM measures of adjacent developments. Alternatively, super pipes with OGS units within the Trafalgar Road ROW could be maintained in developed conditions to provide runoff treatment of flows prior to leaving the Trafalgar Road ROW and before they outlet into the drainage infrastructure of adjacent development.

3.4.3.3 Dundas Street East to Hays Boulevard

Under current conditions, drainage from this urban section of roadway is conveyed by a storm sewer system to East Morrison Creek at culvert crossing 5+225. A roadside ditch west of Trafalgar Road also collects external drainage and outlets upstream of the East Morrison Creek crossing. The total ROW area in this section is approximately 1.3 ha, of which 1 ha will be impervious after proposed widening and other improvements.

Due to the limited space within and beyond the ROW, SWM ponds and enhanced vegetated swales are not feasible stormwater management options. Further assessment of the soils in this catchment is required during detailed design to determine the feasibility of recommended source and conveyance controls discussed in Section 3.3.2. Super pipes are feasible for this section to provide quantity control and the required treatment can be provided by OGS units. Two storm sewer systems will be required north and south of the creek crossing.

The analysis completed in Section 3.4.1 estimated that a storage volume of 186 m^3 is required to control peak flows to existing levels. This volume can be provided by a 975 mm diameter super pipe along this section in conjunction with OGS units. Pre-treatment of flows controlled by the super pipe is recommended to prevent sedimentation build-up within the super pipe. Application of source and conveyance controls could reduce the size of both structures and should be assessed during detailed design for feasibility.

3.4.3.4 Hays Boulevard to Upper Middle Road

The majority of this length of Trafalgar Road (ROW Catchment Area 3) has an urban section with a single storm sewer system conveying drainage to the storm sewer along Upper Middle Road which ultimately discharges to East Morrison Creek. Intermittent roadside ditches are located on the west side of Trafalgar Road from Hays Boulevard

to River Oaks Boulevard and along the east side of Trafalgar Road from Oak Park Boulevard/Postridge Drive to Glenashton Drive. Drainage from the ditches are collected by ditch inlet catchbasins and conveyed to the main storm sewer system on Trafalgar Road.

The proposed widening of this 8.0 ha section will increase the impervious area to 6.4 ha. The proposed roadway improvements for Trafalgar Road will cover the existing intermittent ditch drainage systems and replace them with a storm sewer system.

AECOM completed a preliminary review of the stormwater management plan for Dunpar Developments Inc. prepared by Johnson Sustronk Weinstein (JSW) and Associates (2012), and is provided in Appendix G. The proposed townhouse development is located south of Glenashton Drive on the west side of Trafalgar Road. The report proposes a SWM tank that has a required volume of 231 m^3 (Section 5.3) and is designed to provide a total volume of 250 m^3 (Drawing SD-1). The tank will therefore have a surplus volume of 19 m^3. The tank has limited available capacity and is located in the middle of the subdivision making access difficult from Trafalgar Road. Integration of the storage tank in the Dunpar Developments subdivision is not recommended for treatment of runoff from Trafalgar Road, within the Study Area.

Due to the limited space within and beyond the ROW, SWM ponds and enhanced vegetated swales are not a feasible stormwater management option. Further assessment of the soils in this catchment is required during detailed design to determine the feasibility of recommended source and conveyance controls discussed in Section 3.3.2. Super pipes together with an OGS unit are recommended to provide water quantity and quality treatment to the 2186 m^3 of runoff generated from Catchment Area 3. Pre-treatment of flows controlled by the super pipe is recommended to prevent sedimentation build-up within the super pipe. Treatment of runoff generated from Trafalgar Road ROW Catchment Area 3 should be investigated further during detailed design.

The analysis completed in Section 3.4.1 estimated that a storage volume of 2186 m^3 is required to control peak flows to existing levels. This volume can be provided by a 1350 mm diameter super pipe along the section. Application of bioswales and source controls could reduce the size of the super pipe and OGS and should be assessed during detailed design for feasibility.

3.4.3.5 Upper Middle Road to Leighland Avenue/Iroquois Shore Road

Trafalgar Road has an urban section from Upper Middle Road to approximately midway to White Oaks Boulevard North / Sheridan College. Under existing conditions, curbs and gutters convey runoff to parallel storm sewers ultimately discharging to a roadside ditch on the west side of Trafalgar Road. This ditch continues along the west side of a rural section of Trafalgar Road past Ceremonial Drive then departs due south to West Morrison Creek. The rural section adjacent to Sheridan College extends to approximately 75 m north of Ceremonial Drive and is also drained by a second ditch on the east side of the roadway. Trafalgar Road returns to an urban section south of Ceremonial Road with curbs and gutters conveying runoff to parallel storm sewer systems discharging to the Morrison-Wedgewood Diversion Channel.

The proposed improvements to this section of Trafalgar Road include widening in each direction for almost the entire length from Upper Middle Road to the Morrison-Wedgewood Diversion Channel. The proposed improvements extend along a total proposed ROW area of approximately 7.7 ha, of which 6.1 ha will be impervious. The existing ditch drainage systems will be covered by the proposed road widening and replaced by a storm sewer system. An end-of-pipe SWM pond was considered on the west side of Trafalgar Road, south of Ceremonial Drive but not selected due to the significant environmental impacts associated with removal of a forested area. Due to the limited space within and beyond the ROW, SWM ponds are not a feasible management option. Further assessment of the soils in this catchment is required during detailed design to determine the feasibility of the recommended source and conveyance stormwater management controls discussed in Section 3.3.2.

Super pipes are feasible for this section to provide quantity control of runoff but additional management options would be required to provide the necessary treatment, such as OGSs. Two storm sewer systems would be required for this section to convey drainage to the two existing outlets to the Morrison-Wedgewood Diversion Channel and the drainage course leading westward to West Morrison Creek.

The analysis completed in Section 3.4.1 estimated that storage volumes of 643 m^3 and 717 m^3 are required north and south of White Oaks Boulevard North, respectively, to control peak flows to existing levels. This volume can be provided by a 975 mm diameter super pipe to the north and a 1200 mm diameter super pipe to the south along this section. Pre-treatment of flows controlled by the super pipe is recommended to prevent sedimentation build-up within the super pipe.

3.4.3.6 Leighland Avenue/Iroquois Shore Road to Cross Avenue/South Service Road

Under existing conditions, this urban section of Trafalgar Road includes catchbasins that collect storm drainage into storm sewers conveying roadway drainage north of the QEW to the Morrison-Wedgewood diversion and south of the QEW to Sixteen Mile Creek. Control of peak runoff flows to existing conditions has not been evaluated as road widening is not proposed along this section and it is assumed that existing peak flows will be maintained in proposed conditions.

3.4.3.7 Cross Avenue/South Service Road to Cornwall Road

This urban section of Trafalgar Road falls within the Sixteen Mile Creek watershed. Under existing conditions, storm runoff from the roadway is collected by catchbasins and conveyed through a storm sewer system discharging directly into Sixteen Mile Creek at an outlet located south of Cornwall Road. Control of peak runoff flows to existing conditions has not been evaluated as road widening is not proposed along this section and it is assumed that existing peak flows will be maintained in proposed conditions.

3.5 Mainline Crossing Culverts

The proposed improvements to Trafalgar Road impact all crossing culverts through the Study Area. All culverts must be extended to accommodate the proposed widened roadway platform. Several of the crossings also require replacements to provide sufficient capacity in accordance with hydraulic criteria defined in Section 1.2.2 while others must be replaced due to the poor or very poor condition of the existing structure.

A summary of the recommendations based on the existing conditions analysis of hydraulic performance, assessment of culvert condition, and the NOCCS stream corridor constraint ranking of watercourses are summarized in Table 3.9.

Table 3.9 Summary of Existing Mainline Crossing Culverts Assessments

Station	NOCSS ID	Structure ID	F.G. ID	Existing Hydraulic Performance	Existing Condition Rating	NOCSS Constraint Classification	Recommendations for Proposed Conditions
5+225[3]		03-1182530 CU02	C7	Fail	Very Poor	n/a[1]	Replacement & Extension
5+500	ME-T1	03-1182510	C6	Fail	Good	Medium	Replacement & Extension
5+665	ME-T2	03-1182530 CU01	C5	Fail	Very Poor	Medium	Removal
5+820	ME-T3		C4	Fail	Acceptable	Medium	Replacement & Extension
6+200	ME-T4			Pass	Poor	None	Temporary Replacement & Extension
6+725	ME-T5			Fail	Acceptable	n/a[2]	Replacement & Extension
7+315				Pass	Acceptable	None	Temporary Extension
7+750				Pass	Acceptable	None	Temporary Extension
8+080				Pass	Poor	None	Temporary Replacement & Extension
8+385				Pass	Good	None	Temporary Extension

1 – Culvert 5+225 is beyond the NOCSS Study Area and therefore is located on a watercourse without a constraint ranking

2 – This crossing is located upstream of a high constraint reach of East Morrison Creek, maintenance requirements should be confirmed during detailed design

3 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

Replacements and/or upgrades are required for the five (5) culvert crossings that do not achieve the hydraulic criteria under existing conditions. The remaining five (5) culverts convey drainage swales not classified in the NOCSS will only be required if Trafalgar Road construction proceeds prior to the development of adjacent land. Under the undeveloped conditions scenario, two (2) of these five (5) existing culvert crossings not classified by NOCSS will need to be replaced under undeveloped conditions due to the poor condition where the other three (3) will only require extension. It is assumed that under developed conditions the drainage swales will be replaced by urban drainage infrastructure and these five (5) culverts will be abandoned.

A preliminary hydraulic analysis has been completed to define potential culvert sizes at each crossing under both developed and undeveloped conditions. The permanent crossings are proposed to be replaced with open bottom concrete box culverts that allow for fish passage, as requested by CH in their letter to AECOM on July 7, 2010, while CSP culverts are proposed for temporary crossings as a cost effective option. The results of the hydraulic models and the preliminary sizing of each proposed culvert are discussed in the following sections and summarized for all culverts in Table 3.20 through Table 3.23.

3.5.1 Hydraulic Analysis

The HEC-RAS and CulvertMaster models prepared for the existing conditions analysis were updated to represent proposed conditions, including the following:

- Increased bridge deck widths to represent widened Trafalgar Road
- Extended culverts on the upstream and downstream ends by corresponding road widening lengths
- Adjustment and/or removal of cross sections where proposed culverts and road widening extended beyond existing cross-section

- Increased culvert sizes to provide minimum hydraulic opening required to achieve hydraulic criteria
- Updated downstream boundary condition of the north hydraulic model (known water surface elevations) with using the south hydraulic model, as directed by Janette Brenner of CH on April 13, 2013

As detailed by CH in their letter to AECOM dated July 7, 2010, the lengths of the creeks that have to be enclosed under transportation corridors must be minimized by using features such as retaining walls and/or headwalls. The extended lengths used in this analysis may be reduced during detailed design by including such features.

The proposed improvements to Trafalgar Road maintain the existing centreline profile of the road and therefore the bridge deck elevations in the HEC-RAS models were not revised. In addition, the peak flows under proposed conditions are the same as existing as all development north of Dundas Street must control peak flow for the 2-year to Regional storms to existing conditions in accordance with the NOCSS.

Culvert 8+385

The existing Culvert 8+385 is an 800 mm diameter x 32.6 m long CSP culvert draining to reach JC-10 in the tributary of Joshua's Creek categorized in NOCSS as low constraint riparian corridor. As previously discussed, adjacent development is expected to abandon this crossing and replace it with a fully piped storm sewer system discharging to medium constraint reach JC-10A. The proposed improvements to Trafalgar Road will replace the ditch drainage system with a curb and gutter system draining south through storm sewers. As such, the crossing is only required during undeveloped conditions to drain runoff from undeveloped land west of Trafalgar Road towards the tributary of Joshua's Creek. As previously discussed, the detailed design of the William Halton Parkway is concurrent with this study and includes the storm sewer and road improvements from the future intersection of the William Halton Parkway with Trafalgar Road to Highway 407.

In the unlikely event that development of the adjacent properties does not proceed, the existing CSP culvert would be extended to be 48 m long. The extended culvert was analyzed in CulvertMaster to evaluate the impacts of the extension on freeboard and on upstream water levels. The CulvertMaster model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed culvert length. The results of the model compared to the existing culvert performance are summarized in Table 3.10.

Table 3.10 CulvertMaster Model Output – 8+385

Headwater Calculation Method	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Inlet	50-Year	184.79	184.80
	100-Year	184.82	184.83
	130% of 100-Year	184.89	184.91
	Regional	185.16	185.17
Outlet	50-Year	184.85	184.87
	100-Year	184.89	184.91
	130% of 100-Year	184.96	184.98
	Regional	185.23	185.26

As can be seen from the above table, upstream water levels are anticipated to increase slightly as a result of the proposed culvert extension. The culvert operates under outlet control for both existing and proposed conditions. The invert elevations for the extended culvert maintain the slope of the existing culvert. The extended culvert achieves all freeboard and HW/D requirements, however the extension does cause an increase in headwater

elevation of 0.03 m during the Regional storm, which would need to be addressed. The proposed culvert performance evaluated based on the hydraulic criteria is summarized in Table 3.20 through Table 3.23. An electronic copy of CulvertMaster model is provided on a CD in Appendix B.

Culvert 8+080

The existing Culvert 8+080 is a 1000 mm diameter x 35.5 m long CSP culvert located immediately north of the future William Halton Parkway and achieves all applicable performance criteria under existing conditions. Similar to Culvert 8+385, adjacent development is expected to abandon this crossing and replace it with a fully piped storm sewer system discharging to the medium constraint reach JC-10A. In addition, runoff from Trafalgar Road will be redirected by the proposed curb and gutter system through storm sewers. The crossing is therefore only required during the undeveloped condition scenario to drain the undeveloped land from the west to the east side of Trafalgar Road.

In the unlikely event that development of the adjacent properties does not proceed, the existing CSP culvert will be replaced due to poor condition with a culvert extended by 23.1 m to a total length of 58.6 m to accommodate road widening. The proposed culvert was analyzed in CulvertMaster to evaluate the impacts of the extension on freeboard and upstream water levels. The CulvertMaster model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed culvert length. Using the same diameter as the existing culvert for the proposed temporary replacement resulted in upstream water levels increasing by up to 0.07 m. As the culvert requires replacement due to its poor current condition, a larger replacement culvert was considered in order to meet flood requirements. The results of the model with a 1400 mm diameter CSP replacement culvert compared to the existing culvert performance are summarized in Table 3.11.

Table 3.11 CulvertMaster Model Output – 8+080

Headwater Calculation Method	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Inlet	50-Year	184.62	184.66
	100-Year	184.65	184.68
	130% of 100-Year	184.70	184.72
	Regional	184.86	184.85
Outlet	50-Year	184.68	184.71
	100-Year	184.70	184.73
	130% of 100-Year	184.76	184.78
	Regional	184.92	184.92

As can be seen from the above table, upstream water levels are anticipated to remain the same during the Regional storm but may increase slightly during smaller storm events. The culvert operates under outlet control conditions for both existing and proposed conditions. The invert elevations for the extended replacement culvert maintain the slope of the existing culvert. Freeboard and HW/D criteria are achieved by the temporary culvert, however the minor increases in headwater elevation of up to 0.03 m may occur during rainfall events smaller than the Regional storm, which would need to be addressed. The performance of the proposed culvert based on applicable hydraulic criteria is summarized in Table 3.20 through Table 3.23. An electronic copy of the CulvertMaster model is provided on a CD in Appendix B.

Culvert 7+750

The existing Culvert 7+750 is a 1400 mm diameter x 45.2 m long CSP culvert draining runoff from west of Trafalgar Road to a drainage ditch directing runoff east to culvert JC-B10. Similar to the culverts north of this, adjacent development is expected to abandon this crossing and replace it with a fully piped storm sewer system.

In the unlikely event that development of the adjacent properties does not proceed, the existing CSP culvert will be extended to be 72.2 m long to accommodate road widening. The proposed culvert was analyzed in CulvertMaster to evaluate the impacts of the extension on freeboard and on upstream water levels. The CulvertMaster model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed culvert length. The results of the CulvertMaster model compared to the existing culvert performance are summarized in Table 3.12.

Table 3.12 CulvertMaster Model Output – 7+750

Headwater Calculation Method	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Inlet	50-Year	182.68	182.74
	100-Year	182.72	182.78
	130% of 100-Year	182.81	182.87
	Regional	183.10	183.16
Outlet	50-Year	182.78	182.83
	100-Year	182.82	182.88
	130% of 100-Year	182.92	182.97
	Regional	183.21	183.27

As can be seen from the above table, upstream water levels are anticipated to increase slightly as a result of the proposed culvert extension. The culvert operates under outlet control conditions for both existing and proposed conditions. The invert elevations for the extended culvert maintain the slope of the existing culvert. Freeboard and HW/D criteria are achieved by the temporary culvert, however the extension does cause an increase in headwater elevation of 0.06 m during the Regional storm, which would need to be addressed. The performance of the proposed culvert based on applicable hydraulic criteria is summarized in Table 3.20 through Table 3.23. An electronic copy of the CulvertMaster model is provided on a CD in Appendix B.

Culvert 7+315

The existing Culvert 7+315 is a twin 1390 mm high x 970mm wide x 35.9 m long CSP arch culvert draining runoff from west of Trafalgar Road to a drainage ditch directing runoff east to a tributary of Joshua's Creek. Similar to the culverts north Burnhamthorpe Road, adjacent development is expected to abandon this crossing and replace it with a fully piped storm sewer system.

In the unlikely event that development of the adjacent properties does not proceed, the existing CSP culverts would be extended to be 59.8 m long to accommodate road widening. The proposed culvert was analyzed in CulvertMaster to evaluate the impacts of the extension on freeboard and on upstream water levels. The CulvertMaster model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed culvert length. The results of the CulvertMaster model compared to the existing culvert performance are summarized in Table 3.13.

Table 3.13 CulvertMaster Model Output – 7+315

Headwater Calculation Method	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Inlet	50-Year	180.85	180.85
	100-Year	180.87	180.87
	130% of 100-Year	180.91	180.91
	Regional	181.06	181.06
Outlet	50-Year	180.88	180.89
	100-Year	180.90	180.92
	130% of 100-Year	180.95	180.96
	Regional	181.11	181.12

As can be seen from the above table, upstream water levels are anticipated to increase slightly as a result of the proposed culvert extension. The culvert operates under outlet control conditions for both existing and proposed conditions. The invert elevations for the extended culvert maintain the slope of the existing culvert. Freeboard and HW/D criteria are achieved by the temporary culvert, however the extension does cause an increase in headwater elevation of 0.01 m during the Regional storm which would need to be addressed. The proposed culvert performance evaluated based on the hydraulic criteria is summarized in Table 3.20 through Table 3.23. An electronic copy of CulvertMaster model is provided on a CD in Appendix B.

Culvert 6+725 (ME-T5)

The existing Culvert 6+725 (ME-T5) is a 1880 mm wide x 1260 mm high x 33.0 m long CSP arch culvert. It is proposed to replace this culvert with a larger, open-bottomed structure to mitigate flooding and allow for fish passage. The proposed culvert will also be extended to accommodate road widening. A 2200 mm wide x 1000 mm high x 62.3 m long concrete box culvert is proposed for the crossing at station 6+725 (ME-T5). The culvert inverts will be changed to provide a positive slope, unlike the reversed slope of the existing culvert. With the changes to inverts, length, and size, the existing road profile will not provide sufficient cover over the proposed culvert. Insufficient cover should be addressed at detailed design by raising the elevation of the road profile, proposing a structural culvert to reduce cover requirements, and/or dropping the channel invert.

The proposed replacement culvert was analyzed in HEC-RAS to evaluate the impacts of the culvert replacement on freeboard and upstream water levels. The HEC-RAS model prepared for the existing conditions analysis in Section 2.4.2 was updated to reflect the proposed replacement culvert. The results of the HEC-RAS model compared to the existing culvert performance are summarized in Table 3.14.

Table 3.14 HEC-RAS Model Output – 6+725 (ME-T5)

HEC-RAS Cross Section	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
37	50-Year	180.05	179.89
(immediately upstream of	100-Year	180.05	179.93
replacement culvert)	130% of 100-Year	180.14	180.04
	Regional	180.50	180.31
38	50-Year	180.76	180.68
(200 m upstream of	100-Year	180.77	180.70
replacement culvert)	130% of 100-Year	180.72	180.72
	Regional	180.78	180.78

As can be seen from the above table, water levels in the watercourse immediately upstream of Trafalgar Road are expected to decrease as a result of the replacement culvert. For the design event (50-year storm), the freeboard to proposed edge of pavement 0.01 m more than the 1 m required and the road will not be overtopped during a Regional flood event. The clearance to the top of the culvert will be 0.39 m for the 50-year event, slightly greater than the 0.3 m required. The proposed culvert will therefore achieve the performance criteria and will not impact upstream water levels. Confirmation of achieving required cover for this culvert should be determined during detailed design. The results of the proposed culvert performance during the design storms evaluated as required by the criteria are summarized in Table 3.20 through Table 3.23. An electronic copy of the HEC-RAS model is provided on a CD in Appendix B.

Culvert 6+200 (ME-T4)

The existing Culvert 6+200 (ME-T4) is a 600 mm diameter x 35.2 m long CSP arch culvert. The existing culvert drains a small area west of Trafalgar Road to a drainage ditch connecting to East Morrison Creek.

In the unlikely event that development of the adjacent properties does not proceed, the existing CSP culvert would be replaced due to poor condition with a 64.1 m long culvert to accommodate road widening. The proposed culvert was analyzed in CulvertMaster to evaluate the impacts of the extension on freeboard and on upstream water levels. The CulvertMaster model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed culvert length. Using the same diameter as the existing culvert for the proposed temporary replacement resulted in upstream water levels increasing by up to 0.11 m. As the culvert requires replacement due to its poor current condition, a larger replacement culvert was considered in order to meet flood requirements. The results of the HEC-RAS model with twin 675 mm diameter CSP replacement culverts compared to the existing culvert performance are summarized in Table 3.15.

Table 3.15 CulvertMaster Model Output – 6+200 (ME-T4)

Headwater Calculation Method	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Inlet	50-Year	174.75	174.82
	100-Year	174.76	174.82
	130% of 100-Year	174.78	174.84
	Regional	174.86	174.89
Outlet	50-Year	174.79	174.84
	100-Year	174.80	174.85
	130% of 100-Year	174.82	174.87
	Regional	174.91	174.92

As can be seen from the above table, upstream water levels are anticipated to increase slightly as a result of the proposed culvert replacement. The culvert operates under outlet control conditions for both existing and proposed conditions. The invert elevations for the extended culvert maintain the slope of the existing culvert. Freeboard and HW/D criteria are achieved by the temporary culvert, however the replacement does cause an increase in headwater elevation of 0.01 m during the Regional storm which would need to be addressed. The performance of the proposed culvert based on applicable hydraulic criteria is summarized in Table 3.20 through Table 3.23. An electronic copy of the CulvertMaster model is provided on a CD in Appendix B.

Culvert 5+820 (ME-T3)

The existing Culvert 5+820 (ME-T3) is a twin 1000 mm diameter x 41.4 m long CSP culvert. An extended replacement culvert with larger capacity and an open bottom is suggested to mitigate flooding, accommodate road widening, and allow for fish passage. A single 2100 mm wide x 1100 mm high x 79.5 m long concrete box culvert, or equivalent capacity, was originally proposed for the crossing at station 5+820 (ME-T3), with the culvert inverts changed to provide a positive slope, unlike the reversed slope of the existing north cell culvert.

The originally proposed replacement culvert was analyzed in HEC-RAS to evaluate the impacts of the culvert replacement on freeboard and upstream water levels. The HEC-RAS model prepared for the existing conditions analysis in Section 2.4.2 was updated to reflect the proposed replacement culvert. The results of the HEC-RAS model compared to the existing culvert performance are summarized in Table 3.16.

Table 3.16 HEC-RAS Model Output – 5+820 (ME-T3)

HEC-RAS Cross Section	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Upstream end of culvert	50-Year	170.03	169.67
	100-Year	170.12	169.73
	130% of 100-Year	170.41	169.89
	Regional	170.86	170.42
26	50-Year	170.60	170.60
(100 m upstream of	100-Year	170.61	170.61
replacement culvert)	130% of 100-Year	170.62	170.62
	Regional	170.87	170.72

As can be seen from the above table, water levels in the watercourse upstream of Trafalgar Road are expected to decrease as a result of the replacement culvert. For the design event (50-year storm), the freeboard to the proposed edge of pavement will be well in excess of the 1 m required, and the road will not be overtopped during a Regional flood event. The clearance to the top of the culvert will be above the 0.3 m required for the 50-year event. The proposed culvert will therefore achieve all applicable performance criteria and will not impact upstream water levels. The results of the proposed culvert performance during the design storms evaluated as required by the criteria are summarized in Table 3.20 through Table 3.23. An electronic copy of the HEC-RAS model is provided on a CD in Appendix B.

With the proposed realignment of East Morrison Creek to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3), by Minto, a larger culvert is proposed for this crossing. The preliminary culvert sizing for the culvert at Station 5+820 (ME-T3) proposed by Minto consists of a 7320 x 1250 mm concrete box culvert which is sufficient to accommodate both the active bankfull channel (1.75m), as well as a functional floodplain. Further details are provided in the EIR/FSS reports documenting Minto's proposed creek realignment design under separate cover.

Culvert 5+665 (ME-T2)

The existing Culvert 5+665 (ME-T2) is a 1800 mm wide x 1050 mm high x 37.1 m long concrete box culvert with an open bottom. Originally an extended replacement culvert with larger capacity was suggested to mitigate flooding and accommodate road widening. A 3500 mm wide x 1100 mm high x 69.4 m long concrete box culvert, or equivalent capacity, was proposed for the crossing at station 5+665 (ME-T2).

The proposed replacement culvert was analyzed in HEC-RAS to evaluate the impacts of the culvert replacement on freeboard and on upstream water levels. The HEC-RAS model prepared for the existing conditions analysis in Section 2.4.2 was updated to reflect the proposed replacement culvert. The results of the HEC-RAS model compared to the existing culvert performance are summarized in Table 3.17.

Table 3.17 HEC-RAS Model Output – 5+665 (ME-T2)

HEC-RAS Cross Section	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
Upstream end of culvert	50-Year	168.85	168.14
	100-Year	168.97	168.10
	130% of 100-Year	169.24	168.24
	Regional	169.50	168.62
23	50-Year	169.27	168.60
(96 m upstream of	100-Year	169.28	168.67
replacement culvert)	130% of 100-Year	169.32	168.78
	Regional	169.54	169.03

As can be seen from the above table, water levels in the watercourse upstream of Trafalgar Road are expected to decrease as a result of the replacement culvert. For the design event (50-year storm), the freeboard to proposed edge of pavement will be less than the 1 m required. The design process of this culvert crossing indicated a strong dependence on the downstream backwater influence. It is recommended that detailed design of this culvert crossing consider raising the road profile to accommodate the 1 m freeboard, relaxing the required freeboard criterion or providing further investigation into the impacts of downstream conveyance infrastructure and associated backwater effects. The culvert proposed does indicate that the road will not be overtopped during a Regional flood event. The required clearance to the top of the culvert will be met during the 50-year design storm event and apart from the freeboard criterion during the 50-year design storm event, the proposed culvert will achieve all applicable performance criteria and will not impact upstream water levels. The results of the proposed culvert performance during the design storms evaluated as required by the criteria are summarized in Table 3.20 through Table 3.23. An electronic copy of the HEC-RAS model is provided on a CD in Appendix B.

With the proposed realignment of East Morrison Creek to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3), by Minto, this culvert will be removed.

Culvert 5+500 (ME-T1)

The existing Culvert 5+500 (ME-T1) is a 2440 mm wide x 1520 mm high x 31.4 m long concrete box culvert. It was originally proposed to replace this culvert with a larger, open-bottomed structure to mitigate flooding and allow for fish passage. The proposed culvert will also need to be longer than the existing culvert to accommodate road widening. A 5000 mm wide x 1500 mm high x 49.4 m long concrete box culvert (or equivalent capacity) is proposed for the crossing at station 5+500 (ME-T1). The existing road profile provides sufficient cover over the proposed culvert.

The proposed replacement culvert was analyzed in HEC-RAS to evaluate the impacts of the culvert replacement on freeboard and on upstream water levels. The HEC-RAS model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed replacement culvert. The results of the HEC-RAS model compared to the existing culvert performance are summarized in Table 3.18.

Table 3.18 HEC-RAS Model Output – 5+500 (ME-T1)

HEC-RAS Cross Section	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
20	50-Year	168.72	167.27
(34 m upstream of	100-Year	168.80	167.35
replacement culvert)	130% of 100-Year	168.96	167.70
	Regional	169.17	168.40

As can be seen from the above table, water levels in the watercourse upstream of Trafalgar Road are expected to decrease as a result of the replacement culvert. For the design event (50-year storm), the freeboard to the proposed edge of pavement will exceed the minimum 1 m required, and the road will not be overtopped during a Regional storm event. The clearance to the top of the culvert will slightly exceed the required 0.30 m 50-year event. The proposed culvert will therefore achieve all applicable performance criteria and will not impact upstream water levels. The results of the proposed culvert performance during the design storms evaluated as required by the criteria are summarized in Table 3.20 through Table 3.23. An electronic copy of the HEC-RAS model is provided on a CD in Appendix B.

With the proposed realignment of East Morrison Creek to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3), by Minto, a smaller culvert may be appropriate for this crossing. Culvert sizing will be confirmed during Detailed Design in consultation with Conservation Halton.

Culvert 5+225

The existing Culvert 5+225 is a 3480 mm wide x 2210 mm high x 36.8 m long corrugated steel pipe (CSP) arch culvert. It is proposed to replace this culvert with a larger, open-bottomed structure to mitigate flooding and allow for fish passage. The proposed culvert will also need to be longer than the existing culvert to accommodate road widening. A 6400 mm wide x 2700 mm high x 58 m long concrete box culvert (or equivalent) was originally proposed for the East Morrison Creek crossing at station 5+225. The existing road profile provides sufficient cover over the proposed culvert.

The proposed replacement culvert was analyzed in HEC-RAS to evaluate the impacts of the culvert replacement on freeboard and on upstream water levels. The HEC-RAS model prepared for the existing conditions analysis (Section 2.4.2) was updated to reflect the proposed replacement culvert. The results of the HEC-RAS model are summarized in Table 3.19.

Table 3.19 HEC-RAS Model Output – 5+225

HEC-RAS Cross Section	Storm Event	Headwater Elevation (m)	
		Existing	Proposed
5320.74	50-Year	168.63	166.67
(immediately upstream of	100-Year	168.67	166.85
replacement culvert)	130% of 100-Year	168.76	167.31
	Regional	168.85	167.87
5462.43	50-Year	168.65	167.11
(143 m upstream of	100-Year	168.71	167.25
replacement culvert)	130% of 100-Year	168.81	167.63
	Regional	168.93	168.12

As can be seen from the above table, water levels in the watercourse upstream of Trafalgar Road are expected to decrease as a result of the replacement culvert. For the design event (50-year storm), the freeboard to the proposed edge of pavement will be well in excess of the 1 m required, and the road will not be overtopped during a Regional storm event. The clearance to the top of the culvert will exceed the 0.3 m required for the 50-year event. The proposed culvert will therefore achieve all applicable performance criteria and will not impact upstream water levels. The proposed culvert is greater than the minimal acceptable size that meets all hydraulic requirements to minimize the effect of the tailwater downstream of Dundas Street on the crossings farther upstream. The results of the proposed culvert performance during the design storms evaluated as required by the criteria are summarized in Table 3.20 through Table 3.23. An electronic copy of the HEC-RAS model is provided on a CD in Appendix B.

Subsequent to the preliminary analysis, it was confirmed that this culvert will be required to accommodate 3x bankfull channel width which would require an increase to the originally proposed culvert size (i.e. to 7000 x 2430 mm). Culvert sizing will be confirmed during Detailed Design in consultation with Conservation Halton.

3.5.2 Culvert Design Performance Summary

The results of the proposed conditions hydraulic models using HEC-RAS and CulvertMaster are summarized in Table 3.20 through Table 3.23. As can be seen from Table 3.20, the hydraulic modelling of the 50-year design storm event indicates that the originally proposed culvert at station 5+665 (ME-T3) does not meet the freeboard requirement by 0.34 m while the other nine (9) of the ten (10) proposed culverts achieve the HDDS requirements for freeboard and headwater-to-depth ratio or clearance during the 50-year design storm event. With the larger culvert proposed by Minto for the crossing at station 5+665 (ME-T3), freeboard requirements will be met as documented in the applicable EIR/FSS reports provided under separate cover.

Table 3.20 Proposed Culvert Performance Summary – 50-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Headwater to Depth Ration (HW/D)	Clearance (m)	Freeboard (m)
5+225[1]	25.60	166.67	n/a	0.50	1.90
5+500 (ME-T1)	2.72	167.27	n/a	0.35	1.13
5+665 (ME-T2)	1.91	168.14	n/a	0.31	**0.66**
5+820 (ME-T3)	1.74	169.67	n/a	0.37	1.39
6+200 (ME-T4)– South Cell	0.029	174.84	0.17	n/a	1.85
6+200 (ME-T4)– North Cell					
6+725 (ME-T5)	1.13	179.89	n/a	0.39	1.01
7+315 – South Cell	0.46	180.89	0.28	n/a	1.41
7+315 – North Cell			0.31		
7+750	0.54	182.83	0.44	n/a	1.93
8+080	0.16	184.71	0.23	n/a	1.69
8+385	0.23	184.87	0.60	n/a	1.54
MTO Highway Drainage Design Standards			≤ 1.5	≥ 0.3 m	≥ 1.0 m
PASS	FAIL	N/A			

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The hydraulic modelling results summarized in Table 3.21 indicate that all ten (10) proposed culvert crossings achieve the headwater-to-depth ratio during the 100-year storm event as per the Town's requirements.

Table 3.21 Proposed Culvert Performance Summary – 100-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Headwater to Depth Ration (HW/D)
5+225[1]	28.70	166.85	0.88
5+500 (ME-T1)	3.07	167.35	0.82
5+665 (ME-T2)	2.15	168.10	0.68
5+820 (ME-T3)	1.96	169.73	0.72
6+200 (ME-T4) – South Cell	0.032	174.85	0.19
6+200 (ME-T4) – North Cell			
6+725 (ME-T5)	1.27	179.93	0.65
7+315 – South Cell	0.52	180.92	0.31
7+315 – North Cell			0.34
7+750	0.61	182.88	0.47
8+080	0.18	184.73	0.24
8+385	0.26	184.91	0.65
Town Development Engineering Requirements			≤ 1
PASS	FAIL	N/A	

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The headwater elevation generated by the check flows (130% of the 100-year storm event peak flows) at all ten (10) proposed culvert crossings achieve the MTO HDDS freeboard requirement, as summarized in Table 3.22.

Table 3.22 Proposed Culvert Performance Summary – 130% of 100-Year Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)	Freeboard (m)
5+225[1]	37.31	167.31	1.26
5+500 (ME-T1)	3.99	167.70	0.70
5+665 (ME-T2)	2.80	168.24	0.56
5+820 (ME-T3)	2.55	169.89	1.17
6+200 (ME-T4) – South Cell	0.042	174.87	1.82
6+200 (ME-T4) – North Cell			
6+725 (ME-T5)	1.65	180.04	0.86
7+315 – South Cell	0.67	180.96	1.34
7+315 – North Cell			
7+750	0.79	182.97	1.79
8+080	0.24	184.78	1.62
8+385	0.33	184.98	1.43
MTO Highway Drainage Design Standards			≥ 0
PASS	FAIL	N/A	

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

Regional roads must be free of flooding during the Regional storm event as per CH requirements and changes to culverts must not increase flooding upstream of the crossing as per the Town's and CH's guidelines discussed in Section 1.2.2. The results summarized in Table 3.23 indicate that all ten (10) proposed culvert crossings will achieve the freeboard requirement although four (4) of the ten (10) proposed culverts will slightly increase the headwater elevation due to extensions and/or replacements (under undeveloped conditions).

Table 3.23 Proposed Culvert Performance Summary – Regional Storm Event

Station	Flow (m^3/s)	Headwater Elevation (m)		Freeboard (m)
		Proposed	Change from Existing	
5+225[1]	48.9	167.87	-0.98	0.70
5+500 (ME-T1)	7.55	168.40	-0.77	0.00
5+665 (ME-T2)	5.29	168.62	-0.88	0.18
5+820 (ME-T3)	4.83	170.42	-0.44	0.64
6+200 (ME-T4) – South Cell	0.080	174.92	0.01	1.77
6+200 (ME-T4) – North Cell				
6+725 (ME-T5)	2.72	180.31	-0.19	0.59
7+315 – South Cell	1.26	181.12	0.01	1.18
7+315 – North Cell				
7+750	1.45	183.27	0.06	1.49
8+080	0.43	184.92	0.00	1.48
8+385	0.61	185.26	0.03	1.15
Criteria			≥ 0	≥ 0
PASS	FAIL	N/A		

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

Overall, extending and/or replacing the mainline crossing culverts at stations 6+200 (ME-T4), 7+315, 7+750, and 8+385 causes minor increases in the headwater elevations during the Regional storm, ranging from 0.01 m to 0.06 m, which would need to be addressed in the unlikely event that development of the adjacent properties does not proceed. Adjacent development is expected to abandon these crossing and replace them with fully piped storm sewer systems.

The low road profile at station 5+665 (ME-T2) relative to the elevation of the creek bed is a limitation that leads to insufficient freeboard for this culvert. This issue is addressed with the proposed realignment of East Morrison Creek to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3), by Minto, as this culvert will be removed. In the unlikely event that development of the adjacent properties does not proceed, consideration for raising the elevation of the road profile along with further investigation into the impacts of downstream conveyance infrastructure and associated backwater effects should be reviewed during detailed design.

The remaining six (6) of ten (10) culverts in the Study Area meet the hydraulic requirements under proposed conditions, with or without the development of the adjacent lands.

As previously discussed, the results of the hydraulic models are subject to changes in future phases of the Trafalgar Road Improvements project due to coordination with other development and reconstruction projects. Additional revisions during detailed design may be required such as replacement rather than extension of temporary crossings to provide an open bottom allowing for fish passage, as preferred by CH. The capacity of downstream receiving storm sewers and ditches should be confirmed at detailed design to ensure sufficient capacity is provided for drainage from the Trafalgar Road ROW.

The preliminary sizing of the proposed culverts is summarized in Table 3.24, including the minimum required hydraulic opening to achieve design criteria and the closest standard culvert dimensions.

Table 3.24 Summary of Proposed Culvert Properties

Station	NOCSS ID	Recommendations	Length (m)	Minimum Required Hydraulic Dimensions	Recommended Standard Culvert Dimensions
5+225		Replacement & Extension	58.0	5200 x 2700 mm CONC. box (open footing)	7000 x 2430 mm Precast CONC box
n/a	ME-D2	Existing	61.8	4270 x 2000 mm CONC. box	Same as existing
5+500	ME-T1	Replacement & Extension	49.4	5000 x 1500 mm CONC. box (open footing)	5000 x 1800 mm Precast CONC box
5+665	ME-T2	Removal	n/a	n/a	n/a
5+820	ME-T3	Replacement & Extension	97.0	2100 x 1100 mm CONC. box (open footing)	7320 x 1250 mm CONC box (proposed by Minto)
6+200	ME-T4	Temporary Replacement & Extension	64.1	Twin 675 mm circular CSP	Twin 675 mm circular CSP
6+725	ME-T5	Replacement & Extension	62.3	3500 x 1000 mm CONC. box (open footing)	3600 x 1200 mm Precast CONC box
7+315		Temporary Extension	59.7 (South Cell) 59.8 (North Cell)	Twin 1390 x 970 mm CSP arch	Same as existing
7+750		Temporary Extension	72.2	1400 mm circular CSP	Same as existing
8+080		Temporary Replacement & Extension	58.6	1400 mm circular CSP	1400 mm circular CSP
8+385		Temporary Extension	48.0	800 mm circular CSP	Same as existing

1 – Note: that to be compatible with road stationing, the number 1 should be prefixed to each culvert station

The three culverts requiring temporary extensions are highlighted in cyan in Figure 3.18 while the one culvert to be removed and the remaining six culverts requiring replacement and extension are highlighted in magenta and yellow respectively, subject to development of the adjacent lands.

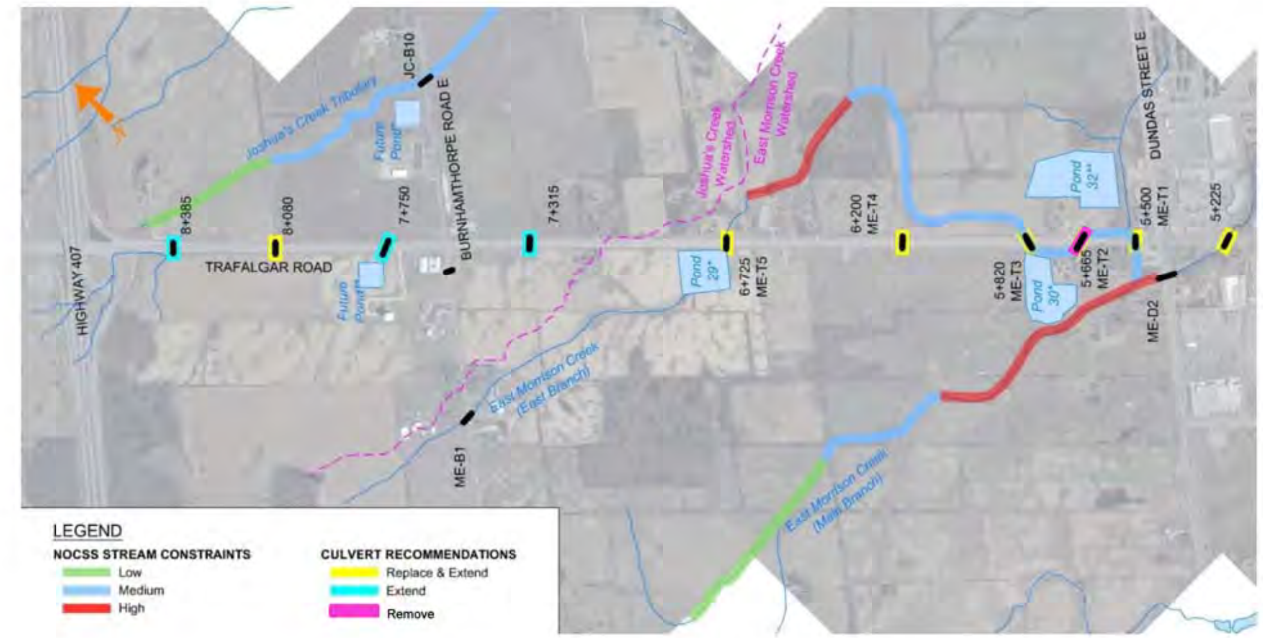

Figure 3.18 Proposed Culvert Replacements, Extensions and Removals

3.6 Proposed Utilities

A subsurface utility engineering (SUE) mapping investigation was completed for the Study Area by T2UE in early 2013 based on utility records and field observations of aerial hydro lines. Field investigation of underground utilities was not included in the scope of work and the maps show several areas with gaps in the available information.

The SUE report recommends that a full field investigation is completed and that the multiple pipeline crossings within the Study Area be addressed at the preliminary design stage. A copy of the SUE will be included in the ESR prepared by AECOM (see ESR Appendix I – Utilities).

4. Sediment and Erosion Control

Appropriate sediment and erosion control measures must be implemented prior to the commencement of construction on the proposed roadway improvements and must be maintained during and following construction until all disturbed areas have been stabilized.

A sediment and erosion control plan will be prepared during detailed design. The sediment and erosion control plan should adhere to the guidelines established by the Greater Golden Horseshoe Area Conservation Authorities Erosion and Sediment Guideline for Urban Construction. In addition, a monitoring plan for construction and post-construction phases will be prepared during detailed design in accordance with the Town's *Stormwater Monitoring Guidelines for South of Dundas Street* (2011) and *North of Dundas Street* (2012).

5. Summary and Conclusions

AECOM was retained by the Regional Municipality of Halton (Region) to undertake an Environmental Assessment for improvements to Trafalgar Road between Cornwall Road and Highway 407. This Stormwater Management Report has been prepared to support the Environmental Assessment.

Through most of its length north of Dundas Street, Trafalgar Road is currently a four-lane rural roadway with roadside ditches for drainage that run parallel to the roadway. The section of the Study Area north of Dundas Street drains to tributaries of Joshua's Creek and the east branch of East Morrison Creek. The southern portion of the Study Area is predominantly an urban cross section with storm sewers directing runoff to the south. Short rural sections with ditch drainage systems are found at several locations in the southern portion of the Study Area. South of Dundas Street, the Trafalgar Road storm sewer systems drain to East Morrison Creek, West Morrison Creek, and the Morrison-Wedgewood Diversion Channel.

There are ten (10) mainline crossing locations in the Study Area, four (4) of which convey tributaries of Joshua's Creek while the other six (6) convey East Morrison Creek. Five (5) of the ten (10) existing culvert crossings provide inadequate hydraulic capacity, and two (2) other culverts were in poor condition and require replacement. The remaining three (3) culverts achieve all relevant criteria regarding clearance and freeboard.

It is proposed to widen Trafalgar Road from the Morrison-Wedgewood Diversion Channel to Highway 407 to an urban section. The proposed widening of Trafalgar Road has the potential to impact water quality, erosion and flooding in the receiving watercourses and downstream storm sewer systems. Alternatives to mitigate the impacts to the receiving systems were developed and summarized as follows:

- The integration of road runoff collection into the design of future SWM ponds on adjacent developments is recommended, where possible, for the Trafalgar Road ROW from Highway 407 to Dundas Street. If additional storage capacity is required beyond what can be accommodated within adjacent development ponds, super pipe storage is recommended to control peak flows with OGS units for water quality treatment, subject to further analysis during detailed design. Pre-treatment of flows controlled by super pipes is recommended to prevent sediment accumulation within the super pipes.
- OGS units in conjunction with super pipes are recommended to manage runoff from Trafalgar Road between Dundas Street and the Morrison-Wedgewood Diversion Channel. This option was selected due to limited space within the proposed ROW. Pre-treatment of flows controlled by super pipes is recommended to prevent sediment accumulation within the super pipes.

In accordance with the NOCSS, detailed consideration of the feasibility of infiltration facilities, such as Low Impact Development (LID) measures (i.e. bioswales and other source controls), should be made during detailed design using site specific information, best-management practices from current guidance documents, and recognition that modifications to facilities may be required to account for local soil conditions. Application of these options may reduce the size of the recommended SWM facilities required to adequately control runoff.

Analyses were completed for the existing culverts through the Study Area to assess the impacts and provide recommendations for replacements and extensions. Four of the existing crossing culverts are to be replaced with larger, extended concrete box structures with open footings to allow for fish passage, as follows:

- a 7000 x 2430 mm concrete box (or equivalent) at Station 5+225
- a 5000 x 1800 mm concrete box (or equivalent) at Station 5+500 (ME-T1)
- a 7320 x 1250 mm concrete box (or equivalent) at Station 5+820 (ME-T3) as proposed by Minto
- a 3600 x 1200 mm concrete box (or equivalent) at Station 6+725 (ME-T5)

The culvert at Station 5+665 (ME-T2) will be removed since it is no longer required due to the realignment of the east branch of the East Morrison Creek to the west side of Trafalgar Road, connecting to the main branch of East Morrison Creek.

Adjacent development is expected to abandon the remaining crossing and replace them with fully piped storm sewer systems. In the unlikely event that development of the adjacent properties does not proceed, two of the existing crossing culverts are to be replaced due to the poor condition of the existing structure as follows:

- a twin 675 mm circular CSP, or equivalent, at Station 6+200 (ME-T4)
- a 1400 mm circular CSP, or equivalent, at Station 8+080

The remaining three existing culverts would require extension to accommodate road widening:

- a twin 1390 x 970 mm CSP arch at Station 7+315
- a 1400 mm circular CSP at Station 7+750
- an 800 mm circular CSP at Station 8+385

Overall, extending the mainline crossing culverts at stations 6+200 (ME-T4), 7+750, and 8+080 would cause minor increases in the headwater elevations during the Regional storm, ranging from 0.02 m to 0.06 m, which would need to be addressed in the unlikely event that development of the adjacent properties does not proceed.

The low road profile at station 5+665 (ME-T2) relative to the elevation of the creek bed is a limitation that leads to insufficient freeboard for this culvert. This issue is addressed with the proposed realignment of East Morrison Creek to the west side of Trafalgar Road via the culvert at Station 5+820 (ME-T3), by Minto, as this culvert will be removed. In the unlikely event that development of the adjacent properties does not proceed, consideration for raising the elevation of the road profile along with further investigation into the impacts of downstream conveyance infrastructure and associated backwater effects should be reviewed during detailed design.

The remaining six (6) of ten (10) proposed culverts in the Study Area meet the hydraulic requirements under proposed conditions.

As previously discussed, the results of the hydraulic models are subject to changes in future phases of the Trafalgar Road Improvements project due to coordination with other development and reconstruction projects.

It is recommended that the proposed conditions hydraulic modelling and SWM sizing be updated during detailed design. In addition, major drainage routes are to be designed and capacity of downstream infrastructure is to be evaluated during detailed design.

A sediment and erosion control plan will be required at the detailed design stage. It is recommended that the sediment and erosion control plan be prepared consistent with the Greater Golden Horseshoe Area Conservation Authorities Erosion and Sediment Guideline for Urban Construction. In addition, a monitoring plan for construction and post-construction phases will be prepared during detailed design in accordance with the Town's Stormwater Monitoring Guidelines for South of Dundas Street (2011) and North of Dundas Street (2012).

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