ENVIRONMENTAL IMPLEMENTATION REPORT / FUNCTIONAL SERVICING STUDY – MAIN REPORT (4TH SUBMISSION)

June 2017 (Addendum August 2018)

14 Mile Creek West and the Lazy Pat Farm Property (3269 Dundas Street West), North Oakville West

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D14-011-18

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Executive Summary

Executive Summary

This Environmental Implementation Report and Functional Servicing Study (EIR/FSS) has been prepared for a portion of lands within the Fourteen Mile Creek West catchment area (FM1001) and the bcIMC Realty Corp. lands, managed by QuadReal Property Group (formerly Bentall Kennedy (Canada) LP) and commonly known as the “Lazy Pat Farms” property (Subject Property). A range of environmental and municipal servicing matters are addressed in this EIR/FSS as required by the approved Terms of Reference for EIR/FSS studies for North Oakville.

The Subject Property is located within the western portion of North Oakville West Secondary Plan (NOWSP) area, which has been defined as the 407 West Employment Area. The Subject Property is located on the north side of Dundas Street West (Highway 5), generally mid-block between Tremaine Road and Bronte Road (Highway 25), in the Town of Oakville. The property encompasses an area of approximately 185 acres (75 hectares).

The purpose of the EIR is to characterize and analyze the natural heritage features and functions and to determine and address the potential impacts of a proposed development application, including servicing requirements, on the Natural Heritage System (NHS). The purpose of the FSS is to identify servicing requirements related to sanitary, water, stormwater, roads, and site grading. Further, the purpose of both the EIR and FSS is to provide a link between the Town’s North Oakville Creeks Subwatershed Study (NOCSS) Management Report and Implementation Report, the NOWSP (OPA 289) and the Draft Plan of Subdivision submissions for development applications and identification of environmental and engineering draft plan conditions of approval for the Subject Property.

The following summarizes the major findings and recommendations of the EIR/FSS.

1.1 EIR Subcatchment Area and FSS Study Area

The Subject Lands are located primarily within the FM1001 subcatchment area, and smaller portions lie within the FM1102 and FM1109 subcatchment areas. The EIR subcatchment boundaries were refined using 2002 Town of Oakville topographic mapping. A comparison of updated existing drainage areas was made with drainage areas reported in the NOCSS Study. There are differences in drainage boundary interpretation resulting in approximately a 14 ha decrease in subcatchment FM1102, a 36 ha decrease in subcatchment FM1001 and a 3 ha increase in subcatchment FM1109; however, all drainage remains within the Fourteen Mile Creek system.

EIR Subcatchment Area is defined to be the FM1001 subcatchment, focusing on the area south of Highway 407. Environmental and engineering requirements for the small portions of FM1102 and FM1109 subcatchment areas have been addressed without the need to prepare an EIR for these subcatchment areas, in accordance with the Terms of Reference.

The FSS Study Area is defined to include the Subject Property; however, additional details have been provided for the entire 407 West Employment Area (lands bounded by Dundas Street West, Tremaine Road, Highway 407 and Regional Road 25 (Bronte Road)), to ensure servicing requirements for the areas external to the Draft Plan of Subdivision are adequate.

1.2 Natural Heritage System Framework

With respect to the Subject Property and the EIR Subcatchment Area, OPA 289, NOCSS and NOCSS Addendum identify various environmental features to be protected and/or studied further during the preparation of the EIR/FSS. As illustrated on Figure NOW 3 from OPA 289 (Figure 2.1), the components of the Natural Heritage System (NHS) that are located within the EIR Subcatchment Area, and related subcatchment areas on the Subject Property include the ‘High Constraint Stream Corridor Area’ and ‘Medium Constraint Stream Corridor Area’, and features designated as ‘Other Hydrological Features’, which includes Low Constraint Stream Corridors, Hydrologic Features “A” and Hydrologic Features “B” and topographic depressions. These natural heritage components are further addressed through Section 2.0 and Section 5.0 of the EIR/FSS.

1.3 Land Use

The proposed land uses for the Subject Property consist of a range of employment uses and associated natural heritage and open space uses, in accordance with the Region’s and Town’s land use and planning directions for the 407 West Employment Area. The development concept envisions the creation of an office and business park with prestige employment uses adjacent to Highway 407, due to increased visibility along this major Provincial Highway. Mixed employment uses, which include limited service and office uses, (i.e., identified as Mixed Employment) are envisioned at the major road intersections along the Dundas Street corridor and at major Arterial intersections to serve the employment area. It is proposed that more general industrial uses, such as mixed warehousing and office uses may be accommodated internal to the business park. The Development Area Concept Plan (Figure 3.1) and proposed Draft Plan of Subdivision (Figure 3.2) are further presented in Section 3.0.

The NOWSP, Figure NOW4 conceptually identifies a Major Trail System along the Burnhamthorpe Road extension, west of Bronte Road, extending to Tremaine Road, in addition to a Major Trail System within the NHS, along the main stream corridor which traverses the Subject Property and around the NHS associated with Fourteen Mile Creek. The Town’s North Oakville Trails Plan, May 2013 provides further guidance with respect to trails planning in North Oakville. Figure 3.3 illustrates the conceptual trails plan within the 407 West Employment Area. Design considerations are provided to guide further trail design at later stages in the development process where the trail system interfaces with the NHS. Section 5.0 provides further details with respect to trail planning in relation to the NHS.

The Planning Rationale Report, prepared by WSP Canada Group Limited (WSP) (formerly MMM Group Limited), in support of the Draft Plan of Subdivision and Zoning By-law Amendment applications, concludes that the development proposal is consistent with the Provincial Policy Statement, the Region of Halton Official Plan and the NOWSP.

1.4 Hydrogeology and Geology

The Subject Property and the three subwatersheds that traverse the property are located in a hydrogeological environment that is not particularly favourable towards mitigation of infiltration losses. The surficial fine-grained deposits of Halton Till found throughout the study area serves to limit infiltration to the groundwater system (69 mm/year) and as a result, the local watercourse systems receive a little over two-thirds of their total water from surface runoff (141 mm/year). Based upon the results of the water balance analysis, almost all of the groundwater base flow into the watercourses occurs over the period of November to May, when the entire shallow system, including upgradient reaches of the channel are saturated and contributing water to the watercourses. The watercourses are observed in a dry to ponded condition during the summer months as identified by the water balance, and the comparisons of measured stream flows to estimates from the water balance methodology are reasonable.

The lower reaches of the FM1001 tributaries (generally to the south of Highway 407) are interpreted as receiving minor groundwater contributions from the Queenston Shale bedrock but these contributions are insufficient to provide enough water to maintain flow in these watercourses during the summer months as the watercourses have been observed in dry to ponded conditions during these periods. Groundwater inputs from the bedrock into the realigned watercourses after development are however expected to increase compared with the pre-development levels. Over the lower reaches of the main channel there may be greater opportunity for bedrock-based groundwater to maintain pools in the channel as the bedrock is exposed in the channel and the watercourse is shaded somewhat by large trees.

The section of the FM1109 tributary (Reach 14W-11 and Reach 14W-11A) passing through the northeast corner of the Subject Property is interpreted from collected site data to be losing water to the ground, due to the nearby influence of a buried bedrock valley to the east. The large human-made Farm Pond at the central portion of the Subject Property is also shown to be maintained almost entirely by surface water inflow rather than from groundwater contributions on the basis of the comparison of the measured surface water levels at the pond against the groundwater elevations at monitoring wells constructed around the pond. Minor, seasonal groundwater seepage potential has been identified at a mini-piezometer station located to the northwest of the west end of the pond alongside Reach 14W-12A where both upward and downward gradients have been recorded. The quantity of water discharging to the channel in this area has been calculated to be quite small and any losses due to construction of the pond will be made up with water from a 40 m length of infiltration trench and from controlled flow of roof runoff from nearby buildings.

The upper weathered zone of the surficial till deposits found throughout the subwatershed provides the bulk of the groundwater inputs to the local watercourses, but on a seasonal basis over about seven months of the year. The enhanced permeability of this upper zone permits infiltrating groundwater to travel through the shallow zone towards the watercourses and it is these conditions that provide the most promising potential mitigation opportunities at this site.

The greatest opportunity for mitigating against infiltration losses at the Subject Property is along the edge of the existing valley lands where the naturally weathered and fractured surficial till soils will remain undisturbed by construction and will retain their ability to convey water laterally towards the watercourses. It is along these lands that infiltration swales primarily receiving clean roof runoff are proposed, and such infiltration measures are calculated to reduce the post-development on-site infiltration deficits from approximately 62% (with no mitigation proposed) to a balance with the pre-existing conditions with the use of the infiltration swales.

1.5 Natural Environment

The Subject Property and surrounding lands consists principally of agricultural lands that are actively farmed intermixed with recreation and rural residential uses that are dissected by a local and regional road network. The notable natural features within the catchments areas of the Subject Property include the Oakville-Milton Wetlands & Uplands Candidate Life Science Area of Natural and Scientific Interest (ANSI), North Oakville – Milton Wetlands – West Provincially Significant Wetland (PSW) Complex, Trafalgar

Moraine Candidate Provincially Significant Earth Science ANSI, Halton Region Significant Woodlands, as well as, features identified in NOCSS including Core #1 and Linkage to Core #2 and Stream Corridors associated with Fourteen Mile Creek including watercourses supporting Redside Dace and Hydrological Features. With the exception of the Stream Corridors and Hydrological Features the remaining features are located beyond the boundary of the Subject Property. Within the boundaries of the Subject Property the main natural features consist of tributaries of Fourteen Mile Creek including Redside Dace habitat, as well as, their associated riparian habitat. Species at Risk (SAR) discussions with the Ministry of Natural Resources and Forestry (MNRF) (formerly Ministry of Natural Resources) were undertaken for the species identified within the Subject Property. Consultation has indicated that approvals under the Endangered Species Act (2007) will be required for impacts related Redside Dace and potentially for Bobolink, Barn Swallow, and two bat species; Little Brown Myotis and Northern Myotis. All approvals will be confirmed during detailed design.

Detailed field investigations were undertaken between 2009 and 2011 to supplement background data from the NOCSS, previous field investigations undertaken on site by WSP (formerly MMM Group Limited which was formerly Marshall Macklin Monaghan Limited) and to address comments received from Conservation Halton (CH) and the Town of Oakville. This data was used to verify the NOCSS classification of habitat, as well as, assess potential impacts to the natural features associated with the proposed concept plan. With the exception of a section of Reach 14W-12 and Reach 14W-14A, generally the field data supported the NOCSS classification of form and function and associated constraints.

Potential effects to the natural heritage system associated with the proposed concept plan were also examined, taking into consideration the habitat present, as well as, mitigation measures, to determine potential residual impacts. Previous consultation with Fisheries and Oceans Canada (DFO) has indicated that a *Fisheries Act* (FA) (1985) Authorization will not be required for the consolidation and realignment of Reach 14W-13 and Reach 14W-14, as well as, the realignment of Reach 14W-11A. The proposed realignments will provide suitable opportunities to undertake restoration works in watercourses that have been altered by agricultural activities including the incorporation of greater habitat diversity (i.e., riffles, pools) and improved riparian cover as identified in the enhancement strategies. These restoration works will be implemented to address potential adverse effects to fish and fish habitat associated with the proposed realignments works.

The development concept plan also proposes to remove the existing Farm Pond (Reach 14W-14A) and its incorporation into the proposed stormwater management plan, with enhanced water quality treatment to improve water quality discharged to downstream fish habitat in Reach 14W-12. This will result in the removal of the constructed agricultural Farm Pond feature that, due to its current form, has adverse thermal and water quality effects to downstream Redside Dace habitat. Its removal is anticipated to benefit fish and fish habitat. DFO has indicated that the effects to Reach 14W-14A will not require a FA (1985) Authorization.

The proposed development will also result in changes to flow within the reaches, most notably within the upper section of Reach 14W-12 (referred to as Reach 14W-12A in this report). The effect of this change in flow was examined based on the ecological function of the relatively short section of the reach to be affected and the anticipated change in flow. Based on the function of this short section, it is anticipated that any adverse effects can be addressed through the proposed habitat enhancements in other reaches.

The natural heritage components are further addressed in Section 5.0.

1.6 Water Resources

The refinement of corridor widths for high and medium constraint streams have been completed based on the guidance provided in the NOCSS. A medium constraint stream corridor (Reach 14W-14) and a low constraint stream corridor (Reach 14W-13) of the West Branch of Fourteen Mile Creek within the Subject Property are proposed to be diverted to Reach 14W-12A, approximately 20 metres upstream of the connection with 14W-12 to accommodate the development. The proposed diversion (Reach 14W-21) along Highway 407 will intercept flows from Reach 14W-13 and Reach 14W-14 just downstream of Highway 407 and eventually divert them to Reach 14W-12A via another proposed diversion (Reach 14W-22) along the southwest limits of the Subject Property. Another medium constraint stream corridor (Reach 14W-11A) of the West Branch of Fourteen Mile Creek will be realigned along Highway 407 and the northeast limits of the Subject Property.

All proposed diversion channels have been developed based on the principles of Natural Channel Design and NOCSS requirements. The proposed Natural Channel Design features (e.g., pools, riffles, and floodplain wetlands) provide great opportunity to sustain or even improve the ecological functions already existing in Reach 14W-13, Reach 14W-14, and Reach 14W-11A.

The HEC RAS model was updated to account for the proposed re-alignments. Changes in bed elevation and water surface elevations, due to changes in connectivity and continuity were analyzed in terms of conveyance, floodplain mapping, and riparian storage. The floodlines under interim and ultimate conditions were delineated, and they fall within the meander belt + factor of safety width in most cases. In a few instances, where floodlines were not encompassed within that limit, the Hazard Allowance setback was offset from the floodlines, following the recommendations of the NOCSS.

For all proposed reaches within the Subject Property associated with the future developments (i.e., 14W-22, 14W-23 and 14W-12A), the results of riparian storage analysis show that the all future channels would have more riparian storages than those under the existing conditions based on both design flows and standardized flows. The only exception is for Reach 14W-14/14W-22, where the decrease in riparian storage of 11% estimated under regional storm was estimated. However, this reduction is reasonable by considering the 23% flow reduction at the channel during the future conditions.

1.7 Stormwater Management

In accordance with the NOCSS, the NOCSS unit flow rates have been used along with the updated existing drainage areas to calculate pre-development peak flow rates at both EIR nodes and reference flow nodes. As required by NOCSS and the EIR/FSS Terms of Reference, alternative Stormwater Management Practices are described and evaluated for application in the EIR Subcatchment Area, and a stormwater management plan was selected to satisfy NOCSS and Town of Oakville stormwater management goals, objectives and targets.

The soils within the Subject Property have been characterized as clay loams that have a relatively low infiltration potential and the proposed employment land uses have a high imperviousness to accommodate viable employment development blocks. Therefore, minimal opportunities to implement infiltration techniques are anticipated, other than the potential for proposed infiltration swales alongside the valley corridors. Opportunities to integrate low impact development measures at the lot level will be considered at the detailed design stage. The current strategy is aimed at addressing stormwater impacts from the dense urban form planned under the Town's policies and guidelines. As the eventual imperviousness of the final blocks will be determined by the prospective tenants, conservative assumptions on block coverages have been utilized to devise a stormwater management strategy. Any built form proposals that reduce lot imperviousness and/or install low impact development techniques or on-site stormwater management controls will reduce flow rates and pollutant loadings to the proposed stormwater management (SWM) facilities and should be encouraged.

A stormwater management plan has been developed for the Subject Property based on the guidance provided in the NOCSS. Preliminary designs have been completed for the four SWM facilities associated with the subject study area, including two SWM facilities within the Subject Property and the other two SWM facilities located outside of the Subject Property, east of Tremaine Road between Highway 407 and Dundas Street. The following provides a summary for the SWM plan:

- Water Quantity: The stormwater management facilities are sized to control the post-development peak flows to pre-development levels for the 2-year to 100-year return period events and the Regional Storm.

- Water Quality: The SWM facilities are designed to meet MOECC's Enhanced Level of water quality protection (Level 1) for water quality control, phosphorus control and fisheries protection (thermal mitigation).

- Erosion Control: The detailed erosion threshold analyses including a fluvial geomorphological study were performed to ensure the proposed SWM facilities would provide adequate erosion control protection for the downstream watercourses, so that existing channel erosion or aggradation is not exacerbated by development.

- Hydrologic Flow Regimes Analysis: A comprehensive investigation of the impact of development has been carried out on all flow nodes within the Subject Property. Where reaches were to be re-aligned or where habitat concerns had been communicated with the study team, detailed assessments were incorporated. Specifically, the magnitude of peak flows will only decrease by 15-20% from existing conditions for Reach 14W-22 and Reach 14W-23, and the duration and frequency will be similar. For Reach 14W-12A, although reductions in stream flows are anticipated, the wetted perimeter and continuity of the flows will be maintained.

  Note that in order to allow a uniform and sustained level of flow to be maintained in the subject receiving 14W-12A channel, flows from rooftops of the proposed buildings with a total area of 5.12 ha will be diverted to Reach 14W-12A directly under ultimate development conditions. Note that it is assumed that the roof drains will be installed at rooftops of the proposed buildings to provide a controlled unit flow rate of 41 L/s/ha at a maximum water depth of 0.15 m on the rooftops.

- Topographic Depression Volumes: Evaluation of the existing depression storage was performed to ensure that the natural depression storage would be maintained in the SWM system.

- SWM Pond Design: The SWM facilities are design to meet all the criteria as enforced by the MOECC and in accordance with the Town of Oakville design guidelines.

- Downstream Impacts for Regional Storm: With the proposed SWM facilities providing Regional controls for the developments within the Subject Property, there will be no impact to the downstream watercourses due to the development of the Subject Property. As a prudent measure, a hydrological analysis for the entire Fourteen Mile Creek subwatershed was carried out to investigate and ensure that there would not be potential increases to flood risk for the entire downstream watercourse to its outlet at Lake Ontario during Regional Storm conditions.

1.8 Municipal Servicing

Section 8.0 outlines the municipal services for the 407 West Employment Area and Subject Property based on the proposed development concept plan. This includes proposed wastewater servicing, water distribution, stormwater servicing and management, and conceptual road and lot grading. The servicing design was developed using the information and guidelines provided by the Region of Halton's Water and Wastewater Master Plan, the NOCSS and the approved 407 West Employment Area – Area Servicing Plan, June 2014, prepared by WSP (formerly MMM Group).

Wastewater servicing design consists of a gravity flow system which drains north to south and connects to the proposed trunk sewer on Dundas Street West, ultimately discharging to the existing Colonel William Parkway wastewater system. The conceptual wastewater servicing design is described in detail in Section 8.2 and illustrated in Figure 8.2.

The water distribution system will be serviced from the Oakville pressure district Zone 3 supply, connecting at Dundas Street West and Bronte Road with an interconnection to Burlington Zone B3, connecting at Dundas Street West and Tremaine Road. Water will be supplied through a system of trunk and local mains within the proposed road network in accordance with the Regional Master Plan. Sizing of watermains was determined using the water model outlined in Section 8.3 and illustrated in Figure 8.4 and Appendix 8.2.

Stormwater servicing will consist of gravity sewers within the conceptual road network that will discharge to SWM facilities for treatment based on the catchment areas indicated in Section 7.0. The major storm system will convey the major storm flows via an overland flow route along the road rights-of-way to the designated SWM facility. The conceptual minor and major storm system designs are illustrated on Figure 8.5.

The conceptual road and lot grading was designed with the intention of matching existing grades as closely as possible while still maintaining necessary elements of the Stormwater Management Plan detailed in Section 7.0. The conceptual grading plan is illustrated on Figure 8.6.

1.0 Introduction

1.0 Introduction

1.1 Study Purpose

This Environmental Implementation Report and Functional Servicing Study (EIR/FSS) has been prepared in accordance with the requirements of the Town of Oakville North Oakville Environmental Implementation Report and Functional Servicing Study Terms of Reference (ToR), August 2, 2007 (Revised May 2013), for a portion of lands within the Fourteen Mile Creek West catchment area, commonly known as the “Lazy Pat Farms” property, as shown on Figure 1.1. This parcel of land is owned by bcIMC Realty Corp. and managed by QuadReal Property Group (previously managed by Bentall Kennedy (Canada) LP) and is herein referred to as the “Subject Property”.

The Subject Property is located within the western portion of North Oakville West Secondary Plan (NOWSP) area, which has been defined as the 407 West Employment Area. The Subject Property is located on the north side of Dundas Street West (Highway 5), generally mid-block between Tremaine Road and Bronte Road (Highway 25), in the Town of Oakville. The municipal address is 3269 Dundas Street West, Oakville and is legally described as Part of Lots 33 and 34, Concession 1, North of Dundas Street, Township of Trafalgar, now in the Town of Oakville, Regional Municipality of Halton. The Subject Property encompasses an area of approximately 185 acres (75 hectares).

This EIR/FSS has been prepared to address the NOWSP policy requirements in support of the approval of a Draft Plan of Subdivision and Zoning By-law Amendment application for the Subject Property. The NOWSP was adopted by Council on May 25, 2009. On December 4, 2009, the Ontario Municipal Board (OMB) approved the majority of the NOWSP, save and except for lands shown as Appeal Area on Attachment A of the decision which generally includes the lands bound by Fourteen Mile Creek on the west; Highway 407 on the north; Bronte Road to the east (including certain lands fronting on the east side of Bronte Road); and Dundas Street to the south. These lands remain under appeal, until such time as an OMB decision is rendered. The balance of the area, which includes the Subject Property is subject to the NOWSP which came into force and effect as of December 4, 2009.

OPA 289 establishes the NOWSP for the lands generally bounded by Dundas Street, Tremaine Road, Highway 407 and the Sixteen Mile Creek. The NOWSP includes land use designations and detailed policies establishing general development objectives to guide the future development of this area.

The NOWSP also sets out the requirements which must be met before any development can proceed. This included the preparation of an EIR/FSS:

- Policy 8.8.3 a) requires that an Environmental Implementation Report (EIR) be prepared for each subcatchment area, in accordance with the directions established in the North Oakville Creeks Subwatershed Study (NOCSS) Implementation Report for each subcatchment area identified in Appendix 8.2. The EIR must demonstrate how the submissions address the overall North Oakville Creeks Subwatershed Management Report. Policy 8.8.3 a) iii) requires that Environmental Implementation Reports be prepared in accordance with ToR approved by the Town of Oakville (the “Town”), the Region of Halton (the “Region”) and the applicant(s), in consultation with Conservation Halton (“CH”).

- Policy 8.8.3.b) requires that a Functional Servicing Report (FSS) be prepared for each plan of subdivision or major development application. The FSS must include a preferred servicing plan based on an analysis of servicing requirements, in accordance with any approved Class Environmental Assessment Studies, Halton Transportation Master Plan and the Master Servicing Plan for the North Oakville West Planning Area and including:
    i. servicing design requirements;
    ii. preliminary sizing of water and wastewater infrastructure;
    iii. layout for roads and other transportation systems including transit and trails;
    iv. preliminary sizing and location of stormwater management facilities; and
    v. integration with environmental features and development areas.

  An Area Servicing Plan (ASP) has been prepared by MMM Group Limited for the 407 West Employment Area (area bound by Dundas Street West, Tremaine Road, Highway 407, and Regional Road 25 (Bronte Road)), based on the Area Servicing Plan ToR provided by the Region. The ASP was approved by the Region on June 2, 2014.

The work completed as part of this EIR/FSS and documented in this report was guided by requirements set out in the EIR/FSS ToR (Revised May 2013) approved by the Town and CH, and is intended to satisfy the policy requirements of OPA 289. A copy of the approved ToR is provided in Appendix 1.1.

As identified in the ToR, the purpose of the EIR is to characterize and analyze the natural heritage features and functions and to determine and address the potential impacts of a proposed development application, including servicing requirements, on the Natural Heritage System (NHS). The purpose of the FSS is to identify servicing requirements related to sanitary, water, stormwater, roads, and site grading. Further, the purpose of both the EIR and FSS is to provide a link between the Town's NOCSS Management Report and Implementation Report, the NOWSP and the Draft Plan submissions for development applications.

The objectives to be fulfilled by the EIR/FSS are set out in the approved ToR, and:
Demonstrate how the subwatershed requirements set out in the NOCSS Management Report (including targets), the Implementation Report, and Secondary Plan are being fulfilled in all proposed Draft Plans;

- Provide sufficient level of conceptual design to ensure that the various components of the NHS and infrastructure can be implemented as envisaged in the NOCSS and Secondary Plan and to ensure that the Draft Plans are consistent with this conceptual design;
- Ensure servicing requirements as determined in the FSS for the areas external to the Draft Plan are adequate;
- Identify details regarding any potential development constraints or conflicts and how they are to be resolved;
- Provide any further implementation details as needed;
- Streamline the Draft Plan approval process; and,
- Facilitate the preparation of Draft Plan conditions.

As set out in the ToR, the EIR/FSS for the Subject Property has been prepared as a joint report to fully integrate environmental and engineering recommendations to protect the function of the NHS and service the Subject Property.

1.2 EIR Subcatchment Area and FSS Study Area

The Subject Property is located primarily within the FM1001 subcatchment area; and smaller portions lie within the FM1102 and FM1109 subcatchment areas. The limits of these subcatchments within the Subject Lands are shown on Figure 1.2 and have been refined from the subcatchment areas identified in the NOCSS based on further analysis undertaken through the preparation of this EIR/FSS as provided in Section 7.0. Table 1.1 notes the subcatchments draining the Subject Property and the areas/percentages of the Subject Property lying within each subcatchment area.

Table 1.1 – Subwatershed Areas

Subwatershed	Subwatershed Area (ha)	Subwatershed Area within Subject Property (ha)	Proportion of Subwatershed within Subject Property (%)	Proportion of Subject Property within the Subwatershed (%)
FM1102	44.4	4.7	11%	6%
FM1001	395.3	60.4	15%	81%
FM1109	365.0	10.0	3%	13%
Subject Property		75.1		100%

The EIR/FSS ToR differentiate between the study area for the FSS and the subcatchment study area for the EIR. The EIR is to be completed on a subcatchment basis, while the FSS will address specific servicing requirements in support of draft plans of subdivision.

The NOCSS provides direction to the preparation of EIRs including the delineation of EIR subcatchments. Figure 7.4.2 from the NOCSS Addendum illustrates the EIR subcatchment areas. With reference to this figure (included at the end of this section) and direction from the ToR, the appropriate study areas for this EIR/FSS are:

- EIR Subcatchment Area is defined to be the FM1001 subcatchment, focusing on the area south of Highway 407; and,
- FSS Study Area is defined to include the Subject Property, which consists of the lands owned by bcIMC Realty Corp.; however, sufficient details have been provided for the 407 West Employment Area.

The EIR Subcatchment Areas and the FSS Study Area for the Subject Property are shown on Figure 1.2.

The ToR recognizes that ownership or draft plan boundaries will not follow subcatchment boundaries and allow for the assessment of portions of subcatchments where reasonable. The ToR recognizes that where the proposed development is within the majority of the EIR subcatchment with minor portions outside:

- Consideration will be given to minor adjustments in subcatchment boundaries with the conditions that the adjustments would not put undue restrictions on the servicing of adjacent subcatchments and demonstrate no negative impacts to flooding, erosion and the NHS; and,

- If no change in subcatchment boundary is proposed, consideration is to be given to how development in the adjacent subcatchment is to be serviced. Conceptual drainage patterns are to be developed and profiles generated to ensure that the area can be serviced.

This EIR/FSS has addressed the subcatchment and draft plan requirements for the small portions of the Subject Property located within the FM1102 and the FM1109 subcatchment areas, without preparing complete EIRs for these subcatchment areas. With respect to the FM1102 subcatchment area, the portion of the Subject Property within this subcatchment is relatively small (4.7 ha), comprising approximately 11% of the entire subcatchment area. With respect to FM1109 subcatchment area, the portion of the Subject Property within this subcatchment is relatively small (10.0 ha), comprising approximately 3.0% of the entire subcatchment area. This EIR/FSS focuses on the FM1001 subcatchment and provides discussion of subcatchments FM1109 and FM1102 to the extent required.

This EIR/FSS consistently uses the following terms when referring to various land areas:

- the “Subject Property” referring to the bcIMC Realty Corp. land holdings managed by QuadReal Property Group (previously managed by Bentall Kennedy (Canada) LP);
- the “FSS Study Area” referring to the Subject Property;
- the “EIR Subcatchment Area” referring to the FM1001 subcatchment area; and,
- the “Study Areas”, referring to both the EIR Subcatchment Area and the FSS Study Area.

As required by the EIR/FSS ToR, land uses as proposed by the Town’s NOWSP for lands adjacent to the FSS Study Area are recognized and considered in planning, transportation and servicing analyses. As such, land use and development assumptions have been made to facilitate the preparation of this EIR/FSS. The land use and development assumptions for purposes of analysis reflect best practices and procedures for undertaking such planning, transportation and servicing analyses. The adjacent lands are designated Employment District and Natural Heritage and Open Space in the NOWSP.

1.3 Study Team

A multidisciplinary study team lead by WSP Canada Group Limited (WSP) (formerly MMM Group Limited) has studied the environment and servicing of the Study Areas. The team and their responsibilities include:

WSP Canada Group Limited (formerly MMM Group Limited):

- lead EIR consultant addressing limits of development, study integration, team/study management and coordination of EIR/FSS report preparation;
- lead FSS consultant addressing municipal servicing, stormwater management and site grading;
- aquatic habitats;
- terrestrial ecology;
- geology and hydrogeology;
- hydrology and fluvial geomorphology; and,
- municipal planning matters and preparing the draft plan of subdivision.

Waters Edge:

- fluvial geomorphological and erosion threshold assessment.

Exp. Consulting:

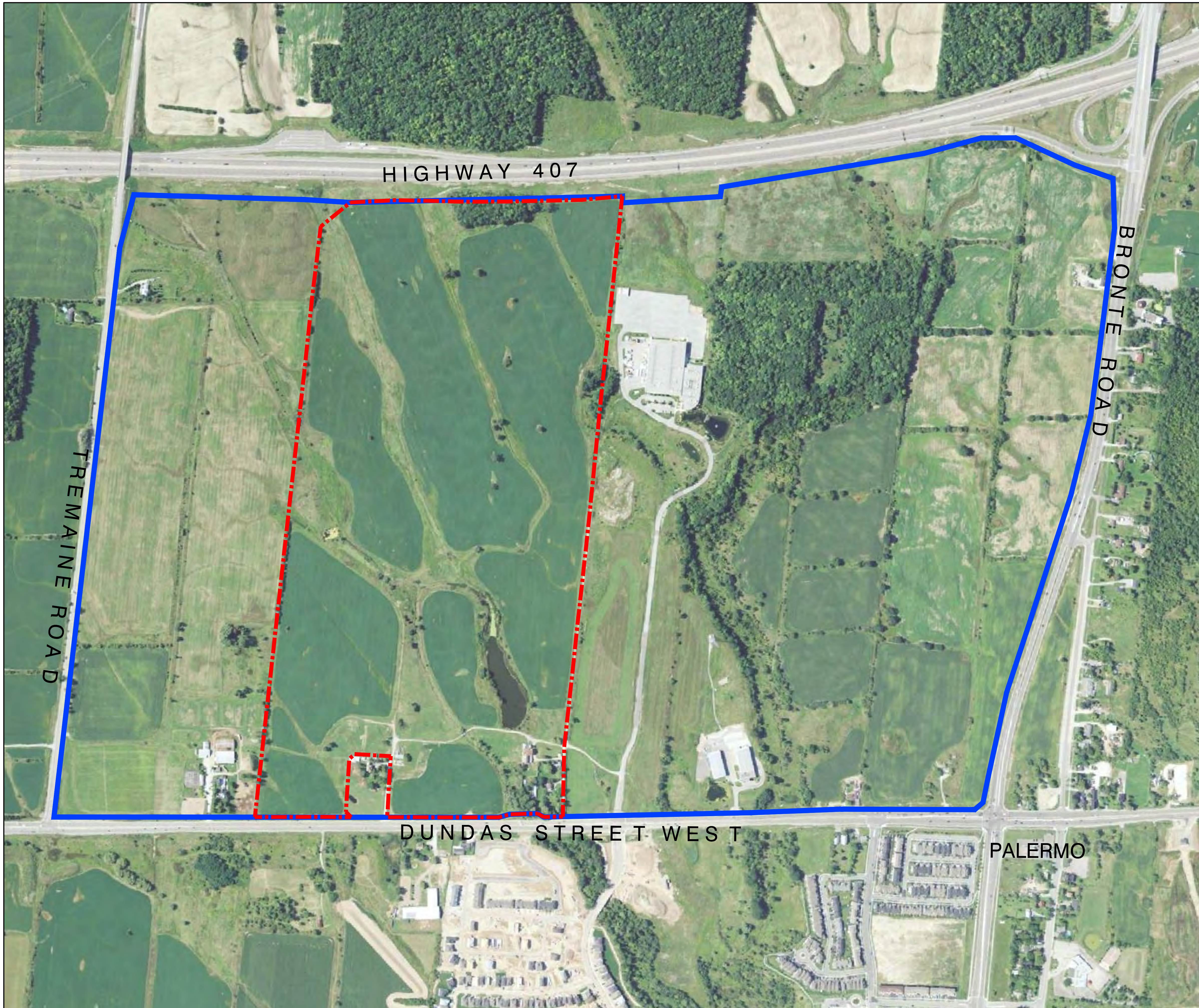
- geotechnical and slope stability analysis.

1.4 References

Included in Appendix A1.2 is a complete list of references, studies, guidelines and documents which have been reviewed in preparation of this EIR/FSS.

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm property

Subject Property with Aerial Photography



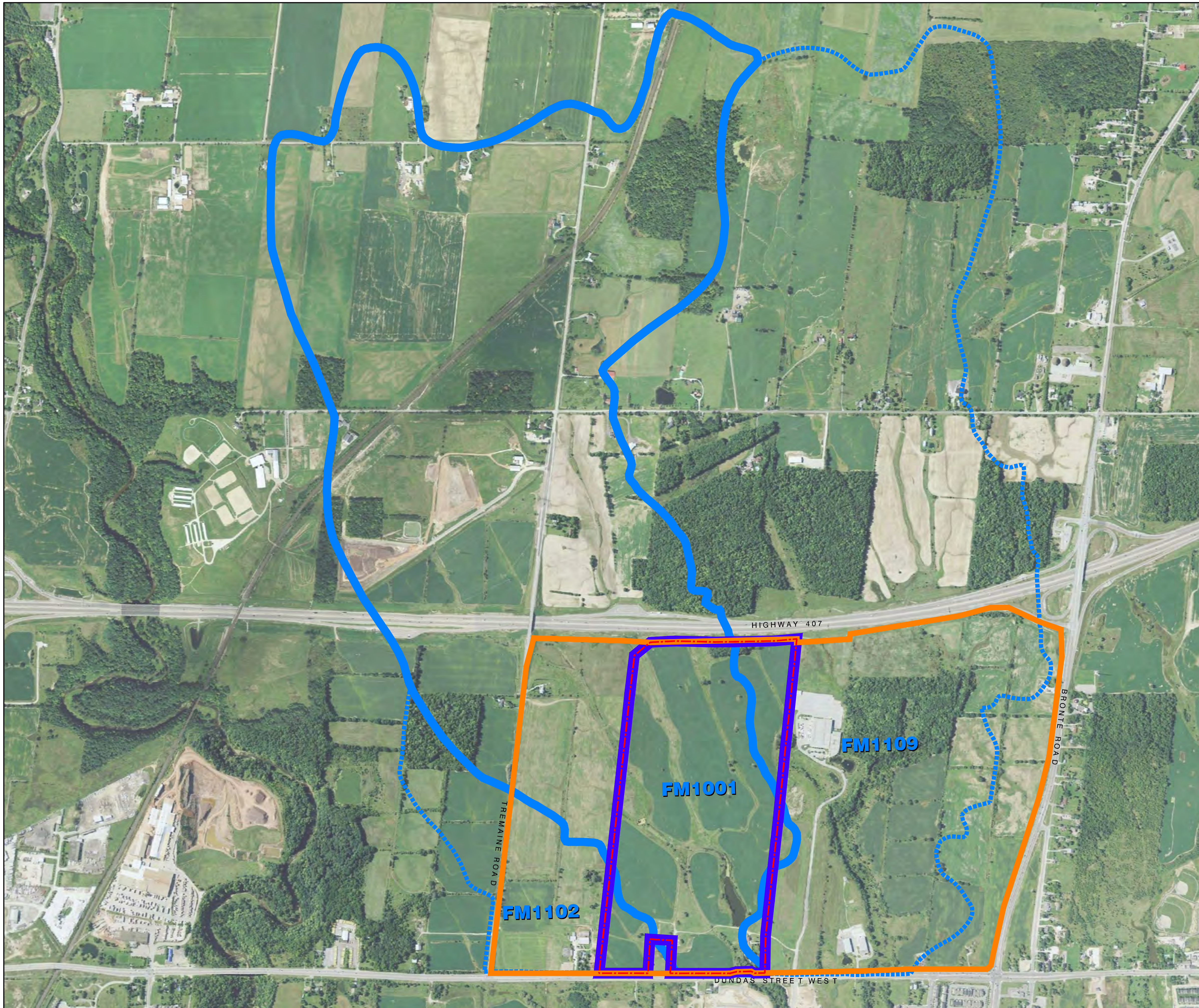
LEGEND

- Subject property
- 407 West Employment Area

Scale 1 : 7500

0m 50 100 150 200 250 500m

Client	Prepared by
QuadReal	wsp
Date: June 2017	Proj. No.: 09M-00013-01 (1409222-001)
Aerial Photo: © DigitalGlobe 2010, Google 2009	**Figure 1.1**



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Study Areas

LEGEND

- Subject Property
- 407 West Employment Area
- Subcatchment Area Boundaries
- EIR Subcatchment Area (FM1001)
- FSS Study Area

Scale

1 : 15,000

0m 100 200 300 400 500 1km

Client

QuadReal

Prepared by

wsp

Date

June 2017

Proj. No.

09M-00013-01
(1409222-001)

Aerial Photo

Figure 1.2

2.0 Natural Heritage System Framework




2.0 Natural Heritage System Framework

2.1 Natural Heritage System Components

The 'Natural Heritage System Area' designation of the NOWSP reflects the components of the Natural Heritage and Open Space System and is intended to protect, preserve, and where appropriate, enhance the natural environment. OPA 289, the Town's NOCSS and the NOCSS Addendum provide policies and/or directions with respect to the protection and management of the North Oakville West Natural Heritage/Open Space System. The NOCSS is divided into four sections, which follow the four phases of a subwatershed management approach, they include Characterization, Analysis, Management Strategy and Implementation.

The Management Strategy outlines requirements with regard to lands restricted from development, lands with development limitations or constraints, stormwater management, input to land use policies and servicing requirements. The Implementation Plan outlines the implementation requirements for the recommended management strategy, studies needed in subsequent stages of the development process, environmental reporting requirements, agency responsibilities, and the approval process with the Town, the Region and CH, and, where applicable, the Ministry of Natural Resources and Forestry (MNRF) and Fisheries and Oceans Canada (DFO).

With respect to the Subject Property and the EIR Subcatchment Area, OPA 289, NOCSS and the NOCSS Addendum identify various environmental features to be protected and/or studied further during the preparation of the EIR/FSS. As illustrated on Figure NOW3 from OPA 289 (Figure 2.1), the components of the Natural Heritage System (NHS) that are located within the EIR Subcatchment Area, and related subcatchment areas on the Subject Property include the 'High Constraint Stream Corridor Area' and 'Medium Constraint Stream Corridor Area', and features designated as 'Other Hydrological Features', which includes Low Constraint Stream Corridors, Hydrologic Features "A" and Hydrologic Features "B" and topographic depressions.

These natural heritage components are further addressed through Section 5.0 of the EIR/FSS.

- *High Constraint Stream Corridor Areas (Red Streams)* – include certain watercourses and associated riparian lands, including buffers measured from stable top-of-bank and meander belts, including the 15 metre allowance measured from the Regional Storm floodplain. They must be protected in their existing locations for hydrological and ecological reasons in accordance with the NOCSS. High Constraint Stream Corridor Areas located on the Subject Property, as identified in the NOCSS include Reach 14W-12 located north of Dundas Street to the confluence with Reach 14W-16; and Reach 14W-11 (High Constraint Stream Corridor Requiring Rehabilitation), along the eastern property boundary. The High Constraint Stream Corridor reaches and associated riparian lands will be protected and enhanced, where feasible.

  Section 5.0 of the EIR/FSS addresses the character, designations, management and protection of these High Constraint Steam Corridors within the EIR Subcatchment Area.

- *Medium Constraint Stream Corridor Areas (Blue Streams)* – include certain watercourses and associated riparian lands, including buffers measured from stable top-of-bank and meander belts, including the 7.5 or 15 metre allowance measured from the Regional Storm floodplain. They must be protected for hydrological and ecological reasons, but may be deepened and/or relocated and consolidated with other watercourses provided the watercourse feature and function of the watercourse is maintained in accordance with the NOWSP (S. 8.4.7.1 e)). In addition, Federal, Provincial and Conservation Authority regulations must be adhered to, and the relocated and/or consolidated watercourses must be designed using natural channel design principles.

  The Medium Constraint Stream Corridor Areas include Reach 14W-16, Reach 14W-14, Reach 14W-14A, and Reach 14W-11A. The NOWSP provides policies for the relocation of Medium Constraint Stream Corridor Areas. The Development Concept proposes modifications to the drainage network, specifically these Medium Constraint Stream Corridors and are discussed further in Sections 5.0 and 6.0.

  Sections 5.0 and 6.0 of the EIR/FSS address the character, designations, management, alteration and protection of these Medium Constraint Steam Corridors within the EIR Subcatchment Area.

The boundaries of the High Constraint Stream Corridor Areas and Medium Constraint Stream Corridor Areas are to be maintained as generally shown on Figure NOW 3 from OPA 289 (Figure 2.1); however, minor modifications have been considered to reflect differences in scale and levels of detail during the preparation of the EIR.

There are no Core Preserve Areas or Linkage Preserve Areas located on the Subject Property. The protection and management of these Core Preserve Areas and Linkage Preserve Areas within the 407 West Employment Area are subject to the NOWSP and NOCSS and are to be further evaluated through EIR/FSS for these respective subcatchment areas.

In addition to the High and Medium Constraint Stream Corridor Areas, there are a number of other hydrological features that also form part of the Natural Heritage and Open Space System to the extent that they are maintained after development occurs. These features include Low Constraint Stream Corridors, Hydrologic Features "A" and Hydrologic Features "B", as described below:

- *Low Constraint Stream Corridors (Green Streams)* – while the streams do not need to be maintained, the function of the watercourse must be maintained in accordance with the NOCSS, and Federal, Provincial and Conservation Authority regulations. Low Constraint Steam Corridor Area (Reach 14W-13) is removed; however, the function of the watercourse is maintained within the relocated channel. The removal of this reach is consistent with the NOWSP policies for Low Constraint Stream Corridor Areas.

- ***Hydrologic Features "A"*** – where a Hydrologic Features "A" is located within a Medium Constraint Stream Corridor which is to be moved or rehabilitated, it is intended that the Hydrologic Features "A" will be reconstructed in the relocated/rehabilitated stream corridor such that the form and function is retained or enhanced. There are three Hydrologic Features "A" located on the Subject Property, including features within Reach 14W-14, Reach 14W-16 and the existing Farm

Pond (Reach 14W-14A). These features have been considered through the detailed hydrological and hydrogeological assessment as part of the EIR/FSS.

- ***Hydrologic Features "B"*** – are not associated with the NHS, and may be relocated and consolidated with other wet features, wetlands or stormwater management (SWM) facilities, provided the hydrologic function of the feature is maintained. There are three Hydrologic Features "B" located on the Subject Property. These features have been considered through the detailed hydrological and hydrogeological assessment as part of the EIR/FSS.

- *Topographic Depressions* – Topographic depressions do not form part of the NHS; however, NOCSS (Figure 6.3.15) identifies topographic depressions, ponds and pits that must be addressed as part of the SWM system design. Constructed ponds do not have to be included in the assessment of depression storage. These topographic depressions have been considered through the drainage and SWM assessment as part of the EIR/FSS, and the analysis has demonstrated that the SWM facilities volumes compensate for the hydrologic influence of the existing depression areas.

2.2 Permitted Uses in the Natural Heritage System

Section 8.4.7.3 of the NOWSP identifies the potential permitted uses within the NHS. Permitted uses within the NHS Area designation shall include only legally existing uses, buildings and structures, and fish, wildlife and conservation management. Development or land disturbances shall generally be prohibited. In accordance with S. 8.4.7.3 b), exceptions are permitted subject to the satisfaction of the Town, in consultation with the Region and CH, to accommodate such uses as:

- required flood and stream bank erosion controls;
- fish, wildlife and conservation management;
- to accommodate stormwater outfalls;
- the relocation of deepening of Medium Constraint Stream Corridor Areas; roads and related utilities;
- expansion of existing water and wastewater services;
- trails, interpretive signage or similar passive recreation uses; and
- SWM facilities,

These uses would be subject to S. 8.4.7.3 c) v), and in accordance with the directions of the NOCCS and any related EIR, and Federal, Provincial and Conservation Authority regulations.

SWM facilities established in accordance with the directions of the NOCSS may be permitted within the NHS Area, as outlined in Section 8.4.7.3 c) v), provided, the number, location and size of the SWM facilities have been identified through the EIR/FSS, and provided that generally such facilities:

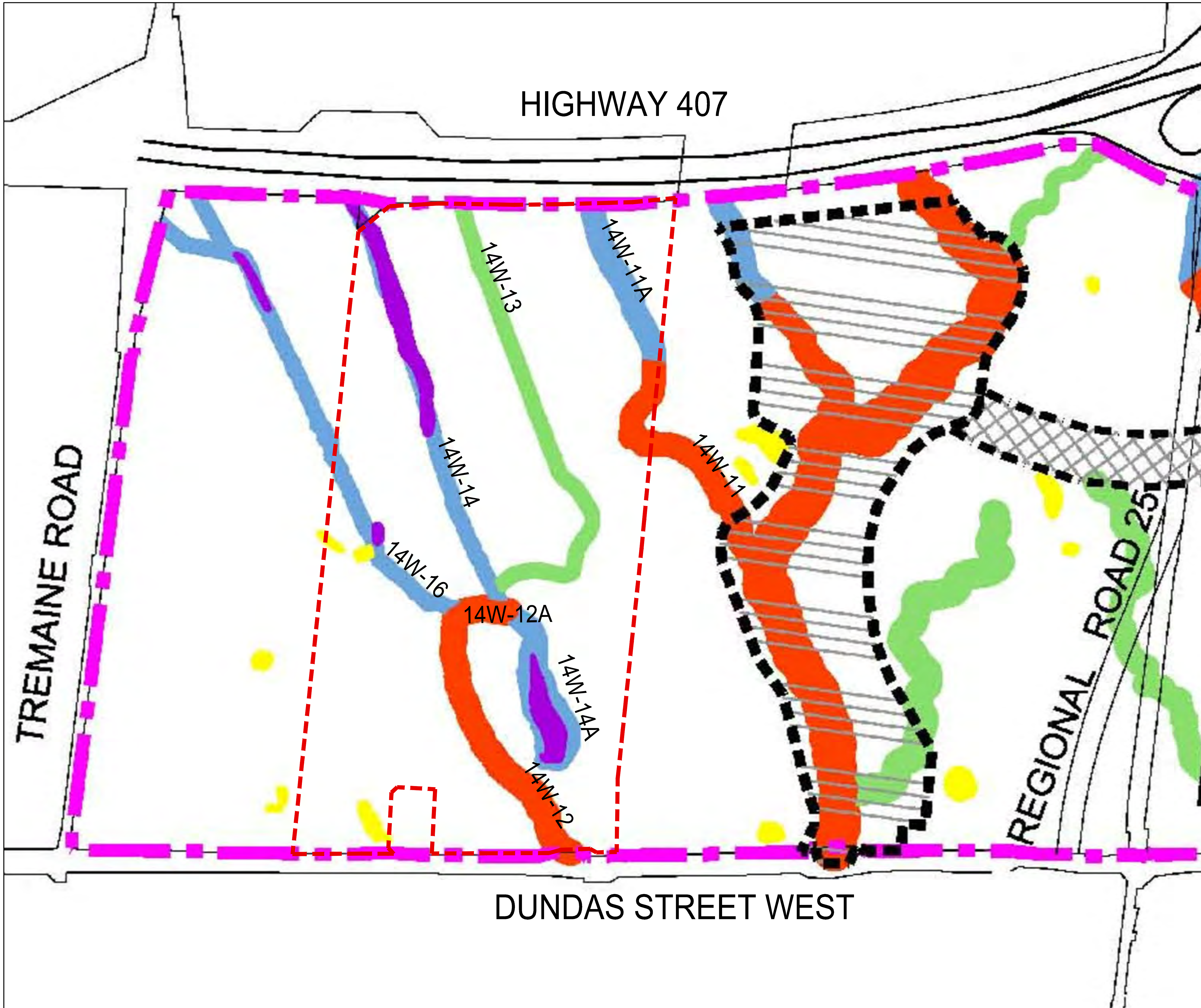
> *"be limited where located in or adjacent to High and Medium Constraint Stream Corridor Areas, which are not located within Linkage Preserve Areas as designated conceptually on Figure NOW 3 [from OPA 289], to areas:*
>
> - *outside the 100 year floodline;*
> - *outside the meanderbelt allowance which is the meanderbelt plus the factor of safety;*

- *outside the erosion/access allowance measured from the meander belt or stable top-of-bank, except that some overlap of the access required for the SWM facility and the erosion/access allowance may be permitted in accordance with the directions established in the NOCSS, and to the satisfaction of the Town and CH;*
- *outside the confined valley; and,*
- *provided that there is no loss of flood storage or conveyance"*

The NHS designation on the Subject Property does not comprise Core Preserve or Linkage Preserve Areas. Stream Corridor Reach 14W-12 is identified on Figure NOW 3 from OPA 289 as High Constraint Stream Corridor, and the human-made Farm Pond (Reach 14W-14A) is identified as a Medium Constraint Stream Corridor and a Hydrologic Feature 'A'.

The EIR/FSS has determined the size and configuration of the SWM facilities and supports the use of the existing Farm Pond (Reach 14W-14A) as a SWM facility. The SWM facilities are proposed to be located outside of the 100 year floodline; outside of the Regional Storm floodline; outside the meanderbelt allowance which is the meanderbelt plus the factor of safety; outside the erosion/access allowance; outside the confined valley, and outside the 30 metre setback. The EIR/FSS demonstrates that there is no loss of flood storage or conveyance.

The Draft Plan of Subdivision delineates the SWM blocks to ensure sufficient area for the detailed design of the SWM facilities and all of the ancillary features such as sediment dewatering areas, and maintenance access. Furthermore, as outlined in the EIR/FSS, from a fisheries perspective the existing Farm Pond (Reach 14W-14A) appears to have a negative effect on downstream aquatic habitat and its removal and reconfiguration as a SWM facility would provide aquatic benefits.



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Figure NOW 3: Natural Heritage Components of Natural Heritage and Open Space System including Other Hydrological Feaures

Client: QuadReal

Prepared by: wsp

Date: June 2017

Proj. No. 09M-00013-01 (1409222-001)

Figure 2.1

3.0 Land Use

3.0 Land Use

3.1 Development Concept Plan

The proposed land uses for the Subject Property consist of a range of employment uses and associated Natural Heritage and Open Space uses, in accordance with the Region's and Town's land use and planning directions for the 407 West Employment Area. The development concept envisions the creation of an office and business park with prestige employment uses adjacent to Highway 407, due to increased visibility along this major Provincial Highway. Limited employment-related commercial and service/retail uses, including office uses (i.e., identified as Mixed Employment (Service/Office)) are envisioned at the major road intersections along the Dundas Street corridor to serve the employment area. Furthermore, limited employment-related commercial and service/retail uses may be accommodated internal to the 407 West Employment Area at major intersections, as part of an employment or office building. It is proposed that more general industrial uses, such as mixed warehousing and office uses be accommodated internal to the business park.

Figure 3.1 illustrates the concept plan for the Study Area based on the direction of the Town's NOWSP. The concept plan for the Study Area is generally consistent with the Town's NOWSP and Master Plan and incorporates modest revisions to the proposed road network based on further study. The road pattern follows a modified grid pattern which responds to the existing environmental and site conditions while encouraging accessibility and a viable transit network throughout the 407 West Employment area. The conceptual road network identified in the NOWSP does not provide a sufficient network to facilitate the appropriate development of the 407 West Employment Area, based on more detailed study undertaken through this EIR/FSS. WSP (formerly MMM) has provided various comments to the Town in relation to the NOWSP road pattern, and based on these discussions with the Town it was recognized that the road network is conceptual and may be further refined, this is further supported by the policies of the NOWSP. Modifications to the road network have been proposed to: minimize the impact on the existing GE Facility site and operations, by shifting Avenue One to the south; minimize the impacts on the NHS by shifting the Burnhamthorpe Road alignment north of the High Constraint Stream Corridor and existing Farm Pond on the Subject Property, and modifying the road alignments to accommodate appropriate access to larger sized employment blocks, particularly to the north of the planning area.

The concept plan accommodates three intersection locations with Dundas Street West, including the existing intersections with Valleyridge Drive and Colonel Williams Parkway. A new intersection with Dundas Street is proposed adjacent to the western boundary of the Subject Property to provide access to the Subject Property and adjacent lands to the west, this new intersection is approximately equal distance between Tremaine Road and the eastern extent of the NHS on the Subject Property.

The proposed road alignments have been identified in order to minimize the number of crossings and the impacts to the NHS, particularly the Burnhamthorpe Road Extension which has been shifted further north to avoid crossing the existing High Constraint Stream Corridor, and is proposed outside the Reach 14W-12A High Constraint Stream Corridor, as identified in the NOWSP. The road crossings through the NHS will be designed to minimize disruption to the watercourses, through appropriate road crossing construction practices, and minimize encroachment into Redside Dace Habitat (i.e., the Burnhamthorpe Road Extension), as discussed further in Section 5.0.

Two major east/west road corridors are proposed as identified in the NOWSP to accommodate access from Tremaine Road to Regional Road 25 (Bronte Road). The proposed road network through the Subject Property provides flexibility for multiple road alignment options through adjacent properties. The southern east/west road aligns with the proposed New North Oakville Transportation Corridor (Burnhamthorpe Road Extension) proposed on the east side of Bronte Road. The Burnhamthorpe Road Extension west of Bronte Road will be under the jurisdiction of the Town. While the intersection locations for Burnhamthorpe Road are fixed at the intersection with Bronte Road and where it enters the Subject Property, the alignment of the Burnhamthorpe Road Extension between these intersections is flexible and may be modified through subsequent planning work on the adjacent lands. The spacing and locations of these intersections is consistent with the NOWSP and aligns with the planning work being undertaken for the Dundas/Tremaine Secondary Plan area in the City of Burlington and the New North Oakville Transportation Corridor EA.

The alignment of Avenue Two is generally consistent with the NOWSP and extends north and to the west of the NHS, to avoid crossing Medium Constraint Stream Corridor Reach 14W-16. The alignment of Avenue Two has been revised following further review and discussion with the Town and CH in order to minimize the number and extent of stream crossings while providing an efficient road pattern which supports the development of the employment area, in addition to addressing landowner coordination issues related to the Avenue Two road location and alignment.

The alignment of Avenue One was designed to minimize the length of required road crossings from that identified in the NOWSP, and minimize impacts to the existing GE Facility. West of the GE Facility, Avenue One shifts to the north, as it traverses the Subject Property, to provide sufficient access to the northern portion of the Subject Property and facilitate suitably sized employment blocks.

Avenue Three aligns with the existing intersection at Dundas Street and Colonel Williams Parkway, and will facilitate access to the Subject Property and the GE Facility, through a new road designed and constructed to the Town's standards. Furthermore, by shifting Avenue Three to the west and onto the Subject Property, the road alignment provides for more suitably sized future employment blocks, particularly on the GE lands fronting the east side of Avenue Three.

The development concept plan delineates the proposed Natural Heritage and Open Space System based on the Town's NOWSP and NOCSS, which has been further refined for the Subject Property based upon the recommendations of the EIR/FSS. The NHS and adjacent SWM facilities on either side of the NHS, will provide a central focus for the business park, and accommodate pedestrian trails and passive recreational uses, integrated with the adjacent employment development. The SWM facilities will accommodate stormwater runoff within their respective subcatchment areas.

Figure 3.2 illustrates the Draft Plan of Subdivision which implements the concept plan for the Subject Property. The Draft Plan of Subdivision also identifies temporary right-of-ways (cul-de-sacs) and existing easements (driveways), which are intended to accommodate an appropriate road network and access to the Subject Property until such time as the proposed roads and intersections have been constructed on adjacent lands, where required. These temporary right-of-ways have been accommodated to facilitate the development of the Subject Property in the short-term, as the timing of development on the adjacent lands, is unknown and may not coincide with the timing of development on the Subject Property. These temporary right-of-ways (cul-de-sacs) are accommodated on Burnhamthorpe Road (prior to the crossing of the NHS, within Block 4), the southerly extent of Avenue Three (within Block 5), and the westerly extent of Avenue

One, prior to the crossing of the NHS. Street Four has been proposed to provide access to the Stormwater Management Facility (Block 9), and provide access to Block 1, Block 2, and the intervening lands.

The Planning Rationale Report, May 2011, prepared by WSP (formerly MMM Group Limited), concludes that the Draft Plan of Subdivision represents good and sound community planning and conforms to and implements the goals, objectives and policies of the Provincial Policy Statement, the Growth Plan for the Greater Golden Horseshoe, the Regional Official Plan, and the NOWSP.

3.2 Trail Planning

The NOWSP (S. 8.5.5.10) states that: "An extensive system of recreational trails will be developed related to the Natural Heritage and Open Space System as well as along certain public road rights of way. A conceptual major trail system which will form the basis for the development of this more extensive system is identified on Figure NOW 4. However, any proposed trail development within the Natural Heritage and Open Space System shall be subject to further study as part of the Implementation Strategy to the satisfaction of the Town, in consultation with the Region and CH. The system may be refined through the preparation of an EIR in accordance with the provisions of Section 8.8.3 a) of this Plan."

The NOWSP, Figure NOW 4 conceptually identifies a Major Trail System along the Burnhamthorpe Road Extension, west of Bronte Road, extending to Tremaine Road, in addition to a Major Trail System within the NHS, along the main stream corridor (Reach 14W-16 and Reach 14W-12) which traverses the Subject Property. The Town has prepared the North Oakville Trails Plan, May 21, 2013 which provides more detailed guidance for trail planning in North Oakville. In addition to the Major Trail System identified in the NOWSP, the North Oakville Trails Plan (May 21, 2013) also identifies a Major Trail along Reach 14W-11A on the Subject Property and around the Core Preserve Area associated with Fourteen Mile Creek and the Zenon Forest. Figure 3.3 illustrates the conceptual trail network as identified in the NOSWP and North Oakville Trails Plan, 2013 in relation to the 407 West Employment Area Concept Plan.

Section 8.4.7.3 of the NOWSP notes that one of the potential permitted uses in the NHS is:

iv) Trails, interpretative displays or signage or other similar passive recreation uses consistent with the purpose of the applicable designation and provided that:

- *for lands in the Linkage Preserve Area designation on Figure NOW 3, such uses shall generally be located in the Linkage Preserve Area, but adjacent to the boundary of the linkage;*
- *trails shall be permitted within the setback from the edge of the Sixteen Mile Creek Valley, and may be permitted within the valley subject to the review of their impact on any environmentally sensitive features;*
- *trails in stream corridors other than the Sixteen Mile Creek shall be permitted adjacent to the valley in the buffer; and,*
- *trails in the NHS Area designation be designed and located to minimize any impact on the natural environment.*

Section 6.3.5.2 of the NOCSS states that:

"*Recreational trails for pedestrian and bicycle use will require special consideration and evaluation when planning their location within the NHS. A designated trail system associated with the NHS will be the best* *strategy to discourage informal trail creation (i.e., trail blazing) for the public wishing to gain access to the NHS.*

The following should be considered when planning the location of future trail systems:

- *Trails should cross the NHS (cores, linkages and stream corridors) within existing and proposed road crossings;*
- *Locations where roads are flanking core areas, trails should be substituted for sidewalks provided winter maintenance is feasible;*
- *Where trail systems are proposed to cross the NHS at locations other than where a road crossing is proposed, an impact assessment will be required to ensure no negative impacts to the NHS (i.e., species migration, impacts to drainage);*
- *Trail systems requiring winter maintenance will need to be located outside the NHS to minimize disturbance (i.e., ploughing, sand and salt); and*
- *Trail systems are not permitted in stream valleys.*

The North Oakville Trails Plan (May 21, 2013) identifies the following trail facilities and their associated standards:

Cycling Facilities

The Cycling and Trails Network is shown in Figure 3.3. Bicycles are designated as a vehicle under the *Highway Traffic Act* (HTA) and as such are required to obey all of the same rules and regulations as automobiles when being operated on a public roadway. The cycling routes proposed as part of the Town's North Oakville Trails Plan (May 21, 2013) network comprise several facility types, each with its own set of minimum design parameters. These are generally consistent with the Ministry of Transportation (MTO) and the Transportation Association of Canada (TAC) guidelines for the design of on-road facilities and standards for signing the on-road cycling system.

The cycling component of the Town's North Oakville Trails Plan (May 21, 2013) network for the 407 West Employment Area consists of multi-use trails and signed bike routes. For roadways labelled as Regional Bicycle Facility in the North Oakville Trails Plan (May 21, 2013), the type of bicycle facility will need to be determined by the Region; however, the following has been assumed for the boundary Regional roadways based on both the ATMP and the North Oakville Trails Plan (May 21, 2013):

- A 3.0 metre asphalt multi-use trail in the boulevard on Bronte Road between Dundas Street and Avenue One;
- A 3.0 metre asphalt multi-use trail in the boulevard on Dundas Street; and,
- A signed bicycle route on Tremaine Road.

Within the Subject Property and adjacent lands within the NOWSP area, all bicycle facilities are proposed to be on-road signed bicycle routes.

The purpose of designating a signed only bicycle route is to promote a road for cycling because it is deemed to be well suited for cycling; it may provide an important connection between destinations, or it is a preferred route identified by cyclists. In the case of signed on-road bicycle routes, the travel lane is shared by motorists and cyclists. These are roads where traffic volumes and vehicle speeds are relatively low. Under these conditions, cyclists can share the road with motor vehicles and there is no need to create a designated space for cyclists. Bicycle route marker signs located at intersections and at regular intervals aid users with wayfinding.

On-road signed bicycle routes are proposed along Burnhamthorpe Road between Bronte Road and Tremaine Road, and along all the Avenues within the 407 West Employment Area. These proposed on-road bicycle routes are to be accommodated within the Town's Avenue/Transit Corridor (22.0m ROW) – Employment Area. The proposed bicycle facilities provide connections to bike lanes along Burnhamthorpe Road, east of Bronte Road, and along Colonel William Parkway, south of Dundas Street. The proposed on-road signed bicycle routes within the Subject Property and adjacent lands of the 407 West Employment Area also connect to planned bicycle facilities on the boundary Regional boundary roads.

It is anticipated that bicycle facilities crossing the Regional boundary roads will be provided at signalized intersections, and where applicable, these crossings are to be designed and implemented in accordance with recommendations of the Town's Active Transportation Master Plan.

Major Trails

The development proposal outlines the proposed Natural Heritage and Open Space System based on the Town's North Oakville Trails Plan and NOWSP Transportation Plan. The central open space system and adjacent SWM facilities will accommodate pedestrian trails and passive recreational uses, integrated with the adjacent employment development. As shown in Figure 3.3 Major Trails are proposed around the Zenon Woodlot/Core area, located east to the Subject Property, as well as, along the west side of the main stream corridor (Reach 14W-16 and Reach 14W-12) which traverses the Subject Property from Dundas Street West to the northwest corner of the 407 West Employment Area.

Major Trails are off-road, soft surface pathways used primarily by pedestrians, although cycling is not restricted. Major trails will be typically 2.1 – 2.4 metres wide, with a compacted limestone screenings surface, and asphalt paving on slopes greater than 5%. Where possible, trail design/layout shall promote the greatest level of accessibility possible. Signage should be provided for recreational cyclists and pedestrians. Major trails within the NHS will not receive regular winter maintenance. Mid-block crossings are to be minimized, with roadway crossings occurring where possible at signalized or stop-controlled intersections.

As identified in the North Oakville Trails Plan, Figure 3 provides an illustration of a typical Major Trail cross-section (Type A) which is supported by the trail design guidelines outlined in Section 3.5.

Figures 5.7 and 5.8 illustrates the proposed Major Trails in relation to the NHS and natural heritage features. The on-road trails will follow the proposed road network thereby minimizing the number of watercourse crossings. The impact assessment of these on-road trail crossings will be included in the impact assessment for said road crossings.

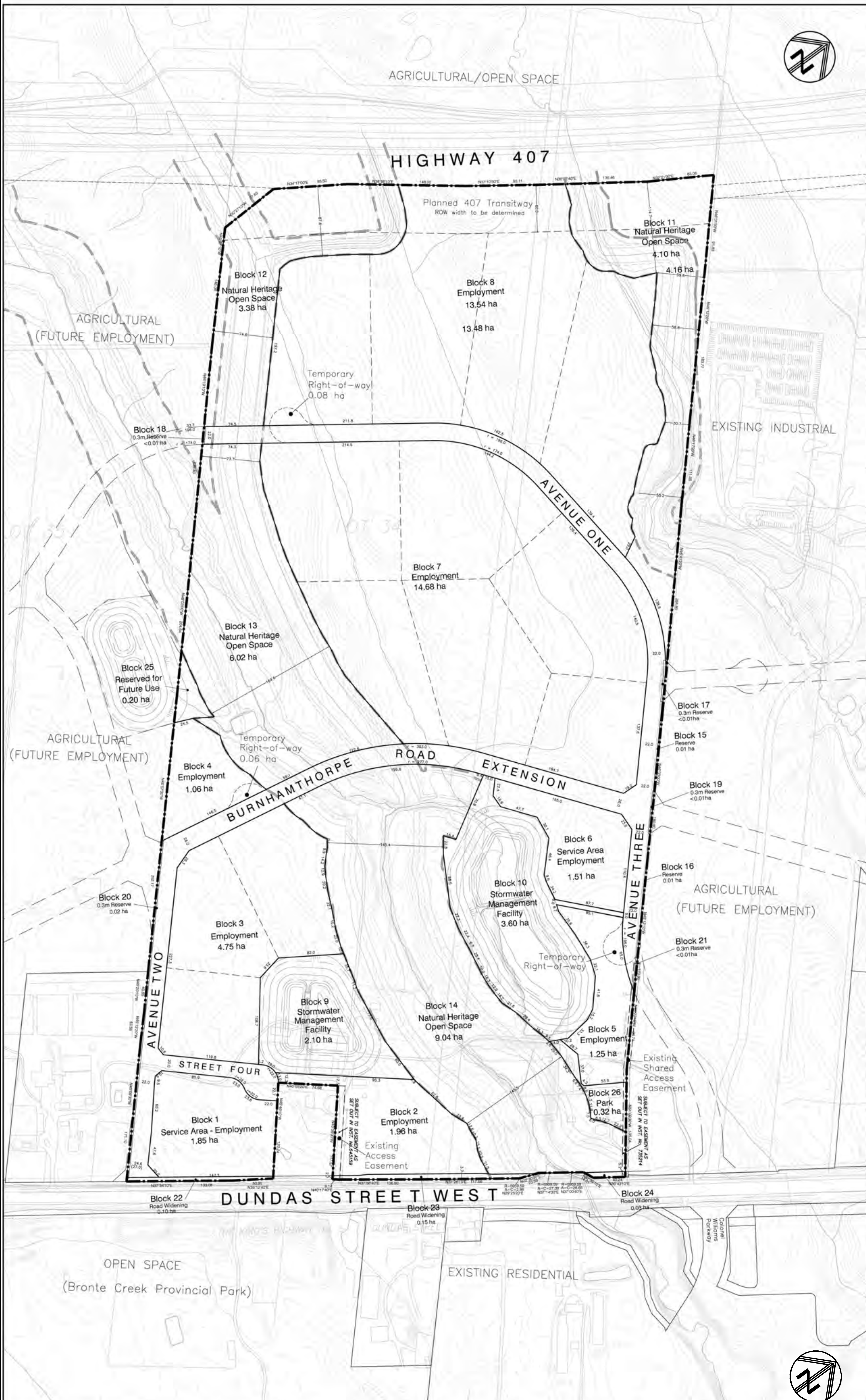
The Major Trails have principally been located along the margins of the NHS to minimize encroachments to the actual natural features and maintain the alignment within the existing disturbed areas (i.e., agricultural fields). As indicated, where the trail system crosses through the NHS other than at a road crossing, an impact assessment will be required. Within the 407 West Employment Area, these occurrences are limited to the proposed Major Trails along the Highway 407 corridor and there is the potential that an impact assessment(s) will be required for the majority of these areas to comply with this requirement. Within the Subject Property, the greater part of the Major Trail system does not cross through the NHS, but instead follows the margins. The exception to this is a section of trail along the Highway 407 corridor within the realigned portion of Reach 14W-11A, as this reach will be realigned there is no existing feature (or setback) present in the proposed trail location and as such, the design of the realigned channel will take into account the trail through this section. The siting of the trails within the NHS of the Subject Property will be undertaken once the stream corridor limits have been agreed upon. This will be undertaken in consultation with the MNRF, and CH as stipulated in NOCSS (Section 6.3.5.2).

The potential impacts (and permitting) for the remaining Major Trails proposed in the EIR lands will be assessed by their respective property owners.

The NOWSP permits trails within stream corridors, other than Sixteen Mile Creek, which are adjacent to the valley and located within the buffer. Trails in the NHS designation are to be designed and located to minimize any impact on the natural environment. In addition to the trail design guidance in the North Oakville Trails Plan, the following provides general guidance where the proposed trail system interfaces with the NHS:

- The trail will only cross the stream corridors along a proposed road crossing;
- The trail will be aligned through the NHS to avoid sensitive natural features and habitats;
- Where trails are proposed in the vicinity of a watercourse, they will be located outside of the valleys in the stream corridor setbacks;
- Walking access should be restricted to a properly sited and established trail;
- The trail alignment through the NHS should be delineated in the field with specific consideration to vegetation cover, slope, and drainage, taking advantage of openings and avoiding sensitive natural features and habitats;
- Boardwalks or viewpoints adjacent to sensitive features or SWM facilities may be appropriate;
- The trail should avoid areas where there are trees that have a tendency to drop excessive debris, to droop or to break under heavy snow loads or wind;
- Where vegetation is dense, access can be provided by thinning the lower branches, but maintaining the stem and root structures;
- If there are sloping areas, the trails should not result in a concentration of surface runoff down the slope in order to avoid erosion. Trails along steep sloping areas should be avoided;
- The trails should not be lit where they traverse natural communities. Where walkways/trails approach or skirt natural areas, they could be lit strategically, and of a parks scale with fixtures low to the ground (e.g., bollard height). The lighting should be focused on the trail. There should be little or no sky-lighting effect due to the environment-friendly design (cut-off refractors);
- Fencing should be avoided around the trails. If bolstering of the trail alignment is required, it should occur through plantings of appropriate native indigenous vegetation, comprising species that produce dense growth and ‘unfriendly’ characteristics, such as thorns. As well, the plantings should be designed and implemented to promote natural succession, help control invasive species, provide for wildlife habitat and be native to the area;
- Over the long term, the establishment of unauthorized trails that may develop through excursions from the built trails, should be addressed through dense plantings and physical barriers, if necessary;
- Prior to construction, the limits of construction activity need to be established. Rutting and compaction of the terrain and scarring of the vegetation beyond the limits of construction should not occur;

- During construction, the smallest size of equipment should be used (specialty narrow width loader/backhoe) to avoid compaction and damage of the existing root zone; and,
- A regular program of inspection and maintenance should be detailed.



DRAFT PLAN OF SUBDIVISION

PART OF LOTS 33 AND 34, CONCESSION 1
NORTH OF DUNDAS STREET
GEOGRAPHIC TOWNSHIP OF TRAFALGAR
NOW IN THE TOWN OF OAKVILLE
REGIONAL MUNICIPALITY OF HALTON

24T-11001

July 9, 2018

KEY PLAN
NTS

ADDITIONAL INFORMATION REQUIRED UNDER SECTION 51 (17) OF THE PLANNING ACT, R.S.O., 1990

(a) AS SHOWN ON DRAFT PLAN
(b) AS SHOWN ON DRAFT AND KEY PLANS
(c) NO ADJACENT LANDS OWNED BY THE APPLICANT
(d) THE LAND IS TO BE USED ACCORDING TO THE SCHEDULE OF LAND USE
(e) AS SHOWN ON DRAFT AND KEY PLANS
(f) AS SHOWN ON DRAFT PLAN
(g) AS SHOWN ON DRAFT AND KEY PLANS
(h) MUNICIPAL WATER SUPPLY TO BE MADE AVAILABLE
(i) SOIL IS CLAYEY SILT TILL
(j) AS SHOWN ON DRAFT PLAN
(k) FULL MUNICIPAL SERVICES TO BE MADE AVAILABLE
(l) SUBJECT TO EASEMENTS AS IN INST. No. 645159 AND 735214 RELATED TO ACCESS, AS SHOWN ON THE DRAFT PLAN

SCHEDULE OF LAND USE

LAND USE	BLOCKS	AREA (ha)	AREA (ac)
SERVICE AREA-EMPLOYMENT	1 & 6	3.36	8.3
EMPLOYMENT	2 to 5, 7, 8	37.18	91.9
STORMWATER MANAGEMENT	9, 10	5.70	14.1
NATURAL HERITAGE /OPEN SPACE*	11 to 14	22.60	55.8
RESERVES	15 to 21	0.05	0.1
DUNDAS ROAD WIDENING	22 to 24	0.28	0.7
RESERVED FOR FUTURE USE	25	0.20	0.5
PARK	26	0.32	0.8
ROADS (LINEAR: 2,600.6m)	BURNHAMTHORPE ROAD EXTENSION, AVENUE ONE, AVENUE TWO, AVENUE THREE and STREET FOUR	5.44	13.5
TOTAL		75.13	185.7

* Limits of Natural Heritage/Open Space Blocks – The boundaries of the Natural Heritage/Open Space Blocks have been determined based on the corridor width delineation recommendations of the EIR/FSS, which considers the: fluvial geomorphologic requirements; regulatory floodplain; stable slope top of bank; fish and fish habitat protection requirements; preservation of hydrologic functions; and setback requirements. The limits of the Natural Heritage/Open Space blocks will be confirmed through field survey.

All internal distance dimensions on curves are chord length unless otherwise stated.

Dashed linework outside of subject property is conceptual only

Development Limits taken from EIR/FSS - April 2018

Scale 1 : 1500

0m 50 100 150 200m

OWNER'S AUTHORIZATION

I AUTHORIZE MMM GROUP LIMITED TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE TOWN OF OAKVILLE FOR APPROVAL.

See Original for Signature
MIKE REEL, VICE-PRESIDENT INVESTMENT MANAGEMENT
BENTALL KENNEDY (CANADA) LP
c/o bcIMC REALTY CORP.
DATE

PLANNER'S CERTIFICATE

PLAN PREPARED BY MMM GROUP LIMITED.

See Original for Signature
CHRIS TYRRELL, MCIP, RPP
MMM GROUP LIMITED
DATE

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

See Original for Signature
Fernando De Luca O.L.S.
MMM GROUP LIMITED – MMM GEOMATICS ONTARIO LIMITED
DATE

wsp

No.	Date
1	December 12, 2012
2	November 26, 2014
3	September 28, 2015
4	June 28, 2017
5	April 24, 2018
6	JUNE 26, 2018

09M-00013-01-P01

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm property

407 West Employment Area Draft Plan of Subdivision

Scale
1 : 5000
0m 50 100 150 200m

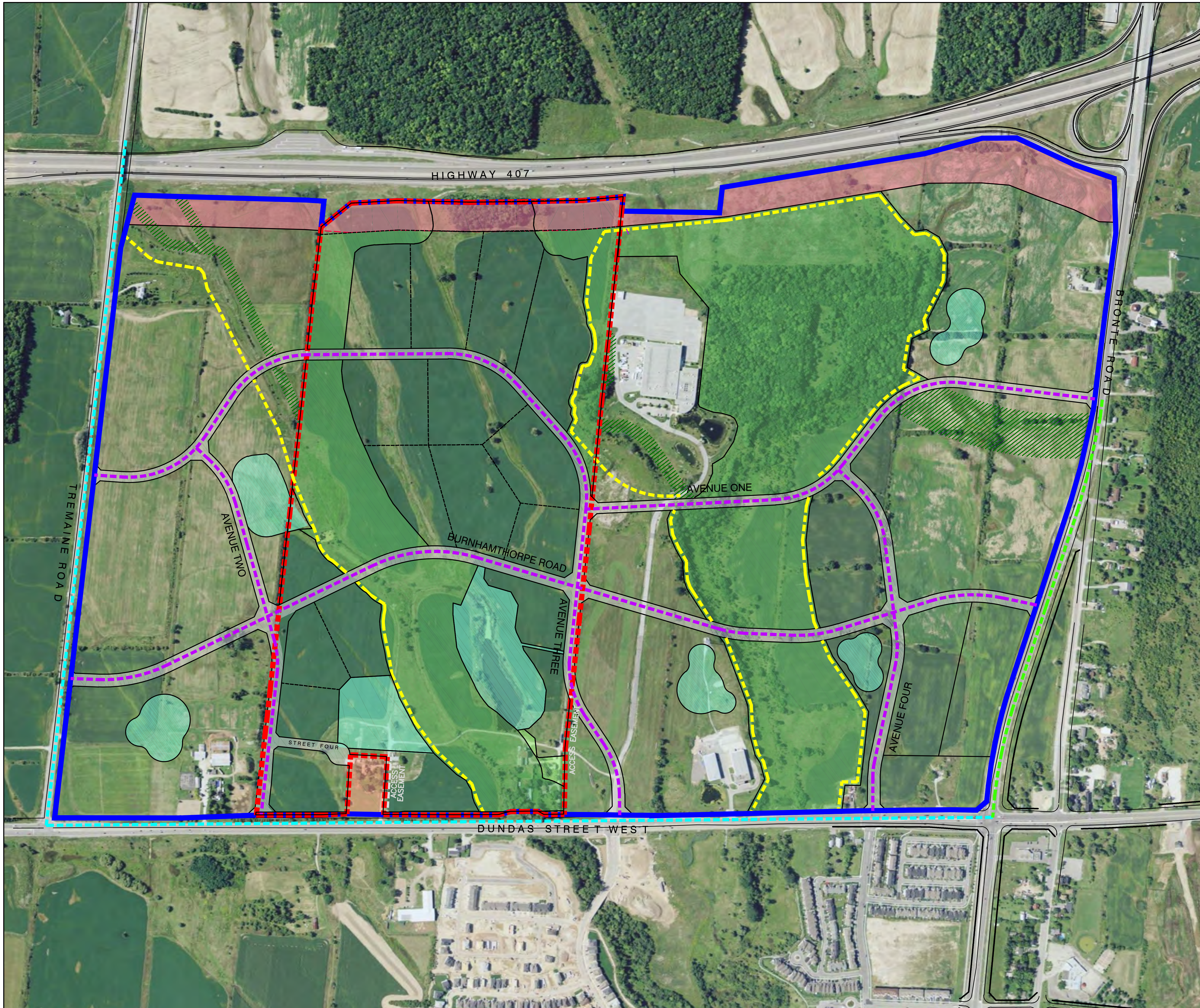
Client

Prepared by
wsp

Date
July 2018

Project No.
09M-00013-01
(1409222-001)

Figure 3.2



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

407 West Employment Area Concept Plan

Trails Plan (Conceptual)

LEGEND

- Major Trails
- Multi-Use Trail (Off-Road / In Boulevard)
- Regional Bicycle Facility
- Signed Bicycle Route (On-Road)
- Park
- Open Space
- Stormwater Management
- Planned 407 Transitway
- Roads
- 407 West Employment Area
- Subject Lands

Notes:

- For the purposes of our analysis we have made land use, natural heritage and storm water sizing and location assumptions for the entire 407 West Employment Area
- Right-of-way requirements for future 407 Transitway to be determined
- The Natural Heritage System on lands owned by others is conceptual, as shown in the North Oakville West Secondary Plan, and is subject to further study.

Scale
1 : 7500

Client
QuadReal

Prepared by
wsp

Date
July 17, 2018

Project No.
09M-00013-01
(1409222-001)

Aerial Photo
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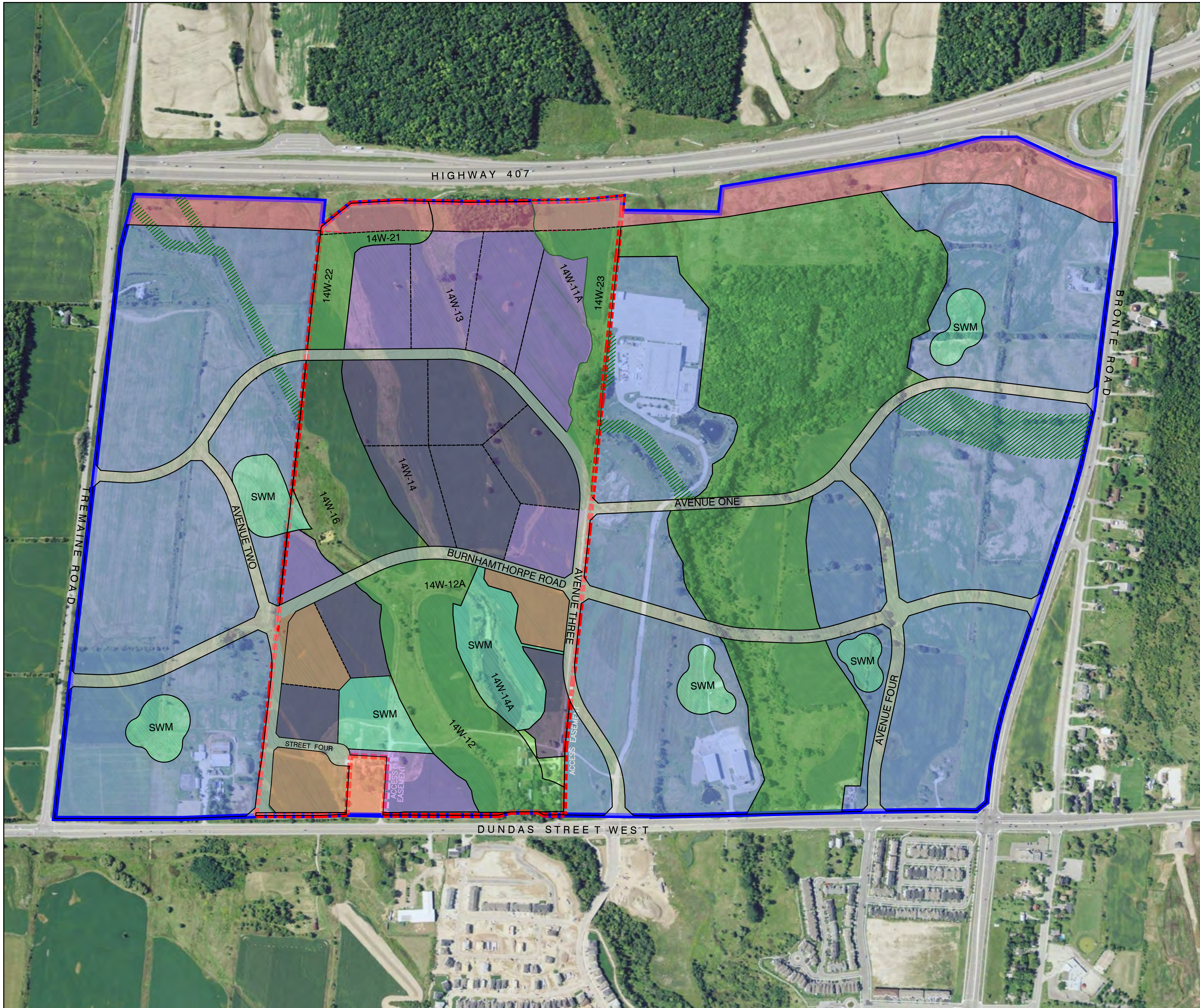
Figure 3.3



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

407 West Employment Area Concept Plan

LEGEND		Area Hectares	*Acres*
	Employment (Specific land use to be determined)	94.1	*233*
Land use on Lazy Pat Property	Mixed Employment (Service/Office)	6.1	*15*
	Light Employment	16.4	*41*
	General Employment	17.3	*42*
	Park	0.3	*1*
	Open Space	72.7	*180*
	Stormwater Management	15.6	*38*
	Planned 407 Transitway	12.3	*30*
	Roads	16.2	*40*
		251.0 ha	*620 ac*

407 West Employment Area

Subject Lands

Notes:

- For the purposes of our analysis we have made land use, natural heritage and storm water sizing and location assumptions for the entire 407 West Employment Area
- Right-of-way requirements for future 407 Transitway to be determined
- The Natural Heritage System on lands owned by others is conceptual, as shown in the North Oakville West Secondary Plan, and is subject to further study.

Scale

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09M-00013-01
(1409222-001)

Aerial Photo

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Figure 3.1

4.0 Hydrogeology and Geology

4.0 Hydrogeology and Geology

4.1 Introduction

The Subject Property is approximately 75.1 ha in area, of which approximately 53.8 hectares is proposed for development. The ground at the Subject Property generally slopes from the northwest to the southeast from a topographic high of about 160 masl at the north boundary to approximately 142 masl in the main watercourse (FM1001/Reach 14W-12) where it passes under Dundas Street West. In general, the lands at the Subject Property are gently undulated, with elevation changes between the crests of the rises down to the watercourses of the order of 5 to 8 m.

The property is bordered by the following existing land uses as illustrated on Figure 4.1:

- Agricultural lands to the southwest, with Bronte Creek located approximately 1 km to the southwest of the western property line;
- Highway 407 and agricultural/forested lands to the northwest;
- An industrial facility (General Electric) and vacant/agricultural and forested lands to the northeast; and,
- Residential development to the southeast.

A quarry owned by Hanson Brick Ltd. is located approximately 1 km to the northwest of the Subject Property. The quarry is located to the north of Highway 407 and west of Tremaine Road.

Three subwatersheds cross the Subject Property, identified as subwatersheds FM1109, FM1001 and FM1102 in the NOCSS. Subwatershed FM1001 (also identified as the West Branch of Fourteen Mile Creek) drains the majority (approximately 81%) of the Subject Property (approximately 60.4 ha of the total 75.1 ha site area), contains three watercourse (Reach 14W-13, Reach 14W-14 and Reach 14W-16) and a small dug pond and Farm Pond (Reach 14W-14A), all of which eventually converge and exit the Subject Property at the southeast through a single main channel (Reach 14W-12).

Subwatershed FM1109 (Central Branch of Fourteen Mile Creek, Reach 14W-11 and Reach 14W-11A) drains about 10.0 ha of the Subject Property area along the eastern and north-eastern portions of the Subject Property, and the watercourse flows across the northeast corner of the property.

The smallest of the three subwatersheds, FM1102 drains about 4.7 ha of the total property area at the extreme southwest corner. There is no defined channel through the Subject Property within this subwatershed but two shallow “swales” were observed in a moist to standing water condition in early May 2009 and in a dry condition in April 2010. No evidence of flowing water was observed in this subwatershed during the course of our investigation. A small pond is located on a farm property that is not part of the Subject Property and water from this pond drains under Dundas Street West through a culvert located to the west.

The present land use over the tablelands on the Subject Property and adjoining lands is primarily agricultural. The farm in the past had been used to raise pigs but this use was discontinued more than 20 years ago. Within the watercourse valleys vegetation is generally comprised of tall grasses, weeds and shrubs.

The future development on the Subject Property will be fully serviced with municipal water and sewers. The development lands are designated for employment uses and will consist of industrial and commercial uses. Two SMW Facilities will be constructed on the Subject Property, which will treat, approximately 56% (Pond 3) and 26% (Pond 2) of the total property area following development. The remaining area is green space.

A hydrogeological evaluation of the Subject Property was carried out by WSP (formerly MMM Group) according to the Town ToR for EIR and FSS carried out in North Oakville. The stated purpose of the EIR is to characterize and analyze the natural heritage features and functions, and to determine and address the potential impacts of a proposed development application, including servicing requirements on the natural heritage system. The ToR further indicate that the EIR be carried out on a subwatershed basis and that only one EIR will be permitted per subwatershed even if multiple property owners (developers) were proposing development within the same subwatershed. The expectation was that investigative works were not only to be carried out directly on the Subject Property, but also within the subwatershed catchment as a whole to characterize the entire natural heritage system.

The hydrogeological evaluation included interpreting regional geology and site-specific geology and hydrogeology, based on fieldwork carried out by WSP at both on-site and off-site locations between May 2009 and April 2017. A detailed breakdown of fieldwork activities is provided in Section 4.1.2.

4.1.1 Subwatersheds

The Subject Property is located within three subwatershed catchments identified in the NOCSS (Figure 4.1). The upper reaches of all three subwatersheds are defined by the crest of the Trafalgar Moraine that forms the topographic high ground to the northwest of the Subject Property. In Table 4.1 below, it is clear that the majority of the Subject Property are currently drained by the central subwatershed (FM1001) and that the Subject Property contains about 15% of the total overall area of this subwatershed. Conversely, the Subject Property only comprises about 3% of subwatershed FM1109, and about 11% of subwatershed FM1102. With further regard to FM1102, the small proportion (4.7 ha) of the Subject Property contained within this subwatershed also makes up only a very small proportion of the total area of the future employment lands to the west of the Subject Property. This hydrogeological investigation; therefore; focuses on subwatershed FM1001 although some discussion of subwatersheds FM1109 and FM1102 is provided.

Table 4.1 – Subwatershed Areas

Subwatershed	Subwatershed Area (ha)	Subwatershed Area within Subject Property (ha)	Proportion of Subwatershed within Subject Property (%)	Proportion of Subject Property within the Subwatershed (%)
FM1102	43.9	4.7	11%	6%
FM1001	395.3	60.4	15%	81%
FM1109	365.0	10.0	3%	13%
Subject Property		75.1		100%

4.1.1.1 Subwatershed FM1001

As discussed above, Subwatershed FM1001 is the main subwatershed found at the Subject Property, draining approximately 81% of the Subject Property. This subwatershed is identified as the West Branch of Fourteen Mile Creek, and in the study, area is comprised of a main channel (Reach 14W-16 and Reach 14W-12) with two smaller watercourse (Reach 14W-14 and Reach 14W-13) that all join on the Subject Property. The topography within the overall subwatershed slopes from northwest to southeast from a topographic high of about 185 masl at Number Two Sideroad to approximately 142 masl where the watercourse crosses under Dundas Street West. The land cover of the subwatershed area is mostly open or agricultural (90%), with about 8% of the total subwatershed area covered in forest (Figure 4.2). The remaining 2% area is considered impervious, comprised mainly of the Highway 407 pavement and the existing extent of the Hanson Brick quarry, which will expand over time as operations continue.

4.1.1.2 Subwatershed FM1109

Subwatershed 1109 is located east of Subwatershed FM1001 and this subwatershed is known as the Central Branch of Fourteen Mile Creek. This subwatershed drains a small portion of the Subject Property, primarily via a defined channel at the northeast corner (Reach 14W-11 and Reach 14W-11A) and through a swale, which drains a portion of the Subject Property near its east property line (Figure 4.2). The topographic relief of this entire subwatershed ranges from approximately 190 masl along the crest of the moraine to the northwest to about 150 masl along Dundas Street West. Approximately 23% of the overall subwatershed area is presently forested, 74% is interpreted as agricultural/open ground cover, and the remaining 3% is considered impervious (Highway 407 and the GE facility make up most of this).

4.1.1.3 Subwatershed FM1102

Subwatershed FM1102 is located to the west of Subwatershed FM1001 and is the smallest of three subwatersheds passing through the Subject Property. No defined channels were observed in this subwatershed on-site, other than two wide, gentle swales affected by agricultural activities (e.g., furrowing through cropping). These swales were found to contain pockets of stagnant/ponded water at the times of all site visits beginning from May 2009. The topography of this small subwatershed ranges from about 170 masl at the western limit of the subwatershed to about 152 masl along Dundas Street West. The current land use of the area is predominantly agricultural (90%) and forested (9%) with only a minor percentage (1%) of imperviousness.

4.1.2 Work Program

The work program for the hydrogeological investigation was designed to address the requirements outlined in the ToR, including:

- Review of background information pertinent to the subwatersheds, including areas beyond the Subject Property limits;

- Field investigations, including:
    - Site visits, initial site inspection and quarterly visits;
    - Drilling boreholes and installing monitoring wells. Streambed mini-piezometers and staff gauges were also installed at on-site locations;
    - Soil sampling and grain size analyses of selected samples;
    - Quarterly groundwater level monitoring, including "continuous" monitoring using data loggers at selected monitoring wells located at both on-site and off-site locations;
    - Estimating watercourse flows at the time of the quarterly site visits;
    - Groundwater and surface water sampling; and,
    - Single well hydraulic conductivity testing and shallow percolation testing.

- Assessing site conditions, including:
    - Characterizing the local geologic and hydrogeologic conditions;
    - Identifying groundwater discharge areas and evaluating surface water base-flows;
    - Establishing surface water-groundwater interactions;
    - Preparing pre-development and post-development water balance analyses at the Subject Property and the overall subwatersheds;

- Analyzing and assessing the potential impacts of the development; and,

- Providing recommendations for the mitigation of any potential impacts.

4.2 Regional Physiography and Geological Setting

4.2.1 Regional Geology and Hydrostratigraphy

The Subject Property and surrounding area are situated in the South Slope physiographic region identified by Chapman and Putnam (1984). The Trafalgar Moraine, a subtle topographic ridge that was formed during the retreat of the Lake Ontario ice lobe 12-13,000 years ago, extends from western Mississauga across the northern part of Oakville and is found to the north and west of the property marking the boundary between the South Slope and the Peel Plain physiographic region to the north. The till plain on which the subject property lies is comprised of reddish coloured Clay-Silt Halton Till which is locally derived from the underlying bedrock.

The underlying bedrock in the area is Upper Ordovician red Shale and interbedded Limestone of the Queenston Formation. It is encountered at shallow depth and is reported in the MOE water well records as red shale with limestone, at depths between 3 to 27 metres below ground surface (mbgs). It is exposed at surface along the steep valley walls of Bronte Creek to the west, and is exposed at surface at the lower reach of the central watercourse (Reach 14W-12) passing through the Subject Property alongside Dundas Street West. On a regional basis the bedrock surface is interpreted to be dipping from the northwest to southeast, generally following the regionally topographic slope, mapped with a surface elevation of approximately 165 to 170 masl in the vicinity of the Trafalgar Moraine to approximately 145 to 150 masl along Dundas Street (Ontario Department of Mines, 1964).

An infilled bedrock valley is identified through interpretation of the water well record logging at wells located east of the subject property, generally below the watercourse draining FM1109 (Reach 14W-11 and Reach 14W-11A, Central Branch of Fourteen Mile Creek, (Figure 4.2)). Bedrock elevations in this “valley” are interpreted between 120 to 130 masl to the east and south of the Subject Property and buried sand and gravel deposits are logged between the surficial tills and the bedrock in this section (water well records are found in Appendix 4-1). Farther north, by Burnhamthorpe Road, the valley bottom elevations are interpreted at about 140 to 145 masl, and low permeability till and/or clay deposits are logged from surface to rock.

Drawing 4.1 (appended to this report) presents the hydrogeological cross-sections A-A’, B-B’ and C-C’ identified on Figure 4.2. These cross-sections were prepared from geological information recorded in the MOE water well records, supplemented with borehole data from WSP investigations in 2009 and data from the Hanson Brick Quarry studies.

Figure 4.3 presents the interpreted bedrock and shallow (till) based groundwater contours. The bedrock contours are based on both water well records and on and off-site borehole data, while the shallow contours are based primarily on borehole monitoring data. On this figure, groundwater in the bedrock is seen to generally flow from northwest to southeast with deflections created by the Bronte Creek valley to the west, and the infilled bedrock valley to the east, which leads to a west to east bedrock groundwater flow at the Subject Property. The regional horizontal gradient within the bedrock is approximately 0.009, increasing locally to 0.013 to 0.015 where the flow is being deflected towards the infilled bedrock valley.

The shallow groundwater system is controlled by the topography of the land declining from roughly 180 masl at the upper limits of Watershed FM1001 (at Number 2 Sideroad) down to approximately 145 masl at the point where the main FM1001 channel passes under Dundas Street West. On a watershed basis, the horizontal gradients in the shallow system are on the order of 0.01 to the southeast. Further discussion on groundwater levels is provided in Section 4.3.2.3.

The Halton Till and the Queenston Shale are poor aquifers due to their fine-grained nature and low permeability and are capable of providing only limited quantities of groundwater to water wells. In terms of existing groundwater usage, within the jurisdiction of the CH, approximately 75% of all wells are completed into the bedrock, which indicates that the surficial overburden deposits of Halton Till are not a significant source of groundwater in the area (Singer et al, 2003). Most wells in the study area are completed into the bedrock, except for wells in the bedrock valley. Wells drilled into the bedrock valley, south of Highway 407, are completed in the buried sand and gravel deposits above the shale bedrock.

The bedrock in the area is also described as a poor aquifer due to poor pore space interconnections in the shale. The Queenston Formation shale does not fracture easily or dissolve, which limits its effective porosity. The upper 3 to 5 m of the bedrock is weathered, and is where most of the available yield is observed. The reported geometric mean averages of the specific capacity and Transmissivity for this formation are 1.5

l/min/m and 2.7 m^2/day, respectively (Singer et al, 2003). The bedrock is therefore considered a poor aquifer with yield capacities barely enough to satisfy individual domestic water needs.

As reported in Singer et al (2003), 92% of all wells completed within the Queenston Shale (across Southern Ontario, not only Halton Region) are reported as providing “fresh” water. Salty water is reported at 5% of these wells and the remaining 3% of wells are reported with either mineralized or sulphurous water. Water quality from the shale is considered highly variable, ranging from good to poor. Water quality from 12 samples were presented in the Singer report, and indicated the water is hard (mean hardness of 472 mg/L), has high levels of sodium and chloride (averages of 88 and 123 mg/L respectively), and an average concentration for sulphate of 251 mg/L.

4.2.2 Topography and Drainage

The Subject Property and surrounding area has moderate relief (between 190 to 130 masl on a regional basis, 160 to 142 masl relief across the Subject Property) with the ground generally falling from the west-northwest to east-southeast. The area is referred to as part of the South Slope physiographic region by Chapman and Putnam (1984). The Trafalgar Moraine, a subtle topographic ridge that extends from western Mississauga across the northern part of Oakville, lies to the north and northwest of the property.

The local drainage network is generally oriented in a west-southwest to east-northeast direction The Subject Property is predominantly drained by subwatershed FM1001, which has four channels (Reach 14W-12, Reach 14W-16, Reach 14W-13 and Reach 14W-14). Subwatersheds FM1109 and FM1102 drain the eastern portion and the extreme south-western corner of the Subject Property, respectively. These three subwatersheds are located in what can be described as a bevelled till plain with local relief provided by creek valleys, which are locally incised in the order of 5 to 10 m. Significant watercourses, such as Bronte Creek to the west are incised deeply into the underlying bedrock (bedrock exposed), with steep side slopes and relief in the order of 20 to 30 m relative to the table lands.

4.3 Hydrogeological Evaluation

4.3.1 On-Site and Off-Site Investigations

WSP carried out hydrogeological field investigations across the Subject Property and at off-site locations to the north and west of the Subject Property commencing in the late spring of 2009. Off-site field work was also carried out within subwatershed FM1001, the focus of this EIR.

WSP’s initial hydrogeological site visit took place on May 5, 2009. During this visit, hydrogeologists from WSP staked out 12 on-site borehole locations (MMM-09-1 to MMM-09-12), installed 7 mini-piezometers (MP-01 to MP-07) within two of the sub-watercourse systems that cross the Subject Property (FM1001 and FM1109) and measured water levels at three of four monitoring wells MW-1 to MW-3 (MW-4 was reported by the farmer on the Subject Property to have been destroyed) installed on the Subject Property by Trow Associates Inc. (Trow, see Section 4.3.1.3). Estimates of stream flows and field parameters such as pH, temperature, electric conductivity and concentration of total dissolved solids were measured in the watercourses at each of the mini-piezometer locations. Monitoring wells associated with the Hanson Brick Quarry site to the northwest of the Subject Property were observed following this site visit during a drive by of the local area.

A total of 16 boreholes were drilled at 12 locations within the Subject Property to depths of between 2.3 and 16.6 mbgs (metres below ground surface) in June 2009 (MMM-09-01 to MMM-09-12). Eleven (11) additional boreholes were drilled at eight off-site locations in November 2009 to depths ranging from 3.6 to 15.6 mbgs. Off-site property access was obtained from the Diocese of Hamilton (MMM-09-13 to MMM-09-15) and from the local municipalities and the Region of Halton (MMM-09-16 to MMM-09-20) for drilling within the road allowances. Borehole and monitoring well locations are presented on Figure 4.3 and Figure 4.4.

Soil samples from the overburden were collected using continuous sampling techniques. At selected intervals, split spoon samples were obtained from the upper portion of the continuous sample intervals. The sampling technique was changed to bedrock coring upon auger refusal at borehole locations where a greater depth was required. Water levels in the boreholes on the completion of drilling were recorded and monitoring wells were installed at each borehole.

The monitoring wells were constructed with 51 mm diameter Schedule 40 PVC screen and riser, equipped with O-rings at the threaded joints. Screens were between 0.5 to 3.0 m in length and a sand pack was installed around the screen, extending 0.3 m above the top of the screen. A bentonite seal was placed from the top of the sand pack to about 0.3 m below grade. A protective lockable steel casing and 0.3 m of concrete at surface completed the installations. Seven of these monitoring locations were constructed as nested wells with both a shallow and deeper monitoring well to ascertain vertical groundwater gradients.

Borehole logs for all boreholes, including stratigraphic descriptions, sampling intervals and monitoring well details, are contained in Appendix 4-2. Grain size analysis results from these boreholes are presented in Appendix 4-3.

4.3.1.1 Supplemental Farm Pond Investigation

Additional monitoring wells and mini-piezometers were installed around the periphery of the large human-made Farm Pond (Reach 14W-14A) in July 2011 as part of an investigation to confirm if this Farm Pond was receiving groundwater. WSP staff installed a staff gauge within the Farm Pond and three mini-piezometers (MP-21, MP-22, and MP-23) at the edges of the Farm Pond on July 4, 2011. Three new monitoring wells (50 mm diameter PVC riser and screen) were constructed in mid-July 2011 by EXP Services Inc. on behalf of WSP at two locations along the west side of the Farm Pond and identified as MMM11-21, MMM11-22 (nested). These wells are located to the west and southwest of the Farm Pond (borehole logs are included in Appendix 4-2). Data loggers were installed at the staff gauge in early July 2011 and at the three new monitoring wells in late July 2011. A data logger had been installed at monitoring well MMM09-02 (located to the east of the Farm Pond) in March 2011 in anticipation of this supplemental study.

A drive-point mini-piezometer nest (MP-24) was installed near the upstream limit of the Farm Pond on October 22, 2013 at a location agreed to with CH's hydrogeologist at a site meeting on October 10, 2013. This mini-piezometer nest is located to the northwest of a topographic rise that separates the Farm Pond from Reach 14W-12A, with the edge of the Farm Pond, as defined by the average Farm Pond water level elevation of 148.7 masl, situated approximately 65 m southeast of the mini-piezometer nest. Two mini-piezometers were installed, the shallower piezometer was screened between 0.31 and 0.44 mbgs, and the deeper piezometer was screened between 1.19 and 1.28 mbgs. Data loggers were installed in both piezometers[1].

Additionally, four boreholes drilled by EXP Services Inc. along the main Reach channel (Reach 14W-12) for a slope stability investigation included piezometers (EXP report dated November 18, 2011 and entitled "*Slope Stability Analysis Report, 14 Mile Creek, Pigott Farm Land, Oakville, Ontario*") and these piezometers were also included in the monitoring for this study (the borehole logs are included in Appendix 4-2).

4.3.1.2 Quarterly Monitoring

Quarterly site visits were scheduled to monitor the Subject Property and off-site monitoring locations over spring, summer, fall and winter conditions. During such visits, manual water level readings were taken at the monitoring wells and mini-piezometers, data loggers were downloaded and when there was flowing water present (and not frozen), flow estimates were obtained in the watercourses at staked locations identified as FMP-1 to FMP-6. These site visits were ideally scheduled to follow periods of dry weather (greater than 3 to 5 days following a rain event), although this was not always possible. Flow measurements were supplemented with stream water levels at staff gauges locations SG-1 and SG-2.

Additional investigative work carried out by WSP at the time of the regularly scheduled monitoring visits included water quality sampling and hydraulic conductivity testing at selected monitors.

4.3.1.3 Investigations by Others

An earlier study was carried out on the Subject Property and additional lands to the north of Highway 407 in 2001, and three of the four monitoring wells installed from this program were still available for use from 2009 to present. This earlier field work was carried out on behalf of Beutel Goodman Real Estate Group and was undertaken at the property by Trow to document the geotechnical and environmental conditions at these lands. The report examined two parcels of land separated by Highway 407 and identified as Parcels A and B. Parcel A coincides with the Subject Property currently under consideration for development. Parcel B was located north of Highway 407 extending north to Burnhamthorpe Road, with an area of about 23 ha. No work was carried out by WSP for this work program on the lands identified as Parcel B in the 2001 Trow reports.

Trow's prior on-site investigations consisted of the following:

- Drilled forty-five (45) geotechnical boreholes (MW-1 through MW-4, and BH-1 through BH-41) to depths ranging between 1.6 to 6.1 m below grade. Four groundwater monitoring wells were installed at the locations identified as MW-1 to MW-4 (MW-4 could not be located in 2009 and was reported by the previous owner as destroyed years ago). Shale bedrock was reported at 16 of the 45 borehole locations, generally those boreholes located along the south and west portions of Parcel A (the Subject Property under current investigation);
- Excavated forty-eight (48) shallow test pits to depths ranging 1.0 to 2.3 m. None of these test pits was reported having encountered the shale bedrock;

[1] The data logger at MP-24S, a very shallow monitor (0.44 m deep), was removed for the winter on December 16, 2013 to prevent damage to the unit from freezing. The data logger was re-installed at MP-24S on April 30, 2014 for the spring to fall seasons.

- One aspect of the Trow work plan was to investigate the potential for contamination near three USTs (Underground Storage Tanks) that had contained pig manure and one UST used for fuel storage. Soil and groundwater samples from the boreholes, monitoring wells and private wells located on the property were submitted for analysis and all met the relevant criteria of the time for the proposed commercial/industrial land use with full municipal servicing.

Copies of the available borehole logs, test pit logs and location plan from the Trow report are also included in Appendix 4-2.

Several hydrogeological investigations were carried out by Golder Associates Ltd. (Golder) on behalf of Hanson Brick in support of their Tremaine Quarry, located to the northwest of the Subject Property. Information from these investigations relevant to the hydrogeological interpretation of the Subject Property was examined. Copies of these reports, including annual monitoring reports up to November 2009 were obtained from those on file at the Regional Municipality of Halton.

The off-site field investigation programs carried out for Hanson Brick by Golder since 2002 consisted of the following:

- Construction of 11 on-site monitoring well nests (MW-1 to MW-11), with a minimum of a shallow monitor completed in the overburden till, and a deep monitor screened deep within the shale bedrock. Six nest locations also include a monitor screened within the upper shale, and 4 nest locations include a monitor screened across the till/shale bedrock interface;

- Construction of three off-site 150 mm diameter drilled test wells, located within the road allowances for Number 1 Side Road/Burnhamthorpe Road West and Tremaine Road. These wells were drilled and tested as part of a Class Environmental Assessment to determine the feasibility of providing a source of water communal water supply system for local residents;

- Static water level monitoring collected on a quarterly basis between 2002 and 2008, and monthly thereafter. The 2008 water level monitoring program included 11 private wells and monitoring of the 11 on-site monitoring well nests and the 3 test wells located on the road allowances. Most of the on-site monitors and all of the 11 private wells were equipped with data-loggers;

- In-situ hydraulic conductivity testing of the overburden and bedrock was carried out at most of the monitors at the 11 monitoring well nests, with the exception of two of the shallow overburden wells;

- Groundwater sampling at the 11 on-site monitoring well nests and at 10 private wells.

WSP staff did not access nor monitor any of the Hanson Brick wells during this study and used the publicly accessible reported data for those wells.

4.3.2 *Site Geology*

WSP's drilling programs confirm the surficial soils encountered within the Subject Property and the EIR Sub-catchment Study Area (FM1001) are comprised of clay-rich Halton Till, underlain by Queenston Shale.

Topsoil generally ranged from 0.1 to 0.3 m thickness at most borehole locations. Thicker topsoil was noted at on-site boreholes MMM-09-4 and MMM-09-10, on the order of 0.5 to 0.6 m thickness. Both of these locations are near to existing watercourses (e.g., valley bottoms).

Generally, the soils at ground surface below the topsoil layer were classified as a brown to reddish brown stiff to very hard Clayey Silt Till, some sand, occasionally classified as Sandy Silt Till, with shale fragments. At six of the borehole locations[2], thin deposits of differing soils were logged between the topsoil and till. These deposits were generally similar in composition as the underlying till (e.g., Clayey Silt, to Silt with some sand and with till-like appearance, extending to depths between 0.5 to 1.4 m below grade) and are possibly representative of soils disturbed by farming activities. At MMM-09-4, located next to Reach 14W-11 in sub-watershed FM1109, a deposit of Silty Sand to Sandy Silt (to 1.4 m depth) overlays the till.

Fracturing within the till was evident at most boreholes, with the shallower depths being highly fractured and weathered, and with fracture frequency noted to decrease with depth. Fractures were observed up to extend downward to between 4 to 6 m depth from the logging of the soil samples. Fractures near surface were observed to have a greyish white infilling of a Silt-Clay composition, or were identifiable through rusty to black oxidation staining.

The till deposits were logged to the underlying shale bedrock at the boreholes where the bedrock, or weathered bedrock was encountered or assumed through auger refusal. At many of the boreholes, the transition from shale/weathered shale to till was quite gradual.

The geological stratigraphy at the off-site drilling locations (MMM-09-13 to MMM-09-20) was similar though as locations progressed northward and the ground elevation increased the shale bedrock was less likely to be encountered.

The shale bedrock was identified as red Queenston Shale, with zones of green banding or green inclusions visible within the cores. The upper surface of the bedrock was weathered, with the weathered depth of the shale bedrock at the on-site boreholes generally extending beyond the lower completion depths of the boreholes. At three locations, the weathered depth of shale was logged to between 0.6 to 1.7 m from the top of the bedrock surface[3]. At MMM-09-15D (off-site location) the shale bedrock was still identified as weathered to 12.3 m depth (bottom of hole), with a highly weathered zone at approximately 5 to 6 m depth reported at this location. The RQD (Rock Quality Designation) of the shale bedrock was generally found to range from 29% at (poor rock mass quality) to 89% (good rock mass quality).

At the Subject Property, the surface of the bedrock was noted to decline in elevation from the southwest to the north-northeast[4]. Bedrock along the western property line was encountered at approximately 150 masl

[2] MMM-09-2 to MMM-09-5 inclusive, MMM-09-9, and MMM-09-12

[3] MMM-09-1 (1.5 m), MMM-09-6 (1.7 m), and MMM-09-10 (0.6 m)

[4] This includes information from the borehole logs prepared by Trow in their 2001 work on the property.

elevation. Towards the southeast corner of the Subject Property, where the main watercourse exits the property and passes under Dundas Street West, the bedrock surface is encountered at around 145 masl, and is in fact exposed at surface within the main stream channel alongside Dundas Street. The shale bedrock is located close to the watercourse channel bottoms up to the west-central parts of the Subject Property, being identified within 0.8 m of the channel at MMM-09-10, and approximately 1.6 m from the channel bottom in the vicinity of MMM-09-9 and MP-07.

At the northeast corner of the Subject Property, the bedrock was not encountered at either MMM-09-4 (borehole terminated at 146.3 masl) or at MMM-09-5D (borehole terminated at 142.8 masl). These on-site boreholes are the ones located in closest proximity to the buried bedrock valley identified in mapping and water well records.

4.3.2.1 Grain Size Analyses

Following installation of MMM-09-1 to MMM-09-20 monitoring wells, ten soil samples were submitted to Thurber Engineering Ltd. (Thurber) for a grain size analyses. The results of these grain size analyses were reviewed and used to provide estimates of hydraulic conductivity and soil classification for use in the water balance analysis. The grain size curves are found in Appendix 4-3.

Table 4.2 presents the location and depth of soil samples that were tested for grain size distribution and the estimated hydraulic conductivity. The estimates of hydraulic conductivity presented in Table 4.2 were obtained based on grain size results using the Hazen approximation:

$$K = 0.01 \times Cd_{10}^2 \text{ (m/sec)}$$

Where:

K = bulk hydraulic conductivity (m/sec);
d_{10} = grain size at which point 10% of the soil passes the sieve (mm); and
C = a constant generally set at 1 for these units.

Table 4.2 – Hazen Estimates of Hydraulic Conductivity

BH ID	Sample ID	Depth (mbgs)	Soil Description	d_{10} (mm)	Hazen K ~0.01 x d_{10}^2 (m/sec)
MMM-09-01D	S2	1.5 – 1.7	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-05D	S3	2.7 – 2.8	Clayey Sandy Silt (TILL)	<0.001	< $1.0X10^{-8}$
MMM-09-08	S1	0.9 – 1.1	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-09	S1	1.0 – 1.1	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-11	S1	1.0 – 1.2	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-12	S3	2.5 – 2.7	Clayey Silt (TILL), trace sand	<0.001	< $1.0X10^{-8}$
MMM-09-13	S1	0 – 1.2	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-17	S4	5.5 – 5.6	Sandy Silt (TILL), some clay	<0.001	< $1.0X10^{-8}$
MMM-09-18D	S1	0.9 – 1.2	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$
MMM-09-19D	S4	3.7 – 3.9	Clayey Silt (TILL), some sand	<0.001	< $1.0X10^{-8}$

From Table 4.2, the Till deposits are estimated by the Hazen approximation to have hydraulic conductivities less than $1x10^{-8}$ m/sec[5]. These are reasonable estimates for unweathered till soils, but will underestimate the apparent (or bulk) permeability of the surficial zone for these soils. The bulk hydraulic conductivities for the shallow soils are expected to be greater as the preferential horizontal movement of water will be through the fractures found in the upper, weathered zones of these soils, and alongside creek valleys where erosion of the original deposit also provides some additional fracturing caused by stress relief.

Table 4.3 – Tri-Linear Soil Classification

BH/SA	Description	Percent Sand	Percent Silt	Percent Clay	Soil Classification
MMM-09-01D	Clayey Silt (TILL), some sand	26	45	28	Clay Loam
MMM-09-05D	Clayey Sandy Silt (TILL)	29	42	28	Clay Loam
MMM-09-08	Clayey Silt (TILL), some sand	26	43	31	Clay Loam
MMM-09-09	Clayey Silt (TILL), some sand	22	52	26	Silty Loam
MMM-09-11	Clayey Silt (TILL), some sand	27	44	29	Clay Loam
MMM-09-12	Clayey Silt (TILL), trace sand	12	60	28	Silty Clay Loam
MMM-09-13	Clayey Silt (TILL), some sand	27	44	29	Clay Loam
MMM-09-17	Sandy Silt (TILL), some clay	28	52	20	Silty Loam
MMM-09-18D	Clayey Silt (TILL), some sand	24	45	31	Clay Loam
MMM-09-19D	Clayey Silt (TILL), some sand	29	47	23	Medium Loam

Note:
Percentages expressed in the table above are based on the proportions of Clay, Silt and Sand sized particles, excluding Gravel content

[5] Hazen estimates of hydraulic conductivity were not used to classify the soil type for use in the water balance calculations.

The tri-linear soil classifications obtained through the grain size analyses were used to derive the soil classification for estimating infiltration input into the water balance analysis (along with published soils mapping of the site (see Section 4.4.3.1). The percentage composition of soils was categorized as percentages of sand, silt, and clay and compared against classifications in a tri-linear soil classification chart. The results are presented on Table 4.3. The predominant soils found at shallow depth are Clayey Silt Till (and typically classified as Clay Loam). The tri-linear soil classifications range between Silty Clay to Medium Loams. On average, Clay Loam was considered representative of the soils found near surface for input into the water balance.

4.3.2.2 In-Situ Permeability Testing

Hydraulic conductivity testing was carried out at nine WSP monitoring well locations in December 2009, January 2010 and October 2010[6] to provide estimates of the in situ hydraulic conductivity of the deposits across the Subject Property and the FM1001 subwatershed. The monitoring well locations were selected on the basis of providing data from locations across the subwatershed, and for representative soil types, and at both shallow and deeper depths.

At six of the nine tested monitors, the hydraulic conductivity was anticipated to be quite low, and recovery was monitored using data loggers installed at those locations (see Section 4.3.2.3 for details of the loggers)[7]. Manual measurements were taken at MMM-09-9 and both wells at the two monitors at location MMM-09-10 as these wells recovered quickly (less than 10 minutes each).

The hydraulic conductivity testing was generally carried out by extracting a volume of water in the monitoring well using either a polyethylene bailer or dedicated *Watterra* tubing and foot-valves, In the case of testing carried out at MMM-09-10, a slug with a known volume was used to displace the water and a falling and rising head test was carried out. In all cases, the recovery of the water levels in the well was measured over time until they had recovered to within approximately 80% of the original water level.

The recovery data was analysed with Aquifer Test Pro (Version 4.2) using the Hvorslev (1951) approach and the results of the hydraulic conductivity testing are presented in Table 4.4[8]. These values are considered representative of horizontal hydraulic conductivity in the immediate vicinity of the well. It is anticipated that the vertical hydraulic conductivities with depth will be an order of magnitude lower than these values.

The measured hydraulic conductivities within the shallow zones of the Till deposits (i.e., 1.5 to 4.5 m depth) were generally one to two orders of magnitude greater than the conductivities estimated using the Hazen approximation from grain size analyses for the Till (see Section 4.3.2.1). The horizontal hydraulic

[6] MMM-09-04, MMM-09-09, MMM-09-15S, and MMM-09-17 (December 2009); MMM-09-19S, MMM-09-19D, and MMM-09-20 (January 2010); MMM-09-10S and MMM-09-10D (October 2010).

[7] Rising head recovery monitoring using data loggers at these locations indicated that recovery of the water levels in these wells over several hours (MMM-09-04, MMM-09-15S) to several days (MMM-09-17, MMM-09-19S, MMM-09-20). The recovery at monitor MMM-09-19D continued on the order of one month.

[8] The Hvorslev analyses are presented in Appendix 4-4.

conductivities in the weathered shale were measured on the order of 10^{-6} m/sec, and are expected to decrease with depth as the effects of weathering and fracturing becomes less pronounced[9].

Table 4.4 – In-Situ Permeability Testing Summary

Monitoring Well	Screen Interval (mbgs)	Description	Hydraulic Conductivity (m/sec)
MMM-09-09	1.8 – 2.3	Clayey Silt Till	9.0×10^{-6}
MMM-09-10S	1.6 – 2.1	Weathered Shale	6.4×10^{-6}
MMM-09-10D	6.2 – 7.7	Weathered Shale	4.4×10^{-6}
MMM-09-15S	1.5 – 4.4	Shaley Till to Weathered Shale	1.8×10^{-7}
MMM-09-04	3.0 – 6.0	Sandy Silt to Silty Sand Till, Clayey Silt Till and Sandy Silt Till	4.4×10^{-9}
MMM-09-17	2.9 – 5.9	Clayey Silt Till and Sandy Silt Till	3.9×10^{-9}
MMM-09-19S	3.2 – 5.9	Clayey Silt Till	4.8×10^{-10}
MMM-09-20	4.2 – 7.2	Clayey Silt Till	3.0×10^{-9}
MMM-09-19D	13.6 – 15.1	Clayey Silt Till	9.8×10^{-11}

Notes:

The calculated horizontal hydraulic conductivity may be underestimated due to effects such as smearing of the borehole wall during drilling. This can reduce the ability of water to be transmitted across the perimeter of the borehole and so may result an underestimate of the hydraulic conductivity.

The geometric mean horizontal hydraulic conductivity of the upper till/weathered shale is calculated at about 3×10^{-6} m/sec (using the first four results in the table above).

The geometric mean horizontal hydraulic conductivity for the deeper till deposits is calculated to range from 3.7×10^{-9} m/sec (MMM-09-04, MMM-09-17, and MMM-09-20) to 2.2×10^{-10} m/sec (data from MMM-09-19 nest only). Vertical hydraulic conductivity is further assumed to be 1/10th the horizontal hydraulic conductivity.

4.3.2.2.1 Percolation Testing

Two percolation tests were performed at locations identified as PT-1 and PT-2 on October 18, 2010. Percolation Test PT-1 was located nearby to the monitoring well nest at MMM-09-10 and PT-2 was carried out in the vicinity to mini-piezometer location MP-04.

The percolation test holes were between 160 to 300 mm diameters and were dug out to a minimum depth of 0.2 m into the till below the base of the overlying topsoil. Each hole was pre-soaked by filling it with water and allowing the water to infiltrate completely prior to the start of the test. If necessary following pre-soaking, silt and sediment were removed from the bottom of the hole and the hole was cleaned to its original depth. Water was then poured into the hole until the water level was approximately 0.15 m above the base of the hole. A small board was placed across the top of the hole and a reference point was marked on the board over the center of the hole. All the measurements were taken from that reference point with a measuring tape. The distance from the top of the board to the surface of the water was measured and recorded at consistent time intervals.

[9] Hydraulic conductivity measurements from the Hanson Brick monitors (Golder Associates. November 2009) show the hydraulic conductivity (geometric means) of the shale bedrock decreasing with depth, from an order of magnitude of 10^{-7} m/sec at the overburden/bedrock interface to 10^{-9} m/sec at depths greater than 30 mbgs – see summary table and plot in Appendix 4-4.

Plotted results of the percolation tests at PT-1 and PT-2 are presented in Appendix 4-4. Percolation testing yielded T-times of 2 to 4.4 min/cm in the Clayey Silt Till at these two locations. These T-times correlate to hydraulic conductivities in the very upper weathered zone of the Till at locations PT-1 and PT-2 on the order of 10^{-3} to 10^{-5} m/sec, or to an infiltration rate equivalent (used in the MOE Storm Water Design Manual, 2003) of between 135 to 300 mm/hour. These results were not used in the water balance calculations[10].
These results, while higher than would be anticipated for a clay-rich Till, are considered useful however for illustrating the effect of weathering and fracturing on increasing the bulk hydraulic conductivity of these types of soils at very shallow depth. The bulk hydraulic conductivity of the clay-rich Till will decrease with depth as the soils become less exposed to the effects of surface weathering. We note that site grading activities will remove essentially all of this upper weathered zone of the Till soils in the developable land parcels, either through removal at cut areas, or from compaction of engineered fill in the low areas. The resulting exposed surficial soils after site grading will be low conductivity clay-rich soils that will not be conducive to mitigating infiltration.

4.3.2.3 Groundwater Level Monitoring

Groundwater level measurements at the monitoring wells and mini-piezometers have generally been carried out on a quarterly schedule since the installation of the on-site monitors in June 2009. On-site and off-site quarterly monitoring has been typically scheduled to occur roughly during the months of January, April, July and October[11]. The complete results of groundwater level monitoring at the Subject Property are tabulated on Tables SWL-1 through SWL-2 found in Appendix 4-5. This table also includes water levels from the previously installed Trow monitors MW-1, MW-2 and MW-3, which are included in the WSP monitoring program.

Groundwater levels were also continuously monitored at selected wells using pressure transducers (data loggers). WSP staff installed *Schlumberger* Mini-Diver DI501 data-loggers at on-site and off-site monitoring wells beginning in June 2009. Table 4.5 identifies the locations and date ranges over which time data loggers have been installed. A *Schlumberger* Mini Baro-Diver DI500 was also installed at the Subject Property to provide barometric compensation of the data. The loggers were suspended from the tops of the monitors by steel cables and were set to record water level fluctuations at hourly intervals.

The data from each data logger and the baro-logger were downloaded during the quarterly monitoring visits. Figures SWL-1 through SWL-20-2 in Appendix 4-5 present plots of the spot level and continuous water level measurements at all locations with data loggers[12]. The data logger plots for the monitoring wells (Figures SWL-7 through SWL-20-2 inclusive) include the spot water level measurements and generalized stratigraphy and well construction details at the boreholes, and where available nearby watercourse channel invert elevations and mini-piezometer spot data measurements. Farm Pond water levels are also shown for comparison to the groundwater elevations at the monitors closest to the Farm Pond (MMM-09-2, MMM-11-21 and MMM-11-22).

[10] Data from the tri-linear soil classifications and published soils mapping were used in the water balance calculations (see Section 4.3.2.1).

[11] Monitoring at the off-site locations was discontinued following the February 2011 event.

[12] The data loggers at the off-site wells north of Highway 407 were removed in February 2011. Two of these data loggers were then installed at MMM-09-02, and at MMM-09-06-D.

Table 4.5 – Data Logger Locations

Monitoring Well	Figure Reference	Start Date	End Date
MMM-09-1S	SWL-7	June 19, 2009	July 27, 2011
MMM09-1D	SWL-7	December 12, 2015	April 4, 2016
MMM-09-2	SWL-16	February 18, 2011	still installed
MMM-09-4	SWL-8	June 19, 2009 December 12, 2015	July 27, 2011 April 4, 2016
MMM-09-6S/D	SWL-15	February 18, 2011	still installed
MMM-09-9	SWL-9	June 19, 2009	July 27, 2011
MMM-09-10S/D	SWL-10	June 19, 2009	still installed
MMM-09-15S	SWL-11	November 11, 2009	February 17, 2011
MMM-09-17	SWL-12	November 18, 2009	February 17, 2011
MMM-09-19S/D	SWL-13	November 17, 2009	February 17, 2011
MMM-09-20	SWL-14	November 18, 2009	February 17, 2011
MMM-11-21	SWL-17	July 27, 2011	still installed
MMM11-22S/D	SWL-18	July 27, 2011	still installed
Farm Pond	SWL-19	July 5, 2011	November 28, 2012
		July 7, 2013	still installed
MP-24S/D	SWL-20-1, SWL-20-2	October 29, 2013	still installed

Notes:
The data loggers at MP-24D and MP-24S were intended to be removed from the mini-piezometers during the 2013-14 winter season to prevent damage to the units from freezing. In 2013, the logger at MP-24D could not be retrieved as it was already frozen in place but the logger at MP-24S was successfully removed for the winter season. Both of these loggers were removed over the winters of 2014-15 and 2015-16 but left in place over the winter of 2016-17. During the winter of 2014-15 both loggers were installed at MMM-09-10 to check their operation against the logger already installed at MMM-09-10 (both were fine). During the winter season, these two loggers were temporarily installed at MMM-09-1D and MMM-09-4.

Groundwater levels exhibit a seasonal pattern from the spring time highs of late March/early April to late season lows at the end of the growing season (late September/early October). On the basis of the quarterly spot measurements at all on-site monitors, the maximum recorded fluctuations in static water levels at the monitors varied from 0.4 to 2.6 m (average of 1.6 m) at monitors located some distance from the watercourses. This range was smaller at the monitors located in the low lying lands next to the watercourses, from about 0.3 to 1.7 m declines observed over the study period (average of about 1.0 m)[13]. The lower magnitude in seasonal fluctuations observed at monitors located next to the watercourses is expected as watercourse valleys act as boundaries to the shallow groundwater system. Figure 4.5 and Figure 4.6 present interpreted groundwater levels at the Subject Property for spring and summer conditions.

The range in seasonal groundwater fluctuations was also examined at most of the data-logger equipped wells[14]. The seasonal range at these wells, with their continuous data sets, when compared to the corresponding ranges obtained from spot measurements at these same wells, was found to be about 0.1 to 0.7 m higher at monitors close to the watercourse (average 0.4 m), and from 0.2 to 0.7 m at monitors located away from the creeks (average 0.5 m). It is therefore not considered unreasonable based on these

[13] On-site monitoring wells MMM-09-04, MMM-09-06S/D, MMM-09-07, MMM-09-09, MMM-09-10S/D, MMM-09-14, MMM-09-17, and EXP-1 to EXP-4 are located nearby to the watercourses. The remaining on-site wells were considered to be included in the other category described above.

[14] MMM-09-19D that experienced very slow recovery of water levels is excluded from this discussion.

observations to conclude that the seasonal groundwater level fluctuations observed from 2009 to 2017 can range in average from between approximately 1.4 and 2.1 m (low ground and higher ground).

Vertical gradients are available from the eight monitoring well nests. At six of the nests, all located some distance from the watercourses; consistent downward hydraulic gradients were recorded[15]. At monitoring well nest MMM-09-01 and MMM-11-22 downward gradients ranged respectively between 0.00 to 0.24 and 0.04 to 0.18 respectively. At MMM-09-01 the downward gradients were observed to increase above 0.10 when the shallow water levels at this location rose in response to rain or snow melt events. At the other five monitors, the measured downward gradients were more pronounced and ranged from 0.34 to 0.81 (MMM-09-18), up to 1.07 to 2.02 (MMM-09-05)[16].

Upward vertical gradients have been generally recorded at the well nest at MMM-09-10, ranging from 0.001 to 0.09[17] (refer Figure SWL-10 in Appendix 4-5). The vertical gradient at the well nest constructed at MMM-09-6 varies depending on the season. Downward gradients are generally observed during the spring season, and reverses to an upward gradient during the summer and fall (July to December typically) as the shallow groundwater levels in the till drain and decline below the groundwater level of the bedrock (refer to Figure SWL-15 in Appendix 4-5). These two nests are located on the Subject Property next to the central watercourse (Reach 14W-14) and the deeper monitors are screened in the shale bedrock. In addition, at monitoring well MMM-09-09 (also screened in the upper shale) which is located close to the main branch of the FM1009 watercourse, the groundwater levels are often recorded above the stream channel bed elevation at mini-piezometer MP-07 (located about 40 m away). The data logger plots for MMM-09-09 and the MMM-09-10 nest indicate the groundwater levels at these locations are above the stream bed elevation over much of the year, declining at or below the channel during the summer season in particular (refer to Figures SWL-9 and SWL-10 in Appendix 4-5).

These findings imply that minor groundwater discharge from the bedrock aquifer is occurring at the Subject Property across both the main channel (Reaches 14W-12, 14W-16) and the central watercourse channel (Reach 14W-14) over much of the year. The volume of bedrock groundwater discharge over Reach 14W-14 (central Reach to FM1001) is insufficient to maintain base flow during the summer months as witnessed by the dry channel conditions during the summer season. Similarly, bedrock discharge into the main channel system is also insufficient to maintain baseflows based on on-site observations of isolated pools of water in the lower reaches and no flows observed at the mid to upper reaches during summer seasons.

Data collected from groundwater monitors and mini-piezometers alongside the easternmost channel of FM1009 (Reach 14W-13) and the Reach to FM1109 at the eastern part of the Subject Property (Reach 14W-11 and Reach 14W-11A) do not indicate bedrock groundwater contributions into these channels, and the interpreted bedrock groundwater contours (see Figure 4.5 or Figure 4.6) are below the channel bed elevations (Reach 14W-13's channel bed declines from 153.9 to 149.0 masl, and Reach 14W-11A declines from 154.9 to 151.3 masl on the Subject Property). Reach 14W-11A is considered to be losing water into the ground over most of the year (refer to Figure SWL-8 in Appendix 4-5).

[15] Monitoring Well Nests MMM-09-01, MMM-09-05, MMM-09-15, MMM-09-18, MMM-09-19, and MMM-11-22.

[16] Early data at some of these monitors is not included in these summaries because the calculated vertical gradients were not accurate (as one or both of the nested wells were still recovering).

[17] A downward gradient of 0.05 was manually recorded at this location on one occasion, July 5, 2011.

The data logger plots also illustrate rapid rises in the shallow groundwater following notable precipitation events and snow-melts, followed by a decline towards pre-event water levels over a two to three week length of time. These observations are consistent with an environment comprised of generally low hydraulic conductivity materials (till and/or clayey silt soils in the overburden and shale in the bedrock). Weathering of the surficial zone (approximately the upper 3-5 m) results in an enhanced bulk permeability of these soils due to the presence of fractures and other openings. This allows the upper zone to more readily receive, and transmit water, with rapid increases in water level due to events such as snow melts (clearly visible in the data logger equipped wells (Figures SWL-7 to SWL-18 in Appendix 4-5), which is then followed by a lowering of the water table as the upper zone drains. With depth, the effects of weathering and the frequency of fractures decreases and the permeability of these till and clayey silt soils becomes lower.

4.3.2.4 Findings of the Supplemental Farm Pond Investigation

An investigation was carried out at the Farm Pond (Reach 14W-14A) to characterize groundwater interactions at the large human-made Farm Pond at the centre of the Subject Property. Aerial photography from 1935 shows no evidence of a Farm Pond at this location but rather the continuation of Reach 14W-14 passing through the present day Farm Pond location before joining with the main channel to the south. According to the farmer living on the property, the Farm Pond was constructed shortly before the Hurricane Hazel storm event in October 1954.

The supplemental Farm Pond investigation study commenced in February 2011 when the surface water elevation of the large Farm Pond at the centre of the Subject Property was surveyed by WSP surveyors (February 10, 2011) and with the installation of a data logger at monitoring well MMM-09-02 (February 18, 2011). As noted earlier, three monitoring wells were constructed at two locations to the southwest of the Farm Pond in mid-July 2011, and a staff gauge was installed in the existing Farm Pond along with three mini-piezometers that were installed along the periphery of the Farm Pond in early July 2011.

Data loggers were installed at the staff gauge in early July 2011 and at the three monitoring wells in late July 2011 (MMM-11-21 and MMM-11-22S/D). WSP hydrogeological staff carried out water level monitoring visits and data logger uploads at these monitors between July 2011 and mid-April 2017[18].

Plots of the water level fluctuations at each of the above monitors (and MP-24, see below) are provided in Appendix 4-5 on Figures SWL-16 to SWL-20-2[19] as are hydrogeological cross-sections plotted through the centre of the Farm Pond (see Figure 4.4, and Figures HG1 through HG3 which are provided in Appendix 4-

[18] WSP staff discovered that the Farm Pond staff gauge was missing in January 2012 (top of T-bar visible at ice surface) and that the data logger (direct read cable with interface at the shore) could not be uploaded (no connection/signal). It is suspected that the staff gauge was sheared off the T-Bar by ice-heave, and at time of a subsequent thaw event sank into the Farm Pond. An estimate of the ice level was made based on the height of the visible T-Bar above the ice. The data logger was recovered, the staff gauge was repaired, and the logger was reinstalled at this location on July 18, 2012. The data logger was found again to be at the bottom of the staff gauge in October 2012 (direct read cable was sheared) and recovered on November 28, 2012. A new Farm Pond gauge installation was set up nearby to MMM-11-21 in July 2013 and Farm Pond level monitoring reinitiated. This location was again found to have been damaged by ice action in the winter of 2013-14 and a fourth installation was made nearby to MMM-11-21 in April 2014.

[19] Data logger plots with 5 m vertical intervals are also provided in Appendix 4-5.

5). Farm Pond levels range between 1 to 2 m higher than the groundwater at the nearby wells during the summer and fall seasons, and from about 0.5 to 1.2 m higher during the winter and spring seasons[20].

The data collected up to the end of 2012 indicated the Farm Pond was losing water into the ground but there remained questions from CH about the potential for groundwater discharge into the Farm Pond at its upstream end where no monitors were immediately located. WSP staff met on-site with CH's Hydrogeologist in early October 2013 and it was agreed to construct a shallow drive-point mini-piezometer nest at the upper (west) end of the Farm Pond and install data loggers at these stations. The purpose for this new nest was to provide a data point location at the upstream end of the Farm Pond to monitor and confirm the previously reported conclusions about the groundwater input into the Farm Pond.

The two drive-point piezometers were installed towards the upstream (west) end of the Farm Pond on October 22, 2013 and the mini-piezometers were screened at depths of 1.19 and 1.28 m below grade (MP24-D), and 0.31 and 0.44 m below grade (MP-24S)[21]. Following the installations, WSP staff manually surveyed the elevations of the new piezometers and also re-surveyed the elevations of the pre-existing wells and mini-piezometers in the immediate vicinity of the Farm Pond[22] to ensure all elevations at these monitors were using a consistent datum.

Figures SWL-20-1 and SWL-20-2 (Appendix 4.5) graphically present the data logger plots of water level fluctuations at the two mini-piezometers with pond levels also shown for comparison. Table 4.6 below provides a summary of the observations seen in the data over the past 3.5 years broken out by dates.

Table 4.6 – Mini-Piezometer MP-24 Observations

Date Range	MP-24S	MP-24D
Oct. 22 - Nov. 24, 2013	Water level fluctuations similar to Farm Pond, but slightly lower.	Water level fluctuations do not behave similar to Farm Pond, remain slightly above grade, and above Farm Pond level.
Nov. 24 - Dec. 13, 2013		Recorded water levels behave oddly with some random spikes not seen at the pond. Data during the winter then generally mimicked what was observed at the Farm Pond, until March 18, 2014. Believed to be due to freezing of mini piezometer (see main discussion).
Dec, 13, 2013 - Mar. 18, 2014	Logger removed for winter.	
Mar. 18 - Apr. 30, 2014		Sudden change in response at the logger (believed to be from ice melting in the mini-piezometer), but response at the logger for the

[20] The narrowing of the difference between the Farm Pond and groundwater elevations during the winter and spring seasons is due to recharge of the shallow groundwater system. On average, the groundwater levels recorded at the Farm Pond monitors are between 1.1 and 1.6 m higher than the Farm Pond.

[21] As explained in Section 4.3.1.1, this mini-piezometer nest was installed just beyond the upper limit of the Farm Pond (as defined by its average water level) and to the northwest of a topographic high point in Reach 14W-12A.

[22] The top of pipe elevation of MMM-09-2 was used as a benchmark for this survey and elevations were then re-surveyed at MMM-11-21, MMM-11-22S/D, MMM-09-10S/D, the Farm Pond logger station and MP-21, MP-22, MP-23, and MP-24S/D. The elevations presented in Tables SWL-1 and SWL-2 reflects these resurveyed top of pipe elevations.

Date Range	MP-24S	MP-24D
Apr. 30 - Nov. 26, 2014	Water level fluctuations similar to Farm Pond but lower. Responses to rain events match those at the Farm Pond and declines afterward are similar to a point, and then decline at a faster rate.	remainder of the year was very abnormal, exhibiting delayed responses (see Figure SWL-20-1 in the appendices). Logger was thought to have been damaged.
Nov. 26, 2014 - Apr. 27, 2015	Logger removed and installed at MMM-09-10 for winter to confirm its operation against the logger installed at that well. Logger is operating normally.	Logger removed and installed at MMM-09-10 for winter to confirm its operation against the logger installed at that well. Logger is operating normally. Logger is not damaged as originally surmised.
Apr. 27 - Jul. 20, 2015	Water levels at both mini-piezometers nearly identical, and nearly identical to Farm Pond, at or slightly below Farm Pond levels.	
July 20 - Oct. 25, 2015	Water levels at the mini-piezometers decline below Farm Pond levels and then dry out.	
Oct. 25 - Dec. 23, 2015	Water levels at the mini-piezometers and the Farm Pond rise rapidly in response to a rainfall event and water levels at the mini-piezometers then are nearly identical and closely mimic those at the pond, generally at or slightly below the pond levels, although they show greater immediate responses to rainfall events than recorded at the Farm Pond.	
Dec. 23, 2015 - Apr. 4, 2016	Logger removed for winter and temporarily installed at MMM-09-1D.	Logger removed for winter and temporarily installed at MMM-09-4.
Apr. 4 - Apr. 14, 2016	Water levels at both mini-piezometers nearly identical and at or slightly below the Farm Pond levels, with similar responses to precipitation events.	
Apr. 14 - Jun. 8, 2016	Water levels at both mini-piezometers are near identical and their responses are similar to those observed at the Farm Pond, but are lower, on the order of 0.1 to 0.2 m lower.	
Jun. 8 - Nov. 4, 2016	Water levels at both mini-piezometers are near identical and they decline and then become dry over the summer. Two short term responses to rainfall events were seen between Sep. 27 - Oct. 9 and Oct. 27-28 that were not seen at the Farm Pond location (likely because Farm Pond location was dry during the same period).	Water levels at both mini-piezometers are near identical and they decline and then become dry over the summer. Logger stopped recording on Aug. 26, 2016 and was returned to the office on Oct.14 in order to upload its data.
Nov. 4 - Nov. 24, 2016	Water levels at the mini-piezometers are near identical, exhibiting a peak response to a rainfall event followed by a decline (MP-24S becomes dry). There is no response observed at the Farm Pond, likely as the Farm Pond station is dry (above the Farm Pond water level) and thus changes in water level at the Farm Pond are not recorded.	Logger reinstalled on Nov. 4. Water levels at the mini-piezometers are near identical, exhibiting a peak response to a rainfall event followed by a decline (MP-24S becomes dry). There is no response observed at the Farm Pond, likely as the Farm Pond station is dry (above the Farm Pond water level) and thus changes in water level at the Farm Pond are not recorded.
Nov. 24 - Dec. 26, 2016	Water levels at the mini-piezometers are nearly identical, and recorded well above the Farm Pond level, which begins to show response (gradual increase) beginning Dec. 2, until a precipitation event on about Dec. 26 where both Farm Pond levels and mini-piezometer levels show a marked increase.	
Dec. 26, 2016 - Apr. 18, 2017	Water levels at the mini-piezometers are nearly identical, and nearly identical to Farm Pond, at or slightly above Farm Pond levels.	

4.3.2.4.1 Atypical Responses of Data Logger at MP-24D (November 18, 2014 to November 26, 2014)

The readings collected from the logger at MP24-D over the first year of monitoring exhibited odd behaviour as can be seen on Figure SWL-20-1. The upper part of the mini-piezometer was found to be solidly frozen on December 16, 2013 and the logger could not be removed for uploading data, and the unit was left in place through the winter[23]. The data recorded by this unit between roughly November 23, 2013 and March 18, 2014 exhibited a number of large and sudden spikes in recorded water levels that do not correlate with changes in water levels at the Farm Pond (see Figure SWL-20-1), although for much of the winter season the water levels recorded at MP-24D mimicked the Farm Pond levels[24]. The data during this 4 month period also shows significantly more variability (i.e., noise) than the data before or after this time frame. A sudden 61 cm decline in water pressure was recorded over a 1-hour period on March 18, 2014 after which the data displayed a more stable looking trend, which matched up with the manual measurement taken on April 30, 2014. We therefore do not consider the data collected at MP-24D during this 4 month winter period to be reliable given the strange behaviour observed. The sudden spikes in pressure readings at the MP-24D data logger appear to correlate to air temperature changes that fall below freezing, particularly in the earlier part of the winter season, and we are of the opinion that the behaviour is related to pressure build-up within the mini-piezometer due to surface freezing and expansion of ice within the pipe.

For the remainder of 2014, the data provided by the data logger installed at MP24-D continued to show odd behaviour in the water level fluctuations at the mini-piezometer. The recorded water level fluctuations at the mini-piezometer did not follow the pattern observed at MP24-S, where water level fluctuations were seen to quickly respond to rainfall events in a like manner to the responses at the Farm pond. Instead, the water level responses recorded by the MP24-D data logger appeared to be delayed and highly averaged.

The data logger was thought to have been possibly damaged from having been left installed over the winter of 2013-2014 and it was removed on November 26, 2016 and installed for the winter season at MMM-09-10 so that a comparison in its response could be made against that well's data logger. A review of the winter data collected at MMM-09-10 indicated that the MP24-D logger was operating correctly and it was re-installed at the mini-piezometer on April 27, 2015. All subsequent data collected at MP-24D by this data logger indicates near identical water level fluctuations to MP24-S in a pattern that resembles those seen at other monitoring wells across the property.

4.3.2.4.2 Discussion of MP-24 Results

Over the roughly 3.5 year period of study at location MP-24 (MP-24D discussions exclude data from the 1 year period discussed in the preceding section), the groundwater levels at the 2 mini-piezometers have generally been closely matched to the water level fluctuations observed at the Farm Pond and are therefore considered to be controlled by precipitation and the water level fluctuations at the Farm Pond and adjacent channel. The average difference between the water level at MP-24S has it at 1 mm (-0.001 m) below the

[23] It had also been intended to remove this unit from the mini-piezometer over the winter months but this could not be done because of the frozen condition.

[24] The Farm Pond levels were frequently higher than the ground elevation at the mini-piezometer suggesting the area was also inundated with surface water following precipitation events.

Farm Pond level (range of -0.32 to +0.71 m[25]) and at MP24-D, water levels at the mini-piezometer were on average 4mm below Farm Pond level (-0.004 m) with a range of -0.84 to +0.69 m. Water levels at the mini-piezometers have been recorded above grade only at times when the Fram Pond level has also been recorded above the grade at the MP-24 monitoring station (grade is approx. 148.8 masl).

We also wish to note that, as the Farm Pond levels decline during the summer season, the Farm Pond edge also recedes to the southeast, moving further away from the mini-piezometer station and therefore; comparisons between water elevations at the mini-piezometer and the Farm Pond as an indicator of groundwater seepage potential relative to the Farm Pond levels become less significant.

The data collected to date at MP-24D indicates that the gradients at this location vary between upward (towards the Farm Pond/channel) and downward (from the Farm Pond/channel into the ground) with an average gradient calculated at +0.001 (downward). This is not unexpected as this monitor is sited in the area where groundwater gradients by the water course system were predicted to change from upward (i.e., to the northwest such as observed at MMM-09-10) to downward (as seen at all the monitors around the Farm Pond to the southeast).

Figure HG-4 (Appendix 4.5) shows the interpreted limits of the potential for seepage towards the upstream (west) end of the Farm Pond. The seepage limits are based on where the interpreted groundwater contours (from April 30, 2014 data) intercept the topographic contours and extends approximately 35 m further east of Station MP-24. This potential seepage area is generally located beyond the proposed limits of Farm Pond construction highlighted by the yellow line shown on the figure, and based on topographic contours, is also located below the topographic rise between the channel and the Farm Pond (see Figure HG-4) that indicates seepage is directed into the channel and will not reach the Farm Pond except under short-term conditions when there is flow from the channel into the Farm Pond (e.g., after rain events).

The data collected since 2011 at the data loggers at the monitoring wells have shown the Farm Pond levels are always higher than the static water levels at the groundwater monitors surrounding the Farm Pond itself, and downward gradients were generally recorded at the mini-piezometers[26] along the edges of the Farm Pond. The monitoring data from MP-24 indicates there is potential for a very small amount groundwater input beyond the upstream end of the Farm Pond entering Reach 14W-12A. Between October 22 and November 22, 2013 the groundwater elevations recorded at MP24-D (see Figures SWL-20-1 and SWL-20-2) ranged from 17 cm below the Farm Pond level (following a surface runoff event into the pond) to 12 cm higher than the Farm Pond water elevation (October 29), and from April 27, 2015 to April 17, 2017 have ranged from between 82 cm below Farm Pond levels to 69 cm above the Farm Pond levels[27]. To date the maximum upward gradient at this location relative to the Farm Pond (excluding data between November 23, 2013 and November 26, 2014) has been measured at about -0.215[28], with an overall average of +0.001, a very slight

[25] The peak high difference at both mini-piezometers occurred on October 25, 2015 over a 2 hour period when water levels at the mini-piezometers and the Farm Pond rose dramatically over a short period of time in response to a rain event. This large difference quickly declined as Farm Pond levels recorded at the Farm Pond logger station continued to rise.

[26] At site visits when the mini-piezometer and/or Farm Pond were not dry or frozen. Mini-piezometers MP-22 and MP-23 were identified as plugged by accumulated silt and cleaned out in early September 2013.

[27] As identified earlier, the data collected after November 23, 2013 through the winter of 2013-2014 and up to November 26, 2014 at the mini-piezometer exhibited strange behaviour and was not considered reliable.

[28] Upward gradients are expressed as negative values, downward gradients as positive values.

downward gradient[29]. In contrast, downward gradients are present at the monitoring wells located around the perimeter of the main area of the Farm Pond where groundwater has always been measured at lower elevation than the water in the Farm Pond (on average at the monitors, between 1.1 and 1.7 m below the water level in the Farm Pond, or downward gradients from the Farm Pond towards the monitors on the order of +0.042 to +0.118).

Given the larger surface area of the eastern part of the Farm Pond, and the larger outward gradients identified in that area, losses of water from the Farm Pond back into the ground will be significantly greater than any potential groundwater inflows originating near the upstream end of the Farm Pond, which as noted earlier, are to the northwest of the Farm Pond alongside Reach 14W-12A, and would discharge into this reach and not into the Farm Pond itself. As the hydraulic conductivity of the clay/silt soils found across the site and at the Farm Pond is on the order of 10^{-7} to 10^{-8} m/sec (very low), the quantity of groundwater entering into Reach 14W-12A and/or the Farm Pond will be low. The new monitoring station data therefore refines but does not change the understanding of the function of the Farm Pond, which is that it is <u>maintained</u> by surface water inflows and not by groundwater contributions.

In conclusion, surface water level data from the Farm Pond as well as groundwater data from surrounding monitors indicate that the Farm Pond does not receive groundwater inputs in sufficient quantities to affect the water level of the Farm Pond, nor to lead to appreciable discharges into the adjacent channel at the top end of the Farm Pond. Flows from the Farm Pond is associated with surface water inputs that fill the Farm Pond following rain events, and then drains back out to the watercourse network afterward. Groundwater elevations at the surrounding monitoring wells showed the water level at the Farm Pond is consistently on the order of 1 to 2 m higher elevation than the groundwater, and therefore; the Farm Pond loses water into the ground rather than receiving groundwater inputs[30]. The very minor groundwater discharge potential that is present near the upstream end of the Farm Pond (calculated at 110 m^3/year, see Section 4.4.4.7) and that enters Reach 14W-12A is far outweighed by the losses back into the ground over the much larger area of the Farm Pond to the east, where the greater downward head differences are recorded.

4.3.2.5 Stream Base Flow Measurements

Estimates of the flows within the watercourses traversing the Subject Property were carried out by WSP staff during site visits between May 2009 and February 2011. Measurements were taken at consistent locations at each Reach, generally at the mini-piezometers and flow monitoring points (MP-1 to MP-7 and FMP-1 to FMP-4, refer to Figure 4.4 for these locations[31]). The flow estimates were generally carried out, if possible,

[29] The gradients presented above have been calculated using the lateral and vertical distances from the edge of the Farm Pond (average Farm Pond water elevation 148.7 masl) or edge of watercourse (e.g., MMM-09-10) to the centroid of the well screen.

[30] Groundwater elevations at a monitoring well nest located approximately 100 m upstream of the Farm Pond inlet (MMM-09-10 alongside Reach 14W-14) indicate groundwater elevations at that location to range between about 0.5 and 1.0 m higher than the surface water levels in the Farm pond located downstream of this station (further note that during the summer season, groundwater elevations at these monitors would typically decline the base of the channel, so inputs to the channel are not year-round). The data from this monitoring well nest and the wells around the Farm Pond indicated that the area where the potential for groundwater inputs changed to surface water losses would be located near the upstream end of the Farm Pond. The data collected at MP-24D supports this as the groundwater levels have been recorded close to ground surface at this location.

[31] FMP-3 is located at the central Reach of the FM1001 watercourse at the southeast corner of Tremaine Road and Number 1 Sideroad.

following 5 days of dry weather, with some exceptions when precipitation events conflicted with staff scheduling.

The measurements were carried out by visually identifying a consistent length of channel and measuring the time for a small floating object to travel from the upstream end to downstream end of the measured length of this reach. A minimum of five to six timed runs were obtained (using the stop-watch function on a GPS) and an average flow velocity was calculated. Runs where the floating object were caught on an obstruction or otherwise prevented from travelling down channel unhindered were ignored and the run was repeated. Saturated channel cross-sectional areas were obtained at the upstream and downstream ends of the length under consideration and an average area was calculated. This allowed for an estimate of total flow at the watercourse. Frictional losses along the channel sidewalls and along the substrate were ignored and thus the calculated flow volumes are recognized to be potentially over-estimated.

Stream flow measurements pertinent to each watercourse are summarized in Table 4.7 below. Flow estimate calculations are also provided in Appendix 4-5. Table 4.7 also presents estimated base flow contributions from groundwater based upon the monthly water balances carried out for this study[32].

The watercourses within the Subject Property and EIR Sub-catchment Study Area were generally observed in flowing conditions during the late fall through to the late spring, although wintertime observations often found the watercourses as completely frozen, or frozen with some flow observed below the ice. In the summer months, the watercourses, particularly the central and eastern watercourse to FM1001 (Reach 14W-13 and Reach 14W-14) and the watercourse for FM1109 (Reach 14W-11 and Reach 14W-11A) are observed to be non-flowing. The main channel for FM1001 (Reach 14W-12 and Reach 14W-16) was observed on the Subject Property during the summer and late summer months with little to no flow, and pooled or standing water. These summertime pockets of water along the lower stretches of the watercourse are likely from a combination of minor groundwater discharge from the bedrock system, and remnants of storm flows collected in depressions along the stream channel.

It is also noted that, based on interpretation of aerial photography, that ditching along both sides of Highway 407 appears to be conveyed directly into the watercourses passing through the Subject Property, without benefit of SWM facilities. One other source of water within Reach 14W-12 and Reach 14W-16 (FM1001) is from quarry discharge at the Hanson Brick operation to the north of Highway 407.

Groundwater and precipitation entering the quarry is reported to be intermittently pumped into a settling pond and discharged into this watercourse. In 2008, a total volume of approximately 44,500,000 litres was pumped from the quarry into this watercourse, at an average rate of 1,078 litres/minute. This is equivalent to an average of about 13 hours discharge per week into this watercourse, which would not be noticeable during fall to spring conditions, but which would lead to additional water to this stream during the summer period when the watercourses are intermittent.

[32] The monthly water balance methodology and pre-development infiltration estimates are presented beginning in Section 4.4.2 of this report.

Table 4.7: Summary of Stream Flow Observations

Monitoring Location	Easting	Northing	5-May-09	29-May-09	19-Jun-09	24-Sep-09	9-Nov-09	18-Nov-09 and 20-Nov-09
5-Day Preceding Weather Description			20 to 25 mm rainfall recorded at Pearson and Oakville Weather Stations on April 30, and additional 1 mm combined over May 1 and 2. May 2 to 5 no precipitation.	Wet weather. May 27-28, 30 mm combined recorded at Pearson, 15 mm combined recorded at Oakville. An additional 3 - 4 mm of rain recoded at both stations on May 29	Rain Event June 16, 12 to 15 mm recorded at Pearson and Oakville over June 16 to 17, bulk falling on the 16th.	3 to 4 mm rain recorded at Pearson and Oakville combined on September 21 and 23 (Pearson only). Previous to these minor events, there was no precipitation recorded after August 28-29 at either station.	3 to 4 mm precipitation recorded at each weather station over November 4 and 5.	Zero precipitation recorded at Pearson or Oakville from November 4-5. Significant Precipitation Event beginning approx. 0500 hours at Oakville/Pearson on the morning of November 19, precipitation ending at 0300 hours on the 20th - 14 mm at Pearson
Subwatershed FM1001	**Est'd Base Flow Rates from Water Balance -->**		**1,127 to 457 LPM (April and May)**	**457 to 27 LPM (May and June)**	**27 LPM (June)**	**0 to 52 LPM (Sept and Oct)**	**52 to 184 LPM (Oct and Nov)**	**184 LPM (Nov)**
Easternmost Tributary (14W-13)								
FMP-4	597523	4809561				Downstream of FMP-4 standing water in pockets - no flow	Standing water in channel, no flow	
Central Tributary (14W-14)								
FMP-3 (Corner of Burnhamthorpe and Tremaine)								No defined channel - water observed flowing in rivulets from concrete bridge/culvert. Water was bright green with algae Some flow from west through culvert that crosses Tremaine Road
MP-06	597348	4809417.944	Mini-piezometer is situated in water but area is spread out with Reed Canary Grass, flow is present but spread out over wide area - no flow estimate possible. Temperature = 14.8C (Air Temp = 22.5C @ 2:00 PM) Conductivity = 873 uS, pH = 7.81					
MP-03/FMP-5	597808	4809266.198	Watercourse flowing. Flow estimated at approx. **365 LPM**	Flow estimated at **43 LPM**		Channel dry		
Main (Westernmost) Tributary (14W-16/14W-12)								
MP-07	597541	4809149.703	Watercourse flowing but no suitable location for flow estimate found during first visit. Temperature = 16.9C (Air Temp = 16.0C @ 2:20 PM) Conductivity = 1,050 uS, pH = 7.95	Watercourse flowing. Flow estimated at **445 LPM**.				
FMP-1 (upstream of SG-1)	597618	4809131						
Staff Gauge #1 (Upstream of small (West) Pond)	597677	4809113.09	Flow estimate downstream of MP-07 immediately upstream of small pond outlet (flowing) into main channel (roughly where SG-1 was later installed). Flow estimated at approx **450 LPM.** Temperature = 20.1C (@ 2:40 PM) Conductivity = 404 uS, pH = 8.55			No flow, standing water observed. Temperature = 20.0C (Air Temp = 26.2C) Conductivity = 862 uS, pH = 7.05	Flow estimated at **106 LPM**	
MP-04/FMP-06	597972	4809088.192	Watercourse flowing. No suitable reach for flow estimate Temperature = 14.3C (Air Temp = 16.0C @ 10:55 AM) Conductivity = 710 uS, pH = 8.78	Water flowing, flow estimated at **268 LPM**.	Water flowing, flow estimated at **645 LPM** - precipitation event recorded 2-3 days prior	Channel dry at MP-04. At farm bridge downstream of MP-04, no flow also observed in channel, standing water only in pools.		
Staff Gauge #2 (by Dundas Street)	598345	4809063.452	Flow in Main Channel by Dundas Street - channel is in bedrock so no opportunity to install mini-piezometer. Flow estimated at approx. **1,020 LPM** - same order of magnitude as water balance estimate. Temperature = 18.9C (time approx. 3:00 PM) Conductivity = 853 uS, pH = 8.45			Standing water - no discernible flow		Nov. 18 - Ponded water observed in main channel with no discernible flow. Nov. 20 - Flow measured in channel, estimated at approximately **1,635 LPM** (after rainfall)
Subwatershed FM1109 (14W-11A/14W-11)	**Est'd Base Flow Rates from Water Balance -->**		**107 to 44 LPM (April and May)**	**44 to 3 LPM (May and June)**	**3 LPM (June)**	**0 to 5 LPM (Sept and Oct)**	**5 to 18 LPM (Oct and Nov)**	**18 LPM (Nov)**
MP-01	597409	4809839.704	Watercourse flowing. Not an ideal location for an estimate but estimated flow rate was approx. **220 LPM** - same order of magnitude as water balance estimate Temperature = 15.8C (@ 1:05 PM) Conductivity = 700 uS, pH = 8.16	Flow estimated at **128 LPM**.		Channel dry at mini-piezometer - standing water observed in low spots - no flow. Temperature = 20.1C (Air Temp = 26.1C) Conductivity = 2987 uS, pH = 6.07	No flow, pooled water in places	
FMP-2 (located between MP-01 and MP-02)	597608	4809788					Channel approximately 1.0m wide intermittent damp to wet areas approx. 0.02m depth. No measureable flow.	
MP-02	597769	4809665.798	Minor/slow/diffuse flow observed - could not be estimated. Temperature = 19.2C (Air Temp = 18.2C @ 12:30 PM) Conductivity = 745 uS, pH = 8.04	Watercourse flowing. Flow estimated at **247 LPM**.		Channel dry	No flow, pooled water in places	
Subwatershed FM1102								
Tributary FM1102 (Tributary passing through SW part of Site)	597989	4808801	No defined channel (ploughed field) and no culvert passing under farm lane to direct flows. Stagnant/ponded water in furrows. Temperature = 21.4C Conductivity = 460 uS, pH = 7.97					
Other Water Features								
Large Pond (21 m to the west of MMM-09-2)			Temperature = 18.9C Conductivity = 630 uS, pH = 8.11					
MP-05 (Small ponded area on hill-top)	597514	4809671.167	Ponded area on crest of hill. Temperature = 21.4C (@ 1:30 PM) Conductivity = 185 uS, pH = 7.98			Dry	Channel dry at mini-piezometer - standing water observed in low spots - no flow. Pooled water 2.5 m west of MP location	
Comments regarding FM1001/FM1109			Flow estimates at the downstream end of FM1001 (14W-12) by SG-2 (1,020 LPM) is of the same order of magnitude order of magnitude estimated by water balance (between 430 to 1,060 LPM). Flow estimates at MP-01 (FM1109/14W-11A) are also the same order of magnitude (though a bit higher) as estimated by the water balance	Measurements obtained at the end of the month, so flow as would be predicted by the water balance is anticipated somewhere between th average rate for May and June. Estimated flows within FM1001 are of the same order of magnitude but higher than the average for May and June. At FM1109, at least an order of magnitude higher than predicted. Weather was wet however so measured flows should be higher than predicted by water balance.	Flows measured at FM1001 an order of magnitude higher than would be predicted by water balance, but measurement was obtained about three days after rain event. These higher flows may also coincide wit a discharge event at the Hanson Brick Quarry located upstream of th site.	Both FM1001 and FM1109 were dry or pooled with no flow which is i line with September estimates of the water balance which predicts no flow.	FM1001 (14W-16) entering site flow estimated at 106 LPM, on the same order of magnitude as predicted by the water balance. FM1109 - no discernible flows, pooled water, but water balance estimates low flows of 5 to 17 LPM	At downstream end of FM1001 (by Dundas Street), no discernible flow was observed on Nov. 18, but two days later after approximately 1-day rainfall event, flow at the same station was estimated at 1,635 LPM.

Notes:
5-day Preceding Weather observations, focussed on precipitation are presented at the top of the table for Oakville and Pearson Airport weather stations. The Pearson data is complete, the Oakville data, while closer to the site does have missing data.
The 5-day weather observations are also colour coded (shaded) per the following:

Stream flow estimates were made by measuring the time for a floating object to traverse a measured length of watercourse, of generally consistent cross-sectional profile and straight alignment. An average time was calculated using between 3 to 6 measurements. As flow velocity was thus obtained.
The area of this typical cross-sectional saturated profile (or a weighted average of multiple profiles along the length of run) was calculated and this, combined with the flow velocity were used to arrive at an estimated flow rate in the channel.
The calculated flow is considered an overestimation as it does not account for lower flows due to friction along the water/channel bed interfaces.

For the purposes of checking the water balance model against estimated stream flows (described above), the monthly water balance volumes of groundwater infiltration was assumed to be converted fully stream base flow.
Estimates (presented in LPM) for the entire subwatershed FM1001, and a portion of the tributary to FM1109 that passes through the northeast corner of the site area from the water balance calculations are identifie **bold blue** text.
Where estimates were obtained towards the beginning or end of a month, a range of the calculated average monthly base flows is presented. Measurements made towards the middle of the month are correlated against the estimated base flow calculated for the month.
The water balance calculations are based on long-term averages and variations in actual precipitation from these averages will affect results. Furthermore a portion of infiltrating water will be directed to the deeper system, though this is estimated at less than 10%.
Most of the infiltrating groundwater is anticipated to flow horizontally through the upper weathered/fractured zone, discharging as this layer drains into watercourses within a 1 to 2 month timeframe.

Considered dry preceding 5-days and suitable for base flow estimates	Precipitation recorded within 5 days	Significant precipitation on the day of or within 1 to 2 days before visit

Table 4.7: Summary of Stream Flow Observations

Monitoring Location	Easting	Northing	18-Dec-09	21-Jan-10	13-Apr-10	5-Aug-10	18-Oct-10 and 19-Oct-10	17-Feb-11 and 18-Feb-11
5-Day Preceding Weather Description			4.5 mm of precipitation recorded at Pearson over December 13 to 16 2.5 mm of this on December 14. Incomplete data at Oakville.	0.2 mm precipitation at Pearson on January 19, zero at Oakville over preceding 5-days.	32 mm precipitation at Pearson Over April 6 to 8 (5-7 days prior), and at Oakville, 12 mm between the 4th to the 6th, 25 mm on the 7th, and 5 mm on the 8th. No precipitation at either station April 9 to 13.	0.2 mm recorded at Pearson (July 31) and 1 mm recorded at Oakville (July 31) otherwise no precipitation at either station in the previous 5 days.	Oakville Data incomplete over 5-day interval. Pearson Airport data indicates 12.4 mm rainfall Oct 14 (and 4.2 mm Oct. 13). MMM staffe visited site late afternoon Oct. 14 to view conditions at main tributary following rain event - main channels were in flood. Quarterly site visit was 4-5 days later with no additional precipitation recorded. Flows observed over Oct 18-19 were continuing to decline from Oct. 14 rates	Minor precipitation recorded at Pearson Airport (1.4 mm) or Oakville (2.6 mm) in preceding 5 days. However, temperatures were generall above 0C in the preceding 5 days with snow cover melting. The maximum daily temperatures on the two days on-site at both weather stations were recorded between 10 and 11C.
Subwatershed FM1001	**Est'd Base Flow Rates from Water Balance -->**		**359 LPM (Dec)**	**550 (Jan)**	**1,127 LPM (April)**	**0 LPM (July and August)**	**52 LPM (Oct)**	**1,156 LPM (Feb)**
Easternmost Tributary (14W-13)								
FMP-4	597523	4809561		Watercourse was frozen, no visible flow	Flow estimated at **88 LPM**.	Dry	No flow estimates made	
Central Tributary (14W-14)								
FMP-3 (Corner of Burnhamthorpe and Tremaine)				(Jan 22) Frozen, ice clear with pockets of trapped air. No flow observed.	Flow estimated at **235 LPM**.		No suitable location to measure flow was available this visit, some flow was observed.	
MP-06	597348	4809417.944		Frozen.		Dry	No flow estimates made	
MP-03/FMP-5	597808	4809266.198		Frozen. No flow observed	Flow estimated at **183 LPM**.	Dry	Flow estimated at **83 LPM**	
Main (Westernmost) Tributary (14W-16/14W-12)								
MP-07	597541	4809149.703		Frozen, no flow observed. Clear ice.		Dry	No flow estimates made	
FMP-1 (upstream of SG-1)	597618	4809131	Flow estimated at **592 LPM**	Frozen, crunchy ice over a denser ice. No flow observed.	Flow estimated at **381 LPM**.	Dry	No flow estimates made	
Staff Gauge #1 (Upstream of small (West) Pond)	597677	4809113.09		Frozen. Crunchy ice over a clear denser ice. Flow observed downstream at culvert crossing.		No flow, some pooled water.	No flow estimates made	
MP-04/FMP-06	597972	4809088.192	At farm bridge downstream of MP-04, flow observed in channel - ice along edges.	Some flow observed north of concrete farm bridge, but frozen at bridge and to the south. MP-04 has been destroyed by ice. Flow estimated at **63 LPM**	Flow estimated at **871 LPM**.	Dry	No flow estimates made	
Staff Gauge #2 (by Dundas Street)	598345	4809063.452		Frozen, some flow under ice.	Flow observed.	No flow, some pooled water.	No flow estimates made	
Subwatershed FM1109 (14W-11A/14W-11)	**Est'd Base Flow Rates from Water Balance -->**		**36 LPM (Dec)**	**496 (Jan)**	**107 LPM (April)**	**0 LPM (July and August)**	**5 LPM (Oct)**	**99 LPM (Feb)**
MP-01	597409	4809839.704		Frozen. No flow observed.		Dry		
FMP-2 (located between MP-01 and MP-02)	597608	4809788	Frozen - water flowing under ice. Ice at least 2 cm thick. Clear and dense ice.	Frozen, dense ice covered with snow	Flow estimated at **100 LPM**	Dry	Flow estimated at **32 LPM**	
MP-02	597769	4809665.798	Frozen. Broke through ice - about 0.1 m of water. No measureable flow.	Frozen. Surface water in area frozen. Wet under ice.		Dry		
Subwatershed FM1102								
Tributary FM1102 (Tributary passing through SW part of Site)	597989	4808801						
Other Water Features								
Large Pond (21 m to the west of MMM-09-2)								
MP-05 (Small ponded area on hill-top)	597514	4809671.167		Frozen. Surface water in area frozen.				
Comments regarding FM1001/FM1109			Flow in FM1001 (14W-16) at same order of magnitude (but higher) than predicted by the water balance but also within about 3 days of a rainfall event. At FM1109, low flows are predicted by the water balance, and low flows seen but channels also ice-covered frozen.	All watercourses frozen at time of visit - water balance infiltration estimates suggest flow potential but very little opportunity to measure flow - one measurement obtained at FM1001 is an order of magnitude lower than predicted).	FM1001, flows estimated at about 870 LPM just upstream of Dundas Street, which is in line with water balance estimate of 1,060 LPM. FM1109 estimates of flow at 100 LPM, vs. 102 LPM estimated by water balance.	All watercourses dry (or pooled water in low areas) which agrees with water balance estimate (no flow)	Flows where measured are a bit higher than (but same order of magnitude) as flows predicted by water balance. Rates were noted t be declining still following a significant rain event on Oct 13-14.	Channels were in flood and flow measurements were not attempted by field staff.

Notes:
5-day Preceding Weather observations, focussed on precipitation are presented at the top of the table for Oakville and Pearson Airport weather stations. The Pearson data is complete, the Oakville data, while closer to the site does have missing data.
The 5-day weather observations are also colour coded (shaded) per the following:

Stream flow estimates were made by measuring the time for a floating object to traverse a measured length of watercourse, of generally consistent cross-sectional profile and straight alignment. An average time was calculated using between 3 to 6 measurements. As flow velocity was thus obtained.
The area of this typical cross-sectional saturated profile (or a weighted average of multiple profiles along the length of run) was calculated and this, combined with the flow velocity were used to arrive at an estimated flow rate in the channel.
The calculated flow is considered an overestimation as it does not account for lower flows due to friction along the water/channel bed interfaces.

For the purposes of checking the water balance model against estimated stream flows (described above), the monthly water balance volumes of groundwater infiltration was assumed to be converted fully stream base flow.
Estimates (presented in LPM) for the entire subwatershed FM1001, and a portion of the tributary to FM1109 that passes through the northeast corner of the site area from the water balance calculations are identified in bold blue text.
Where estimates were obtained towards the beginning or end of a month, a range of the calculated average monthly base flows is presented. Measurements made towards the middle of the month are considered against the estimated base flow calculated for the month.
The water balance calculations are based on long-term averages and variations in actual precipitation from these averages will affect results. Furthermore a portion of infiltrating water will be directed to the deeper system, though this is estimated at less than 10%.
Most of the infiltrating groundwater is anticipated to flow horizontally through the upper weathered/fractured zone, discharging as this layer drains into watercourses within a 1 to 2 month timeframe.

Considered dry preceding 5-days and suitable for base flow estimates	Precipitation recorded within 5 days	Significant precipitation on the day of or within 1 to 2 days before visit

4.3.2.6 Groundwater and Surface Water Quality

Groundwater samples were collected by WSP staff at selected locations on September 24, 2009 and January 21, 2010 for background general chemistry. The samples were obtained from nine monitoring wells (MMM-09-4, MMM-09-10S, MMM-09-10D, MMM-09-11, MMM-09-15S, MMM-09-15D, MMM-09-17, MMM-09-19S, and MMM-09-19 D (See Figure WQ-1 in Appendix 4-6 for the sampling locations)). One surface water sample was collected from a water stream, where a staff gauge SG-1 was installed (also shown on Figure WQ-1). Dedicated polyethylene bailers were used for the purging and sampling of the groundwater into laboratory prepared sample bottles. The samples were then placed in a cooler with ice and transported to the laboratory (*Maxxam Analytics*) under standard Chain of Custody procedures.

Water quality sample results are provided in Tables WQ-1 and WQ-2 found in Appendix 4-6. Selected inorganic and metal parameter concentrations are plotted in Figure WQ-2 to facilitate the water quality characterization discussion. A graphical representation of cation and anion water chemistry is depicted in a Piper/Trilinear diagram, as shown in Figure WQ-3 (Figures WQ-2 and WQ-3 are also presented in Appendix 4-6). Water quality results were compared to the Ontario Drinking Water Standards (ODWS) and the Provincial Water Quality Objectives (PWQO)[33]. For comparative purposes, the groundwater sample results were also grouped according to the geological unit in which the wells are screened. The groupings include monitoring well sample results screened in Halton Till, the till/bedrock interface, Queenston Shale (deep/shallow), and surface water.

As shown in Tables WQ-1 and WQ-2 and Figure WQ-2 several parameters exceed the ODWS, PWQO, or both comparative standards, from at least one location, including boron, cobalt, iron, manganese, silver, sodium, uranium, zinc, hardness, total dissolved solids (TDS), dissolved organic carbon (DOC), sulphate, chloride, and nitrate.

Water quality results were generally indicative of rural land uses, with no widespread evidence of inorganic parameter impacts at the Subject Property. Dissolved metals sample concentrations (cobalt, sulphate, magnesium, molybdenum, DOC and manganese), were higher in wells screened within the Halton Till as compared to samples collected from wells screened in the Queenston Shale. Samples collected from bedrock monitors indicated relatively higher boron concentrations as compared to collected till water quality samples.

Surface water quality samples indicate higher concentrations of conductivity, manganese and lower concentrations of DOC and sulphate as compared to the collected groundwater sample concentrations.

With the exception of MMM-09-15S, there is no marked variance in water chemistry between wells screened within the same geological unit. MMM-09-15S exhibited elevated concentrations of conductivity, sodium, chloride, and iron in comparison to other bedrock wells, indicating it may be affected by road de-icing salt from Tremaine Road.

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[33] ODWS are from Table 2 (Chemical Standards) and Table 4 (Chemical/Physical Objectives and Guidelines) of Technical Support Document for Ontario Drinking Water; Standards, Objectives and Guidelines (MOE), June 2003, revised June 2006.

PWQO are from Table 2 (Table of PWQOs and Interim PWQOs) of Water Management, Policies, Guidelines, Provincial Water Quality Objectives (MOE), July 1994, and revised February 1999.

The Piper/Trilinear diagram (Figure WQ-3) shows good segregation between the till, bedrock, and surface water samples, with each grouping occupying a close-knit area within the diagram. Therefore, water from the different aquifers have a unique 'geochemical fingerprint', and can be characterized within a defined area of the Piper diagram. It is apparent from these distinct groupings that there was limited groundwater - surface water mixing at the time of sampling.

4.3.3 Local Hydrogeological Setting

The following discussion of the local hydrogeology is based on the information gathered during this investigation and from previous studies conducted on the property and elsewhere within the watersheds.

The surficial fine-grained deposit of Halton Till found throughout the study area serves to limit infiltration to the groundwater system and as a result, the local stream systems receive a little over two-thirds of their total water from surface runoff. As will be demonstrated in the water balance discussion, average infiltration in this environment is approximately 69 mm/year. Of this 69 mm/year of infiltration, on the order of 0.3 to 5 mm/year is estimated to recharge the deeper bedrock system[34], with the majority of the groundwater inputs to the local watercourses considered to flow laterally through the upper, weathered zone of the till. Almost 100% of this contribution occurs primarily in the period of November to May when the entire shallow system, including upgradient reaches of the channel are saturated and contributing flow to the watercourses.

The upper weathered zone of the till is estimated to have a bulk horizontal hydraulic conductivity on the order of $3x10^{-6}$ m/sec. This enhanced permeability permit infiltrating groundwater to travel somewhat quickly through the shallow zone towards the watercourses. During the late fall to late spring seasons, the streams are generally observed to be in flow, which is predicted by the water balance (groundwater infiltration is predicted during these periods). The higher bulk conductivity in the shallow system can also be observed through the rapid rise and subsequent steady declines in shallow groundwater elevations following precipitation and snow melt events visible in the data logger plots (Appendix 4-5).

Because of this enhanced conductivity, most (approximately 90%) of the infiltrating groundwater moves horizontally through the shallow system, and provides a source of base flow to the local streams during the late fall to late spring. During the growing season groundwater infiltration ceases (there is a water deficit and plants are active and using up water), the shallow system drains, and the watercourses become dry. Figure 4.5 and Figure 4.6 illustrate this decline in the shallow groundwater levels that lead to the reduction in base flow contribution from the spring into the summer seasons.

Towards the lower (southern) reaches of watershed FM1001 the watercourse valleys approach the underlying Queenston Shale bedrock, which is exposed at surface at the extreme southern limits of FM1001 (at the southern end of Reach 14W-12), just before it passes under Dundas Street. Minor groundwater inputs from the bedrock discharging into the main watercourse (Reach 14W-12 and Reach 14W-16) and the central watercourse (Reach 14W-14) across the entire Subject Property is interpreted from the monitoring well data. Bedrock discharge into the main watercourse is anticipated to continue up to a point roughly where this

[34] These estimates are based upon an average downward vertical gradient through the till of approximately 0.4, and vertical hydraulic conductivity ranging between $3.8x10^{-10}$ to $2.2x10^{-11}$ m/sec (see notes from Table 4.4). The greater vertical recharge (approx. 5 mm/year) is considered the more representative value for this system.

watercourse passes under Highway 407, and in Reach 14W-14 up to a point somewhere between the Highway and Number 1 Sideroad (see Figure 4.3)[35]. The extent of the length of these reaches with potential bedrock discharge may become reduced somewhat by ongoing and future activities at the recently constructed Hanson Brick quarry, which is being excavated into the shale, and thus will lead to a localized lowering of the groundwater within the bedrock around the perimeter of the pit over time.

The seasonal groundwater elevation changes within the bedrock are not as highly variable as in the surficial tills, and thus its contribution of groundwater towards these two watercourse channels is considered to continue throughout the year. However, the volumetric rate of water moving towards these watercourses is low, and during the summer months, is insufficient to provide enough water to maintain flow in these watercourses, particularly in the reaches from about the mid-point of the Subject Property and to the north, where the channels have been observed in a dry state during the summer period. Over the lower reaches of the main channel there may be greater opportunity for groundwater to maintain pools in the channel as the bedrock is exposed in the channel and the watercourse is shaded somewhat by large trees.

4.4 Impacts of the Proposed Development

For the purposes of this study, the employment lands development for the Subject Property and adjacent lands to be developed was considered to be 90% future imperviousness[36] within the development limits. This is based on the maximum lot coverage requirement of 90% of the North Oakville Zoning By-Law, which anticipates more urban and intensive employment uses in North Oakville. Lands designated to remain in their natural state, or to be reconstructed in a natural state were assumed to be 100% pervious after development.

Under existing conditions, four watercourses currently enter the Subject Property from the west and northwest. The three reaches associated with watercourse FM1001 (Reach 14W-13, Reach 14W-14 and Reach 14W-16) converge into one main channel (Reach 14W-12) at about the middle of the Subject Property, and one watercourse (Reach 14W-11 and Reach 14W-11A) FM1109 cuts across the northeast corner of the Subject Property.

It is proposed to re-align the central and eastern reached (Reach 14W-14 and Reach 14W-13) of the main watercourse (FM1001) at the north boundary of the Subject Property, to the west and then southerly along the western property line via a new channel (Reach 14W-22) into Reach 14W-12A upstream of its confluence with Reach 14W-12. The watercourse to FM1109 that enters the property at the northeast (Reach 14W-11A) is also proposed for re-alignment (Reach 14W-23) along the northern and eastern property lines up to the point where it currently exits on the Subject Property (Reach 14W-11).

The main focus of the following impact assessment will be on the effects of the proposed development on the overall water balance, more specifically on changes to infiltration to the groundwater system. In addition to the water balance analysis, the potential impacts related to the proposed stream channel realignments will also be examined (Reach 14W-13, Reach 14W-14, and Reach 14W-11A).

[35] Note that across much of the identified channel reaches shown on Figure 4.3 with groundwater discharge potential from the bedrock, there are overlying Till sediments between the rock and the channels.

[36] Lots at 90% imperviousness. Road allowances with grassed boulevards are assumed as 70% impervious.

4.4.1 Water Balance Methodology

The MOE Stormwater Planning and Design Manual (2003) offers a method to estimate the infiltration on the site, based on a local infiltration factor “i", which is applied to the available water surplus to determine the groundwater recharge for a given area with pervious cover. The methodology considers factors such as the soil type, topography, and vegetation to arrive at the infiltration factor that is then applied against the water surplus to provide an estimate of the amount of water infiltrating into the ground. The remaining water surplus is considered runoff.

Under the post-development conditions the infiltration factor is recalculated to account for changes in soil types, vegetation and topography after development, and the infiltration and runoff at the pervious land areas are recalculated. As the land after development will have impervious surfaces that prevent infiltration, such as building footprints, roads and parking areas, the pervious area available for infiltration is reduced. Furthermore, there is limited opportunity for evapotranspiration on these impervious surfaces, other than evaporative losses from wetting and ponding of water in shallow depressions (estimated at 10% of total precipitation), and so total precipitation is applied to these surfaces instead of the water surplus.

The discussions that follow focus on subwatershed FM1001 only, which is the main system passing through the Subject Property and is the subwatershed for which this EIR is specifically addressing. The adjoining subwatersheds FM1102 and FM1109 will behave in a similar manner though the magnitude of change under post-development conditions will depend in part on the proportion of development area in North Oakville compared to the total subwatershed area in these other subwatersheds.

4.4.2 Climate and Water Surplus

The inputs used for the water balance calculations are based on information provided by Environment Canada using climate data from the Oakville Gerard meteorological station (43°26’-N 79°42’-W), for the period 1990 to 2006. This climate station is considered to be more representative of climatic conditions at the Subject Property than the Hamilton Royal Botanical Garden (HRBG) station used in the NOCSS. The Oakville Gerard station is located approximately 7 km southeast of the Subject Property, whereas HRBG is located about 17 km southwest from the Subject Property, along the edge of Hamilton Harbour. Furthermore, the Oakville Gerard station is also not located immediately adjacent to the lake (as is the case of the HRBG) and therefore will experience less climatic lake effect potential.

Environment Canada inputted their climate data into a computer model (Johnstone and Louie, 1983) to provide actual evapotranspiration and water surplus inputs for soils with different water holding capacities (WHCs). Under existing conditions the WHC of the soils at the Subject Property and surrounding areas are estimated to be 200 and 400 mm (see Section 4.4.3.1). The Environment Canada data is presented in Appendix 4-7 and is also found on Table WB-1 within this same Appendix.

The Subject Property is located in an area of temperate climate with a mean annual temperature of 9.0 C and a mean annual precipitation of 819 mm. The potential evapotranspiration estimate that was provided by Environment Canada based on the Thornthwaite approach is 656 mm per year. The mean actual evapotranspiration in the vicinity of the Subject Property (pervious areas excluding existing imperviousness runoff contributions) is 607 and 644 mm respectively for soils with WHCs of 200 mm and 400 mm (see below) reflecting periods of soil moisture deficiency. The pre-development water surplus, the water available for infiltration and runoff, is estimated to be 198 mm per year under existing conditions across the entire subwatershed (FM1001) and 209 mm per year on the portion of the Subject Property found within this subwatershed.

4.4.3 Inputs to Water Balance

Site specific inputs used in the water balance analysis are summarized in Table 4.8 and the inputs under the post-development case are explained below. The rationale for the pre-development and post-development inputs is discussed in Sections 4.4.3.1 and 4.4.3.2.

The infiltration factors and WHCs presented in Table 4.8 are considered to be the same across all subwatersheds for the purposes of this analysis. The increase in imperviousness across the entire subwatershed also includes increased imperviousness at developable lands owned by others in North Oakville as well as increased imperviousness at the Hanson Brick quarry north of Highway 407, which will expand over time.

Table 4.8 – Watershed Specific Inputs Used in the Water Balance – FM1001

Infiltration Factor Based on Land Conditions	Pre-Development	Post-Development
Topography	0.11	0.11 to 0.13
Soils	0.12	0.12
Vegetation	0.11	0.11
Thicker Topsoil/Amendment within Development Areas	-	0.05
Sum	0.34	0.34 to 0.41
Water Holding Capacity of Soils (mm)	Pre-Development	Post-Development
	200 and 400	100, 200 and 400
Site Areas for Use in Calculations (ha) Subject Property Only (within FM1001)	Pre-Development	Post-Development
Pervious	60.4	20.7
Impervious	0.0	39.7
Total Area	60.4	60.4
Entire Subwatershed, including Subject Property	Pre-Development	Post-Development
Pervious	379.4	296.5
Impervious	15.9	98.8
Total Area	395.3	395.3

Notes:
The individual infiltration factors presented in this table are weighted averages across the entire subwatershed (bcIMC and other developer owned lands south of Highway 407 as well as the lands north of 407).
Post-development areas are based on the conceptual development plan which is subject to revision. Because site grading is expected to reduce slopes in developed lands to the order of 2%, the infiltration factor for topography increases from

0.11 to 0.13 within the developable lands only. This also includes an assumption pertaining to increased future imperviousness at the Hanson Brick Quarry lands as that operation expands.

A proposed mitigation measure is the tilling/scarifying and compost amendment of the sub-soils with placement of thicker topsoil, which is modelled to promote additional infiltration. An increase in the "cover" infiltration factor by 0.05 for the landscaped areas within the developable lots was incorporated into the water balance analyses with mitigation.

Water Holding Capacity of Soils is based values presented on Table 3 from the MOE Stormwater Management Manual (2003).

4.4.3.1 Pre-Development Conditions

The surficial soils at the Subject Property and surrounding area within the subwatersheds, as described previously, are generally comprised of Clayey Silt Till, underlain by Shale Bedrock (exposed at surface in watercourses near to Dundas Street). As described in Section 4.3.2.1, the surficial soils are best classified as Clay Loam.

Soils mapping of the Subject Property presented on Figure 4W.6.1 in the NOCSS (included in Appendix 4-7) identifies most of the Subject Property as comprised of Oneida Clay Loam (Hydrologic Soil Group D (i_{soil} = 0.10), ref. Table 4W.6.2 from NOCSS), with Chinguacousy Clay Loam (Hydrologic Soil Group C (i_{soil} = 0.20)) mapped within the natural valley features at the site. The Chinguacousy Clay Loam comprises approximately 23.7 ha of the 109.7 ha area of Subwatershed FM1001 south of Highway 407, or about 21.6% of the total area. This results in a weighted average for the i_{soil} of 0.12 and this has further been assumed to be representative of the soil conditions across the three subwatersheds.

The existing vegetation at the Subject Property is predominantly agricultural with soy beans having been planted on site in 2013. Corn is also a major local crop grown within the subwatershed areas. The soil and vegetation conditions at the Subject Property lead to a soil water holding capacity of 200 mm and 400 mm as defined on Table 3 of the MOE Stormwater Planning and Design Manual.

The pre-development infiltration factor for the Subject Property and the main subwatershed (FM1001), "i", is calculated at 0.34 based on the following:

- Topography is considered to be hilly, i_{topo} = 0.11 (average slopes across the three subwatersheds is approximately 3.0%)
- Soils are considered to be a clay loam from grain size analysis, i_{soils} = 0.12
- Cover is predominantly cultivated land with some forest cover, i_{cover} = 0.11

The pervious surface area of the Subject Property within FM1001 under existing conditions is approximately 60.4 ha. Approximately 45.4 ha of this area is situated within future developable lands and will be changed following development; the remaining 15.0 ha will not be developed. Most of this 15.0 ha area (approximately 9.5 ha) will essentially remain untouched, other than from works such as road crossings and sewer outfalls. It is proposed to realign the watercourses entering the Subject Property along the north (Highway 407) property line. The central and eastern watercourses to FM1001 (Reaches 14W-14 and 14W-13) are proposed to be diverted to the west and then southerly along the property line with the Arch-Diocese lands (proposed Reach 14W-22) and into Reach 14W-12A upstream of where it joins the main channel (Reach 14W-16). Reach 14W-11A is proposed to be diverted easterly along the north property line and then to the south (proposed Reach 14W-23) to the point where it currently joins Reach 14W-11 before exiting the Subject

Property. The proposed channel realignments are shown on Figure 4.7. The approximate area of the FM1001 channel realignments (within FM1001) is 4.1 ha[37].

4.4.3.2 Post-Development Conditions

Future development of the Subject Property and adjacent development lands from agricultural to employment land use will change the evapotranspiration, runoff and infiltration conditions of these lands by adding hard surfaces such as roads, driveways, parking lots, sidewalks and roofs that are effectively impervious. For the purposes of the water balance analyses, the total area covered by impervious surfaces for this type of development is estimated at about 88%[38] over the 45.4 ha of developable area. This is equivalent to about 66% imperviousness over the full 60.4 ha of site area (within Subwatershed FM1001) with the 15.0 ha of "natural" area at 0% imperviousness included.
Post development conditions on lands northwest of Highway 407 are anticipated to remain essentially the same as the pre-development situation. These lands are currently designated Protected Countryside (Greenbelt Plan, 2005) and Agricultural in the local and Regional Official Plans. The post-development water balance on a subwatershed basis (FM1001) includes allowance for a minor increase in imperviousness in the lands northwest of the 407 that reflect a projected increase in size of the Hanson Brick Tremaine Quarry over time.

It is also noted however, that runoff from pervious areas surrounded by streets within the developed lands will eventually be directed to the stormwater management system, as it will drain onto the road network and from there into the storm sewer system. The exception would be the runoff from pervious areas abutting and draining to natural features or runoff conveyed to these features by means of mitigation such as infiltration swales.

Under the post development condition, the soil composition is expected to remain classified as a Clay Loam after site grading, as soils used for fill are expected to be obtained from the Subject Property, and the soils exposed by cutting activities are anticipated to be similar to the existing surficial soils. While compositionally the soils will remain unchanged at finished grades within the developable limits, the infiltrative benefits of weathering and fracturing will have been lost through the cut and fill activities. The vegetation following development is anticipated to be comprised predominantly of short-rooted vegetation such as grassed lawn in landscaped areas, with natural vegetation remaining as-is elsewhere where these areas are to remain undisturbed or with new plantings in areas to be created through the proposed channel realignments.

Based on Table 3 from the MOE Stormwater Management Manual (2003), Clay Loams with short rooted vegetation such as lawns are shown to have a WHC on the order of 100 mm. Therefore, under the post-development scenarios, the local climate data provided by Environment Canada for soils with a WHC of 100 mm was used to estimate the future water surplus for the developed areas of the Subject Property and surrounding development lands. With a WHC of 100 mm, the Actual ETR is reduced from 607 and 644 mm/year (pre-development conditions) to 536 mm/year at areas to be landscaped. The reduction in Actual ETR across pervious areas of the developed lands results in an estimated water surplus of about 229

[37] The 4.1 ha is the approximate area of the proposed channel where cuts below existing grade will be required, necessitating the removal of the upper weathered soils within this area.

[38] Based on 39.8 ha of developable lots and SWM's at 90% imperviousness, and 5.7 ha of internal roads and future transit way at 70% imperviousness.

mm/year compared to the pre-development surplus of 209 mm/year, over pervious areas of the property. These changes apply to the future landscaped grounds within the development lands only, or to about 5.7 ha of the total 45.4 ha of lands to be developed within the 60.4 ha total area within FM1001. On a subwatershed basis, the estimated water surplus (pervious area) rises from 198 mm/year to about 209 mm/year.

4.4.4 Water Balance

Water balance analyses were performed for the entire Subject Property area, and for the three subwatersheds that are partially located within the Subject Property. As noted earlier, discussions will be focussed upon subwatershed FM1001. Water balance analyses for the other two subwatersheds FM1109 and FM1102 are also presented in Appendix 4-7 for completeness. In addition, a pre-development water balance analysis was carried out for a portion of the FM1109 subwatershed that passes through the east corner of the Subject Property to compare observed watercourse base flows against predicted base flows from these analyses (identified on Figure 4.2). This is discussed in Section 4.4.4.1.1.

4.4.4.1 Pre-Development Water Balance

Under pre-development (existing) conditions the Subject Property is considered pervious over its full area (e.g., 60.4 ha within FM1001). The water surplus under these conditions was calculated as 209.4 mm/year (see Section 4.4.2) and the infiltration factor was calculated to be 0.33. Therefore, pre-development infiltration across the full property area and leading towards the watercourses of FM1001 is estimated at about 69.3 mm per year (41,902 m^3/year), which is consistent with the reported infiltration values for these types of soils. Most groundwater recharge occurs during the spring melt period when soil moisture content is high. The remaining 140.1 mm per year (84,670 m^3/year) would be available for surface run-off, most of which occurs during the spring melt period.

On a subwatershed basis, the predevelopment water balance indicates that FM1001 will receive 263,546 m^3/year of infiltration (66.7 mm/year equivalent) and 637,237 m^3/year (161.2 mm/year) of runoff. The subwatershed volumes reflect pre-existing imperviousness within the entire subwatershed (e.g., Highway 407, Hanson Brick quarry).

The major contribution of water to the subwatershed occurs, as expected, in the late winter and spring. Water surpluses during the majority of the growing season (June through October) are essentially zero as the ETR remains high and the soil moisture goes into a deficit. Soil moisture starts to become replenished in September/October.

The pre-development water balances for the Subject Property and the overall subwatershed are summarized on Table 4.9 and Table 4.10 (in Section 4.4.4.2); with the detailed, monthly water balance calculations presented in Appendix 4-7 on Table WB-2-FM1001.

4.4.4.1.1 Base Flow Comparisons to Pre-Development Water Balance

During the course of the site investigations, estimates of surface water flows were made at selected locations in the watercourses of FM1001 and FM1109 that passed through the Subject Property. No flow estimates were attempted at FM1102, as there was no defined channel or any measurable flow at this part of the Subject Property.

One of the requirements of the EIR and FSS TOR is to validate the pre-development water balance where possible. The water balance analyses provide monthly estimates of infiltration and runoff. For purposes of this comparison, we have assumed that monthly infiltration calculated by the water balance is representative of base flow conditions in the watercourses less 10% to allow for recharge of the deeper shale bedrock aquifer, leaving 90% of the infiltration calculated by the water balance available for base flow to the creeks.

Table 4.7 presents the watercourse base flow estimates against the water balance calculated infiltration volumes (90% as noted above), converted to equivalent flow rates at the downstream edges of the watercourses. For FM1001 (West Branch of Fourteen Mile Creek) this is at SG-2 by Dundas Street (bottom end of reach 14W-12). For FM1109, (Central Branch of Fourteen Mile Creek) only a portion of a contributing watercourse passes through the Subject Property (Reach 14W-11 and Reach 14W-11A). The upgradient portion of this Reach was identified on Figure 4.2 and a pre-development water balance analysis was carried out for this small portion of FM1109 (see Table WB-2-14W-11A in Appendix 4-7).

The water balance is based upon averages from a 16-year weather record and the calculated monthly average infiltration is being treated as a proxy for base flows to the watercourses. These monthly averages were then compared to measured estimates of channel flows (with inherent inaccuracies) that are a function of real (non long-term averaged) weather patterns. Notwithstanding the above, as can be seen from Table 4.7, the predicted stream flows and measured stream flows are in good agreement when measurements were possible without influence from rainfall or snow-melt events (e.g., February 17-18, 2011), and generally of the same order of magnitude. Thus it can be concluded that the water balance methodology used in this study is a simple, yet valid, model of the hydrogeological system in which the Subject Property is situated.

4.4.4.2 Post-Development Water Balances

In addition to the pre-development water balance, two post-development water balance scenarios were examined. The first of these scenarios examined the worst case situation with no mitigation measures applied at the Subject Property and the second scenario examined the improvements from the worst case scenario with mitigation measures employed. The post-development scenarios were compared against the pre-development case. The results for the water balance calculations are described below and summarized on Table 4.9 and Table 4.10. The detailed calculations are presented on Tables WB-2-FM1001 through WB-4-FM1001 located in Appendix 4-7.

The following assumptions have also been made to estimate the post-development water balance including recharge mitigation measures:

- Total imperviousness of the developable lots is assumed as 90%, which reflects the Town of Oakville's planned land use and maximum lot coverage requirements for more intensive employment development. Imperviousness of the road allowances with grassed boulevards is assumed at 70%, resulting in weighted imperviousness of 88%;

- There is no infiltration occurring on hard surface areas and evapotranspiration is significantly lower than that under pre-development conditions (10% as evaporation only), due to rapid runoff of precipitation;

- Runoff from the road network, as well as roof areas not directed to mitigation is discharged directly into the storm sewer network[39];

- The characteristics of the native soils and bedrock limit the choices of suitable measures to infiltrate water into the ground at both the Subject Property and the surrounding areas. The data collected over the course of this investigation indicates the upper, weathered zone of the till soils has enhanced (secondary) permeability from fracturing. The most promising locations for infiltration-promoting mitigation measures will therefore be within areas where the native soils are to be left undisturbed by construction activities;

- The imperviousness of the Subject Property after development is calculated at about 66% (39.7 ha) of the total 60.4 ha site area found within subwatershed FM1001. Of this 39.7 ha, roofs are assumed to account for approximately 40% of the total imperviousness or about 16.0 ha. Runoff from the roof areas may be suitable for use in mitigation measures depending upon the nature of the businesses that eventually are developed (e.g., businesses with zero to low emissions versus heavy industries with the potential to release particulate matter that collects on roofs). For the purpose of this analysis the runoff collected on the roofs has been considered usable for mitigation measures, though as noted above the opportunities to mitigate in this hydrogeological environment are limited;

- Landscaped areas within the developable areas and the newly created natural environment areas associated with the channel realignments will have the newly exposed sub-soils tilled/scarified/ripped to 500 mm depth and amended with compost (resulting in organic content of 8 to 15% by weight / 30 to 40% by volume) prior to placing approximately 0.25 m of topsoil. This increased thickness of organic soils with additional void space will retain a greater proportion of precipitation and/or runoff over these pervious areas and therefore promote additional infiltration. Within the developable lots, this activity would be deferred to the time of individual lot development once the proposed layout of buildings and paved areas within the individual lots are known;

- Infiltration works such as infiltration swales constructed along the periphery of areas retained in their natural state are considered viable (see Figure 4.7). By carefully constructing these measures within the undisturbed natural environment areas, they are anticipated to be capable of recharging a portion of the relatively clean roof runoff that can be directed to these swales, provided the existing surficial fractured and weathered zone of the native till soils remains intact. This will require using specified construction techniques to minimize smearing of the walls and bases of these swales, which would dramatically reduce the potential effectiveness of these measures. Constructing infiltration swales within portions of the Subject Property with engineered fill or deep cuts into unweathered and relatively unfractured soils will not be as effective for mitigating infiltration, but, if connected to infiltration swales along the perimeter of the natural features, will provide temperature moderation to the roof runoff;

- Construction of small off-line open water wetlands within the proposed valley realignment (Reach 14W-22) that will convey the central and eastern reaches (Reach 14-W-14 and Reach14W-13) into Reach 14W-12A and will be recharged by flood events will provide for some measure of additional

[39] A portion of the runoff from roofs at the central part of the Subject Property will be diverted to the small channel (14W-12A) located to the northwest of the central SWMP to maintain flows across that section of channel (see Section 7.4).

infiltration, though this will be limited somewhat by the fact that such ponds will be constructed alongside the realigned channels at lower elevations where groundwater discharge from the underlying bedrock is anticipated; and,

- Additional mitigation measures, such as vegetative swales at parking areas, landscaped infiltration ponds/wetlands, green roofs, cistern systems for grey-water use and/or landscape irrigation, etc. are specific to lot configurations, intended use, building design and so forth and should be examined during later stages of detailed design or at the time of building permit applications. For example, construction of landscaped ponds/wetlands would not appear feasible on a lot with a large warehousing facility and extensive parking facilities, but may be feasible at a lot housing a corporate headquarters facility. As such specific measures on a lot by lot basis are not identified at this time and they have not been included in the post-development water balances.

4.4.4.3 Post-Development Water Balance with No Mitigation

This first scenario, examines the worst-case condition, where there will be no mitigation measures incorporated. This assumes that all impervious area runoff (less impervious surface losses to evaporation), including roof runoff, is conveyed directly into the stormwater management system. This scenario considers that groundwater infiltration is supplied only by precipitation that falls upon pervious areas. The potential maximum loss of infiltration from the proposed development was calculated to provide a worst-case estimate of the potential impacts on infiltration due to the introduction of hard surfaces. Detailed monthly water balance calculations may be found on Table WB-3-1001 in Appendix 4-7.

Table 4.9 – Pre and Post Development Water Balance – No Mitigation

	Pre-Development		Post-Development		Change	
Parameters	mm/year	m^3/year	mm/year	m^3/year	m^3/year	%
Subject Property Only (within FM1001)						
Precipitation	819.0	495,004	819.0	495,004	0	0.0%
Total AET	607.5	367,167	201.2	121,584	-245,583	-66.9%
Evaporative Losses at 10% Precipitation	0.0	0	53.9	32,552	32,552	N/A
Infiltration (MOE Methodology)	69.3	41,902	26.4	15,969	-25,932	-61.9%
Runoff (MOE Methodology)	140.1	84,670	536.8	324,428	239,757	283.2%
Entire Subwatershed, incl. Subject Property						
Precipitation	819.0	3,237,507	819.0	3,237,507	0	0.0%
Total AET	585.4	2,314,021	455.8	1,801,628	-512,393	-22.1%

Evaporative Losses at 10% Precipitation	3.3	13,022	20.5	80,923	67,901	521.4%
Infiltration (MOE Methodology)	66.7	263,546	53.0	209,312	-54,235	-20.6%
Runoff (MOE Methodology)	161.2	637,237	287.8	1,137,703	500,466	78.5%

Notes:
Evaporative losses are losses of precipitation though simple evaporation on impervious surfaces (such as from ponding at puddles).

As indicated in Table 4.9 under this worst-case scenario, the water balance method estimates a 62% reduction in groundwater infiltration from the Subject Property falling within subwatershed FM1001 while on a total subwatershed basis the reduction in infiltration is estimated at about 21%[40]. On-site runoff contribution to the watercourse system is calculated to increase about 283%, or by 79% on a subwatershed basis. The change to the local groundwater recharge function assumes that all runoff from hard surfaces is conveyed to the storm sewer network. Some additional loss of groundwater flow may occur due to foundation drains and permeable backfill surrounding services, however, most of recharge loss is anticipated to be due to rapid runoff from impervious surfaces.

4.4.4.4 Post-Development Water Balance with Mitigation

A post-development water balance analysis was carried out with mitigation measures. The choice of mitigation measures was constrained by site conditions (e.g., site soils, location and orientation of natural features) and design constraints (e.g., site grading, requirements for connections to adjacent future developments). The locations of the proposed mitigation measures examined under this scenario are shown on the conceptual plan of development presented on Figure 4.7.

The improvements to recharge and runoff contributions of the following mitigation measures were examined:

- A portion of the roof runoff is collected and directed into infiltration swales located at the rear of the lots at the edge of the buffers to the NHS. Locating these swales immediately adjacent to the NHS will ensure that the functionality of these swales will not be compromised because of site grading activities on the Subject Property. These swales are also proposed alongside the “natural” areas that are to be created because of the proposed watercourse diversions. The surficial soils in those areas are expected to be deeper, less fractured soils exposed by cutting the grades, and the proposed tilling/scarifying and addition of compost amendments and topsoil within these newly created areas will provide additional infiltration potential. The locations of infiltration swales will need to be confirmed at detailed design as other factors such as final site grades must be considered in the siting of these facilities. Figure 4.8 presents the conceptual design of the proposed infiltration swales. As these swales are not designed for stormwater management purposes, they do not have to adhere strictly to the criteria specified by the MOE Stormwater Planning and Design Manual (2003) in particular a requirement that they drain in 24 to 48 hours.

[40] The overall subwatershed calculations includes, in addition, to the effects identified at the Subject Property, effects from development on lands owned by others, and from the proposed expansion of the Hanson Brick Quarry lands to the north of Highway 407.

- Published research studies by Toronto and Region Conservation Authority (Young, et al, 2013) and Credit Valley Conservation (2014) of infiltration trenches and galleries constructed in low permeability glacial tills within the Greater Toronto Area indicate that these LIDS can be effective at infiltrating water into the ground. Our review of these studies indicates that infiltration rates on average of the order of 3 mm/hour (equivalent to a percolation rate T-Time of 200 minutes/cm) have been measured at trenches and galleries constructed at sites located in Richmond Hill, Bolton, Brampton and Mississauga (2 sites). The grain size distributions of the till at these sites where reported are similar in nature to the till found at the Subject Property. The water balance calculations with respect to the infiltration swales are therefore based on this 3 mm/hour rate;

- Landscaped areas within the development lands and the newly created natural environment areas will include thicker topsoil and 0.5 m of tilling/scarifying/ripping of the sub-soils with compost amendments to promote additional infiltration. To model this effect in the water balance, an increase in the “cover” infiltration factor by 0.05 (from 0.10 to 0.15) for the landscaped areas was considered appropriate, putting this value mid-way between the factors for cultivated lands (0.10) and forested areas (0.20);

Small off-line open water wetlands are proposed within the valley of the westernmost of the two proposed channel realignments (Reach 14W-22) to address removal of wetlands in Reach 14W-13 and Reach 14W-14, as well as, the wetland and open water function of the Farm Pond (Reach 14W-14A). These wetlands would be maintained through storm flood events (surface flows) and while they have the potential to provide the additional infiltration to the shallow system, the post-development water balance does not account for any infiltration benefits from these off-line wetlands as the static water level within the underlying bedrock ranges from about 155 to 150 masl along the proposed channel realignment, and the invert of the realigned channel profile will range from about 152 to 149 masl. In order for there to be potential for vertical infiltration through the bottom of these off-line wetlands, the design water levels in these ponds would need to be higher than that of the groundwater in the bedrock.

Notwithstanding the above, these wetlands can be expected to provide some level of infiltration enhancements during the drier summer season when shallow groundwater levels in the valleys have declined somewhat due to the effects of evapotranspiration. Contributions to groundwater infiltration from these measures are not however included in the water balance calculations as a conservative assumption and the potential volumes of infiltration will also be relative to the final design sizing of these features.

Additional enhancements to the post-development infiltration at these development lands may be realized through the promotion of additional infiltration measures within the development such as wet (landscaped) ponds, bio-retention facilities, vegetated swales, etc. The feasibility of such measures is; however, a function of the individual lot configurations, proposed lot uses and site design opportunities. The infiltration contributions from these potential opportunities are anticipated to be minor because these features will likely be constructed within the limited available pervious areas. Infiltration from these undetermined mitigation measures are therefore not accounted for in the water balance calculations.

Table 4.10 summarizes the results of the water balance assessment for the Subject Property including pre-development and the post-development conditions with the implementation of mitigation measures described above. The detailed calculations are found on Table WB-4-FM1001 in Appendix 4-7.

With the proposed mitigation, the water balance method estimates the post-development groundwater infiltration at the Subject Property within FM1001 will be balanced, which is a significant improvement from the 62% loss calculated under the worst-case scenario and in consideration of the low permeability soils and proposed lot coverage at the Subject Property. This balancing of the post-development infiltration with the pre-development level exceeds the expectations of NOCSS (Sections 5.5.2, 7.4.4.2). The increase in post-development runoff generated at the Subject Property for the mitigated scenario is reduced from about 283% to 252%. Volumetrically, approximately 25,955 m^3/year of potential runoff is redirected into infiltration through these proposed mitigation opportunities compared to the unmitigated scenario.

Table 4.10 – Pre and Post Development Water Balance – With Mitigation

	Pre-Development		Post-Development		Change	
Parameters	mm/year	m^3/year	mm/year	m^3/year	m^3/year	%
Subject Property Only (within FM1001)						
Precipitation	819.0	495,004	819.0	495,004	0	0.0%
Total AET	607.5	367,167	201.2	121,584	-245,583	-66.9%
Evaporative Losses at 10% Precipitation	0.0	0	53.9	32,552	32,552	N/A
Infiltration (MOE Methodology)	69.3	41,902	69.5	41,923	21	0.1%
Runoff (MOE Methodology)	140.1	84,670	493.7	298,474	213,804	252.5%
Entire Subwatershed, incl. Subject Property						
Precipitation	819.0	3,237,507	819.0	3,237,507	0	0.0%
Total AET	585.4	2,314,021	455.8	1,801,628	-512,393	-22.1%
Evaporative Losses at 10% Precipitation	3.3	13,022	20.5	80,923	67,901	521.4%
Infiltration (MOE Methodology)	66.7	263,546	63.7	251,708	-11,839	-4.5%
Runoff (MOE Methodology)	161.2	637,237	277.1	1,095,307	458,070	71.3%

Notes:
Evaporative losses are losses of precipitation though simple evaporation on impervious surfaces (such as from ponding at puddles).

On a total subwatershed basis (FM1001 only), and where opportunities are present, using similar mitigation measures on development lands owned by others, about 42,395 m^3/year of runoff may be redirected into the ground as infiltration. Mitigation at the Subject Property and development lands owned by others to the west is calculated to reduce overall infiltration losses by about 4.5% of the unmitigated totals[41].

[41] On a subwatershed basis, the total infiltration reduction across the development lands south of the 407 is calculated at approximately 47,300 m^3/year without any mitigation and with mitigation, at about 4,900 m^3/year on lands owned by others to the

4.4.4.5 Discussion of Water Balance Results

The preceding tables and discussion present the potential impacts and results of mitigation measures on the post-development water balance for the Subject Property within subwatershed FM1001. From the tables it can be seen that with the proposed mitigation measures it can be anticipated that impacts to recharge across the Subject Property can be fully mitigated, meeting one of the stated goals of NOCSS (to protect groundwater quantity, Section 7.4.4.2), even with the Subject Property situated within a setting where the predominant surficial soil is low permeability clayey silt till (confirming the soil conditions expected by NOCSS, Section 4W.3.2.2, Section 5.5.1, Section 5.5.2). Clayey silt till is not considered an ideal soil for constructing infiltration measures, and with an infiltration rate of 3 mm/hour as demonstrated from local conservation authority pilot projects, this balance is achieved on-site through an extensive infiltration swale network, totaling about 2.6 km in length[42]. We caution that construction activities at the Subject Property as well as placement of compacted earth fill will serve to reduce the native infiltration capacities of this clayey silt till soil and that care during construction must be taken in the immediate area of the proposed mitigation measures to prevent this from occurring.

The infiltration swales must be constructed along the edges of the watercourse valleys where weathering and stress relief of the low permeability deposits has resulted in a highly fractured upper soil zone conducive to recharge and are considered to be the most opportune locations for installing mitigation measures for infiltration. These areas will not be greatly affected by site grading which would lead to scraping and compaction and which would degrade or remove the ability of these low permeability soils to transmit water through the weathered zone (e.g., fractures)[43]. As noted above, specific construction limitations will also be required for these measures to be successful. Heavy equipment must not be permitted to travel across the areas proposed for these devices. Construction of the swales can only be done in dry weather to avoid remoulding the soil that would effectively line the swale sides and base with an impervious smeared layer. Manual scraping and removal of smeared soils from the sidewalls and base of the swales to expose the natural fracturing should be contemplated.

The potential for effective mitigation measures elsewhere across the Subject Property is affected by the proposed site coverage where a conservative 90% imperviousness ratio has been assumed on the development lots of the Subject Property. This constraint leads to reduced lot level perviousness and reduced infiltration potential as there is simply much less available area in which to infiltrate large volumes of water. Reducing lot coverage, which would result in more pervious area and therefore higher infiltration

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west of the Site (increasing the in the width of the infiltration swales in these lands from 1.1 m to about 1.5 m is one possible way to lead to a calculated balance for these lands). This is a 90% improvement in the total calculated infiltration losses from the redevelopment of these future employment lands (Subject Property and lands owned by others). The above stated volumes exclude infiltration reductions assumed and accounted for in the water balance from the future expansion of the Hanson Brick Quarry lands to the northwest (calculated reduction of about 6,900 m^3/year at the Hanson Brick site).

[42] 1,680 m length on the Subject Property, 950 m length on the lands owned by others to the west, within subwatershed FM1001 only.

[43] Excluding the proposed re-alignments that are to be constructed within unweathered till soils exposed through cuts. The exposed sub-soils within these areas are recommended to be tilled/scarified/ripped to a depth of 0.5 m and amended with compost to their improve infiltration capacity. Placement of 0.25 m of topsoil in addition to this will further provide additional moisture retention.

potential, is however in conflict with the Town's planned land use and maximum lot coverage requirements (more intensive employment development).

4.4.4.6 Discussion of the Potential for Base Flow Reductions to Watercourses

The surficial soils across the entire watershed system are comprised of low permeability Halton Till and as a result, the local stream systems receive a little over two-thirds of their total water from surface runoff with the balance derived from groundwater (based on the water balance and validated by stream flow measurements made at the Subject Property). The majority of the groundwater inputs to these watercourses is derived from the shallow till zone, and almost 100% of this contribution occurs primarily in the period of November to May when the entire shallow system, including upgradient reaches of the channel are saturated and contributing water to the streams. The NOCSS recognizes that minimizing changes (reductions) in infiltration will be difficult given the low permeability of the surficial soils found in North Oakville, estimated in the NOCCS as up to a 60% reduction in infiltration without mitigation within development limits (ref. Section 5.2.2 of the NOCCS).

The proposed mitigation measures are concentrated along the perimeter of the natural environment areas, which focuses this infiltration towards the watercourses where it will emerge from the embankments and mimic shallow groundwater discharge. In order to allow a uniform and sustained level of baseflow to be maintained in the Reach 14W-12A channel, a Redside Dace identified watercourse, additional mitigation measures will be incorporated. During Interim Development Phase 1B, flows from rooftops of the proposed buildings (2.56 ha) together with runoff from the part of the existing area (7.68 ha) will bypass the proposed SWM Pond 3 and be diverted directly to Reach 14W-12A by a storm sewer system. Under Interim Phase 2 and the Ultimate Development Conditions, flows from rooftops of the proposed buildings (5.12 ha) will be diverted to Reach 14W-12A directly in order to allow a uniform and sustained level of baseflow to be maintained in the subject receiving watercourse. Please refer to Section 7.4 (Development of GAWSER Hydrological Model) and Section 7.6 (Hydrologic Flow Regimes Analysis) for more details.

The development, with the incorporation of mitigation measures described above will result in a balance in infiltration across the Subject Property area for FM1001. This infiltration balance is calculated for the Subject Property as a whole over the year. As illustrated on Figure 4.9, the predicted monthly distribution of the infiltration at the Subject Property leads to potential for base flow increases to the three watercourses after development (Reach 14W-12, Reach 14W-22 (realigned) and Reach 14W-16) over a 7-month period (June to December, by between 18 to 48 litres/minute) along with potential for base flow reductions at the during a 3-month period (February to April[44]). The daily base flow reduction over this 3-month time period is calculated to range from 67 to 128 litres/minute[45] across the combined three watercourse at the Subject Property. These are considered minor reductions as:

- The watercourses will continue to receive contributions from the upgradient areas (north of Highway 407), which are not planned for urban development and are not expected to undergo major land use changes, with the exception of the expansion of quarrying at the Hanson Brick property to the northwest. These upgradient areas are on the order of 2.6 times the catchment area of the future

[44] Calculated infiltration is approximately balanced in January (97%) and May (96%) at the Subject Property.

[45] This is based on daily averages calculated by the monthly water balance for each of the 3 months.

development lands south of Highway 407[46] and therefore these reductions will be small compared to the overall flow received from upgradient land areas. These are calculated by the monthly water balance to range between 800 and 1,200 litres/minute of upstream base flow during the same February to April timeframe. The calculated base flow reductions at the Subject Property also occur over the part of the year where the natural system is fully saturated and thus upgradient flow contributions will be at their greatest during the year; and,

- Baseflow at the lower reaches will also be further augmented at watercourse channel 14W-12A from runoff from about 5.12 ha of rooftop area under the ultimate built out condition. This water will enter the watercourse system to the north of the central SWM Facility (via Reach 14W-12A).

Figures 4.9 and 4.10 graphically presents the monthly and cumulative infiltration calculated using the water balance methodology for the pre-development and post-development with mitigation scenarios across the FM1001 within the Subject Property (Figure 4.9) and for the overall subwatershed (Figure 4.10). As discussed in Section 4.3.3 of this report, approximately 90% of the infiltration is considered to flow laterally towards the watercourses providing base flow, the balance recharging the shale bedrock. Figure 4.9 shows that the calculated monthly infiltration under post-development conditions at the Subject Property ranges between 53 to 64% of the pre-development values between February and April and for the overall subwatershed during this same time interval, from 83 to 86%. Infiltration both on the Subject Property and for the overall subwatershed over the period between June and December is calculated to be higher than the pre-development conditions and may lead to a slight lengthening of the period when baseflow contributions to the watercourses do occur at the Subject Property. The net effect is that overall balance is achieved and that additional infiltration will be directed towards the on-site watercourses during the summer and fall months when the channels have little to no baseflow than currently is the case. During the wetter late-winter and early-spring periods, although the calculated post-development infiltration is reduced from the existing condition, this also occurs during the time of the year when the area is expected to be fully saturated from snowmelt and other runoff. The net effect to the lower reaches of FM1001 is considered positive given the potential for additional water during the summer and fall months.

FM1109 Reach 14W-11 and Reach 14W-11A that traverses the Subject Property at the northeast corner is interpreted to lose water to the ground over much of the year, because of the nearby influence of a buried bedrock valley located to the east. Nonetheless, the water balance predicts an overall calculated increase in infiltration at the Subject Property within this subwatershed of approximately 45% (refer to Tables WB-2-1109 and WB-4-1109 in Appendix 4.7). During the period between February and April, the potential reductions in shallow base flow contributions to this reach are calculated between 4 to 13 litres/minute. We note that this is an overestimate as data collected at the site indicate this stream generally loses water into the ground.

As identified earlier in this report, the existing channel reaches for the main and central watercourses of FM1001 (Reach 14W-16, Reach 14W-14, and Reach 14W-12) are below the interpreted bedrock groundwater levels and so there is minor upward flow of groundwater from the underlying bedrock and intervening till soils towards these channels. These bedrock contributions are small and are insufficient to maintain flow in this watercourse during the summer months (watercourses were observed in dry to pooled

[46] Future development lands to the south of Highway 407 total approximately 109.7 ha (28%) of the total FM1001 subwatershed area.

conditions during both the 2009 and 2010 summer seasons). The bedrock contributions are; however, expected to remain consistent after development.

The proposed realignment of Reach 14W-13 and Reach 14W-14 into a combined Reach 14W-22 alongside the western property line of the Subject property will not result in reduced groundwater inputs from the bedrock into this watercourse system. Under existing conditions, Reach 14W-13 is not interpreted to receive groundwater inputs from the bedrock except at its point of convergence with Reach 14W-14 as its' channel inverts decline from approximately 154 to 149 masl while the interpreted bedrock groundwater elevations (spring conditions, see Figure 4.5) decline from roughly 153 to 148 masl. Reach 14W-14 on the other hand is interpreted to receive bedrock groundwater inputs over its entire on-site length down to the point where it joins with Reach 14W-12A. The channel invert declines from about 154 masl at the northwest corner of the Subject property to about 148.5 masl where it joins up with Reach 14W-12A, while the interpreted bedrock groundwater drops from 155 to 148 masl over this same distance. On average, the groundwater levels at the bedrock are interpreted at between 0.5 and 1.0 m above this Reach's channel bottom during the spring condition. Reach 14W-14's total channel length (existing) is approximately 801 m (see Table 6.24).

Under post-development conditions, the proposed Reach 14W-22 channel inverts will decline from approximately 153.8 masl at the northwest corner of the Subject Property down to about 149.3 masl where it converges with Reach 14W-12A upstream of that reach's confluence with Reach 14W-12. The interpreted bedrock groundwater levels along the proposed channel alignment drops from about 155 to 149 masl. This places the spring bedrock groundwater level, or from between 0.4 m below to about 1.9 m above the proposed channel invert, at an average of about 1.1 m above the channel. The total length of channel interpreted to be below the bedrock groundwater is 1,143 m, which includes 157 m length of Reach 14W-14 that is to remain undisturbed at the upstream end, a 206 m length of proposed Reach 14W-21 (western portion) that diverts upstream flows from Reach 14W-13 into this channel, and the 780 m length of proposed Reach 14W-22 (see Table 6.24).

Therefore, considering the length of proposed channel below the bedrock water table (1,143 m) is about 43% longer than the existing length at Reach 14W-14 (780 m), and the upward head differential is also greater at the proposed channel (-0.4 to +1.9 m, +1.1 m average) compared to +0.5 to +1.0 m, bedrock groundwater contributions into the proposed channel realignment should exceed the existing condition. This is in addition to the calculated infiltration balance in the shallow system with the use of infiltration swales.

As described elsewhere, Reach 14W-11 and Reach 14W-11A, located in watershed FM1109, loses water into the ground. The existing channel bottom is also located between approximately 5 and 7 m above the interpreted bedrock groundwater levels and therefore does not receive any bedrock inputs from within the Subject Property. The proposed realignment (Reach 14W-23) along the north and east property lines will not alter these conditions and therefore no change is expected in the bedrock contributions to this reach after the realignment.

4.4.4.7 Potential Groundwater Seepage Area Near Upper End of the Farm Pond

As discussed in Section 4.3.2.4, there is potential for minor groundwater inputs beyond the upstream end of the Farm Pond in the vicinity of monitor MP-24 as our interpretation of the data indicates this seepage enters Reach 14W-12A to the northwest of the Farm Pond and the topographic channel high between MP-24 and the Farm Pond, meaning that this seepage does not flow to the Farm Pond except during runoff events when the channel flows temporarily raise the Farm Pond levels. The data collected to date at this monitoring nest indicates that the groundwater levels at the two mini-piezometers are closely matched to the surface water level fluctuations of the Farm Pond and are considered to be influenced by precipitation and the changes in surface water levels at the Farm Pond that are induced by these precipitation events. The gradients at this location vary between upward and downward with the water levels at the mini-piezometers being on average, 0.001 and 0.004 m lower than the water levels recorded at the Farm Pond (MP-24S and MP-24D respectively). The upstream end of the Farm Pond therefore is located nearby to an area where groundwater gradients to the water course system are predicted to change from upward (i.e., to the northwest towards MMM-09-10) to downward (the monitors around the Farm Pond to the southeast). The top end of the central SWMP is to be constructed near this area (see Figure HG-4, Appendix 4.5), and the limits of the Farm Pond work is located beyond the predicted extent of the minor seepage area which extends about 35 m east of MP-24.

While these temporal groundwater inputs are predicted to be quite small, should they be impacted by the construction of the SWM facility, they will be replicated in the post-construction condition. A 40 m length of infiltration swale is proposed to the north of the central SWM facility and is expected to easily make up for any losses of minor groundwater discharge presently found at the upstream end of the Farm Pond in the vicinity of MP-24. Infiltration input from this length of trench is calculated at 620 m^3/year of water[47].

An estimate of the groundwater discharges to the edge of the watercourse (Reach 14-12A) within the SWM facility Block[48] was made using a simple Darcy calculation:

$$Q = kiA \ (m^3/year)$$

Where:

- K = bulk hydraulic conductivity (m/year) = 94.6 m/year ($3x10^{-6}$ m/sec, Section 4.3.3);
- i = hydraulic gradient (dimensionless, m/m) = 0.0332 (average of all upward gradients relative to the Farm Pond recorded to date at MP-24D, excludes all negative (downward) gradients in the calculation);
- A = Area of seepage face (m^2) = 70 m^2 (assumed 70 m total length with 1 m seepage face along banks of Farm Pond and channel); and,
- It is assumed that upward seepage potential is present over a 6 month time period

For these calculations we have assumed a 1 m seepage face over 70 m length of shoreline (35 m either side of Farm Pond/channel to the east of MP-24), an area that could be affected by the construction of the central SWM facility. Monitoring station MP-24, as noted, has gradients that vary between inward and outward, and therefore seepage potential to the east of this monitor is expected to be even less as the lands transition to the those with a downward gradient. We have also only considered the time when upward seepage potential may exist (assumed 6 months) and have applied the average of all upward gradients recorded to date (0.00

[47] Pro-rated based on annual calculated infiltration of 25,129 m^3/year over 1,620 m total proposed length of trenches (Table WB-4-1001).

[48] The area to the west is designated as NHS and will not be disturbed and thus is not considered in the calculation. As described in Section 4.4.4.6, groundwater base flow contributions from the removal of Reach 14W- 14 is predicted to be increased by the creation of Reach 14W-22 which will be constructed deeper into the bedrock water table, and results in a longer length of channel that intercepts the bedrock groundwater table.

to 0.215, average 0.0332) over a 6 month period. The hydraulic conductivity for the soils used in the equation is 94.6 m/year, equivalent to $3x10^{-6}$ m/sec obtained from field testing as reported earlier in this report.

Based on the above stated factors, an upper limit of seepage potential in this area that may be lost due to construction of the Farm Pond is calculated at 110 m^3/year. This is not an unreasonable figure given the nature of the native soils (clays and silts with a low hydraulic conductivity) and limited area in which such seepage may occur. The calculated infiltration at the 40 m infiltration swale of 620 m^3/year will make up for this potential loss by a factor of about 5.6 times[49]. Additionally, baseflow at the Reach 14W-12A located in this same area will be further augmented with controlled rooftop runoff measures described earlier in this report.

4.4.4.8 Dewatering Potential

Extensive construction dewatering is not anticipated across the majority of the Subject Property other than for removal of minor seepage into excavations. Dewatering related to building construction will be in large part a function of the proposed building designs. Minimal dewatering would be expected for buildings with slab-on-grade foundations whereas buildings constructed with basements and/or underground parking may require more extensive groundwater removal.

The excavations of the SWM facilities will be mainly within the Clayey Silt Till found at surface across the entire subwatershed, but are also anticipated to be partially completed into the underlying Shale Bedrock. As noted in Section 4.2.1, the Shale is weathered in the upper 3 to 5 m, and is considered the local aquifer, albeit a poor aquifer with low yields. Because the SWM facilities are expected to be constructed fully within low permeability till deposits and in places into the upper weathered zone of the bedrock, some dewatering during construction is anticipated. Groundwater entering the SWM facilities excavations through localized sand seams within the till or from the upper weathered zone of the shale are expected to be managed through passive drainage and pumping through filtered sump pumps. Clay liners will be necessary where the SWM facilities intercept the Shale Bedrock and at localized sand seams within the Till, and the native soils are likely suitable for this purpose[50]. Additional geotechnical drilling investigations should be considered at the proposed SWM facilities to better characterize the expected conditions and dewatering potential during detailed design.

The development will be serviced with municipal water and sewers. The sewer services are expected to be mainly located in the till soils and as such, no dewatering other than local sump pumping for construction of sewer services, is anticipated. Granular pipe bedding backfill material used for buried services may become a preferential flow path for percolated surface water and groundwater. Anti-seepage collars should be installed at regular intervals to prevent continuous groundwater flow along the backfill. The frequency of collar installation will depend on final grade elevation, slope of services and thickness of granular pipe bedding.

[49] The 620 m^3/year of water to be provided by the infiltration trench could conceivably offset a loss of seepage across a total seepage face length of 175 m, or seepage along the shoreline of the watercourse/Farm Pond extending about one quarter of the Farm Pond length to the east. However, as noted elsewhere in this report, the extent of this potential seepage area is limited to the immediate vicinity of monitoring station MP-24, as strong downward gradients from the Farm Pond into the underlying clay/silt soils are present at monitoring wells to the east.

[50] Subject to confirmation by a geotechnical engineer.

Based on the proposed concept plan (refer to Figure 4.7) three watercourse crossings, with buried services (e.g., water, sewer) are proposed within FM1001, with two of these crossings located on the Subject Property. It is understood that the crossings will be carried out using trenchless techniques that will preclude the need for trenching across the existing watercourses. Access pits would need to be constructed at each side of the watercourse and removal of minor groundwater seepage from these pits may be required.

Scheduling excavations for the late summer, if practical, will further serve to reduce groundwater seepage into excavations as this is the time of year when groundwater levels are typically at their lowest. In particular, scheduling the channel crossing works for the late summer when these channels are observed in dry condition is recommended, as this will minimize potential for localized impacts to aquatic life. It is further recommended that the service crossing of the proposed realigned channel be completed at the time of construction of the new channel. In this one location, simple trenching can be used, provided the work is carried out before the realigned channel becomes operational.

Dewatering volumes are not anticipated to exceed 50,000 litres/day. However, dewatering potential is dependent upon a number of factors such as the proposed depth and size of excavations, the time of year and groundwater elevation. It may be later determined that a Permit to Take Water (PTTW) or Environmental Activity and Sector Registry (EASR) from the Ministry of Environment and Climate Change will be required. The need for this permit would be identified at detailed design. The application requirements for a PTTW or EASR requires the applicant to address how much water will be withdrawn, over what time period, where it will be discharged to, the water quality discharge parameters that are to be met, the expected zones of influence and effects on natural features and other users, among other things. Monitoring and mitigation measures would also be required and would be identified in the application. PTTW and EASR applications are submitted after detailed design and in advance of the construction works.

4.5 Conclusions and Recommendations

The Subject Property and the three subwatersheds that traverse the property are located in a hydrogeological environment that is not particularly favourable towards mitigation of infiltration losses (ref. NOCCS Sections 5.5.2 page 5-11, 7.4.4.2, page 7-22). The surficial fine-grained deposits of Halton Till found throughout the study area serves to limit infiltration to the groundwater system (69 mm/year) and as a result, the local stream systems receive a little over two-thirds of their total water from surface runoff (141 mm/year). Almost all of the groundwater base flow into the watercourses occurs over the period of November to May, when the entire shallow system, including upgradient reaches of the channel are saturated and contributing water to the streams. The watercourses are observed in a dry to ponded condition during the summer months as predicted by the water balance, and the comparisons of measured stream flows to estimates from the water balance methodology are reasonable.

The lower reaches of the FM1001 watercourses (generally to the south of Highway 407) are interpreted as receiving minor groundwater contributions from the Queenston Shale bedrock based on water level monitoring carried out at the Subject Property. However, the rate of influx of bedrock groundwater is low, and during the summer months, is insufficient to provide enough water to maintain flow in these watercourses, observed in the summer months as dry to pooled condition. Groundwater inputs from the bedrock in the realigned watercourses after development are however expected to increase compared with the pre-development levels. Over the lower reaches of the main channel there may be greater opportunity for bedrock-based groundwater to maintain pools in the stream channel as the bedrock is exposed in the channel and the watercourse is shaded somewhat by large trees.

The channel section of the FM1109 (Reach 14W-11 and Reach 14W-11A) passing through the northeast corner of the Subject Property is interpreted from collected site data to be losing water to the ground, due to the nearby influence of a buried bedrock valley to the east. The large Farm Pond at the central portion of the Subject Property is also shown to be maintained almost entirely by surface water inflow rather than from groundwater contributions on the basis of the comparison of the measured surface water levels at the pond against the groundwater elevations at monitoring wells constructed around the Farm Pond.

Both upward and downward gradients have been recorded at the mini-piezometer nest (MP-24) located near the upstream end of the Farm Pond. Therefore some minor groundwater contribution to adjacent channel (Reach 14W-12A) may be occurring at times of the year, but the limits of the seepage area is interpreted to be to the northwest of the upper end of the Farm Pond (see Section 4.3.1.1, and Figure HG-4, Appendix 4.5). Even should this seepage make its way towards the Farm Pond, given the larger surface area of the eastern part of the Farm Pond, and the larger outward gradients identified in that area, losses from the Farm Pond will be significantly greater than the potential groundwater inflows from near the upstream end of the Farm Pond.

The 40 m length of infiltration swale proposed to the north of the central SWMP is expected to make up for the potential minor losses of groundwater discharge presently found at the upstream end of the Farm Pond by MP-24. Additionally, baseflow at the lower reaches will also be further augmented at Reach 14W-12A from runoff from about 5.12 ha of rooftop area under the ultimate built out condition. This water will enter the watercourse system to the north of the central SWM facility (via Reach 14W-12A).

The upper weathered zone of the till, with an estimated bulk horizontal hydraulic conductivity on the order of $3x10^{-6}$ m/sec therefore provides the bulk of the groundwater inputs to the local watercourses, but on a seasonal basis over about seven months of the year. The enhanced permeability of this upper zone permits infiltrating groundwater to travel somewhat rapidly through the shallow zone towards the watercourses and it is these conditions that provide the most promising potential mitigation opportunities at this site.

However, these opportunities are of limited extent as:

- The Town of Oakville's land use policies and maximum lot coverage requirements for more intensive employment development dictate 90% of the lots proposed for actual development are assumed to be covered with impervious surfaces, either asphalt/concrete or building envelope, leaving very little pervious area within the developable portion of the Subject Property;

- Significant site grading is proposed within the developable lands, where the tops of the gentle ridges at the Subject Property will be removed by cut and these materials will be placed and compacted in the lower lying lands to raise grades. This will lead to most of the surficial soils within the developable zone consisting of deeper unweathered deposits and reworked and compacted layers of the clayey silt till. These soils will therefore have significantly less transmissive ability to convey large quantities of water at any mitigation devices proposed within the developable lands. This can be improved by tilling/scarifying/ripping the sub-soils (0.5 m depth) and amending them with compost prior to placing topsoil (0.25 m).

Therefore, the most promising opportunity for mitigating against infiltration losses at the Subject Property is along the edges of the existing valley lands where the naturally weathered and fractured surficial till soils will remain undisturbed by construction and will retain their ability to convey water laterally towards the watercourses. It is along these lands that infiltration swales receiving primarily clean roof runoff are proposed, and such infiltration measures are calculated to reduce the on-site infiltration deficit from approximately 62% with no mitigation, to a balance with the pre-existing conditions with the use of the infiltration swales. The balancing of the post development infiltration with existing conditions exceeds the expectation of NOCSS. Post-development base flow during the period between June and December is predicted to be at or above the existing base flow contributions, which includes the dry summer season, where a slight increase in infiltration is provided to the groundwater system from the proposed mitigation measures.

The following recommendations are provided:

- Construct infiltration swales along the edges of the NHS and direct clean roof runoff into these swales and allow it to infiltrate into the ground. These will consist of narrow swales filled with clear stone and amended soils constructed at the rear of developable lots (see Figure 4.8). Clean surface runoff from landscaped areas can be directed towards these swales via vegetated filter strips. No runoff from roads and parking areas are to be directed into the infiltration swales;

- Construction of the swales should only be done in dry weather to avoid remoulding the soil and effectively lining the swale sides and base with an impervious smeared layer. Manual scraping and removal of smeared soils from the sidewalls and base of the swales to expose the natural fracturing should be contemplated;

- Additional investigative techniques such as percolation testing at the proposed infiltration swale locations should be carried out during detailed design to confirm the infiltration rates of the surficial soils along the alignment of the proposed swales, and this information be used in refining the sizing of the swales. It is further recommended that a short length of swale be installed during the detailed design stage and tested to confirm its suitability for its intended purpose;

- Grading at the Subject Property should be, if possible, designed to moderate runoff and enhance recharge characteristics subject to the Town's standards for lot grading;

- Grade the rear/side landscaped grounds on lots adjacent to the natural features (reach valleys) towards these features. This recommendation is also applicable to the SWM facility blocks, where as much of the block area as feasible should be graded towards the valleys rather than back into the SWM facilities;

- Steps to minimize post-development reduction in the infiltrative capacity of the low permeability till soils should be implemented where feasible. These steps are more pertinent to the parts of the Subject Property where minimal site grading is anticipated and they include:

    - Scheduling site grading and heavy construction activities during the drier summer months to reduce the potential of lowering the permeability of these materials while they are in a wet state;

- Where possible, designating areas that should see a minimum of construction traffic. In particular heavy construction equipment must be kept away from the crests of the slopes by the valley lands (along the rear lot lines of the abutting lots), where infiltration swales are proposed;

- Scarify and till the upper 0.5 m of soil within the proposed channel realignments to amend these soils with organic matter and/or placement of thicker topsoil cover (0.25 m) to provide for water storage. This should also be done at the landscaped areas within the development lands. There will be a substantial volume of topsoil at the property after grading and this material can be re-used at the site:

  - However, within the future development lots, it is recommended to defer this mitigation measure to the time when each lot is individually developed and the landscaped areas are known;

- Additional mitigation measures, such as vegetative swales at parking areas, landscaped infiltration ponds/wetlands, green roofs, cistern systems for grey-water use and/or landscape irrigation, etc. are specific to lot configurations, intended use, building design and so forth and should be examined during later stages of detailed design or at the time of building permit applications. For example, construction of landscaped ponds/wetlands would not appear feasible on a lot with a large warehousing facility and extensive parking facilities, but may be feasible at a lot housing a corporate headquarters facility;

- Construct trench plugs at intervals along sewers and buried service trenches to prevent high permeability conduits from intercepting and redirecting groundwater away from discharge areas across the Subject Property;

- Construction of the watercourse crossings should be scheduled if possible during late summer to take advantage of the typically lower groundwater elevations during this season, and will reduce groundwater seepage into the pit excavations required for the trenchless techniques envisioned. The watercourses at the Subject Property have been observed to be in a generally dry condition during the summer and scheduling this work at this time will minimize potential for localized impacts to aquatic life and would potentially limit dewatering during construction;

- The service crossing proposed at the realigned channel should be completed at the time of construction of the new channel (before it comes into service) and in such case can be constructed using standard trenching methods;

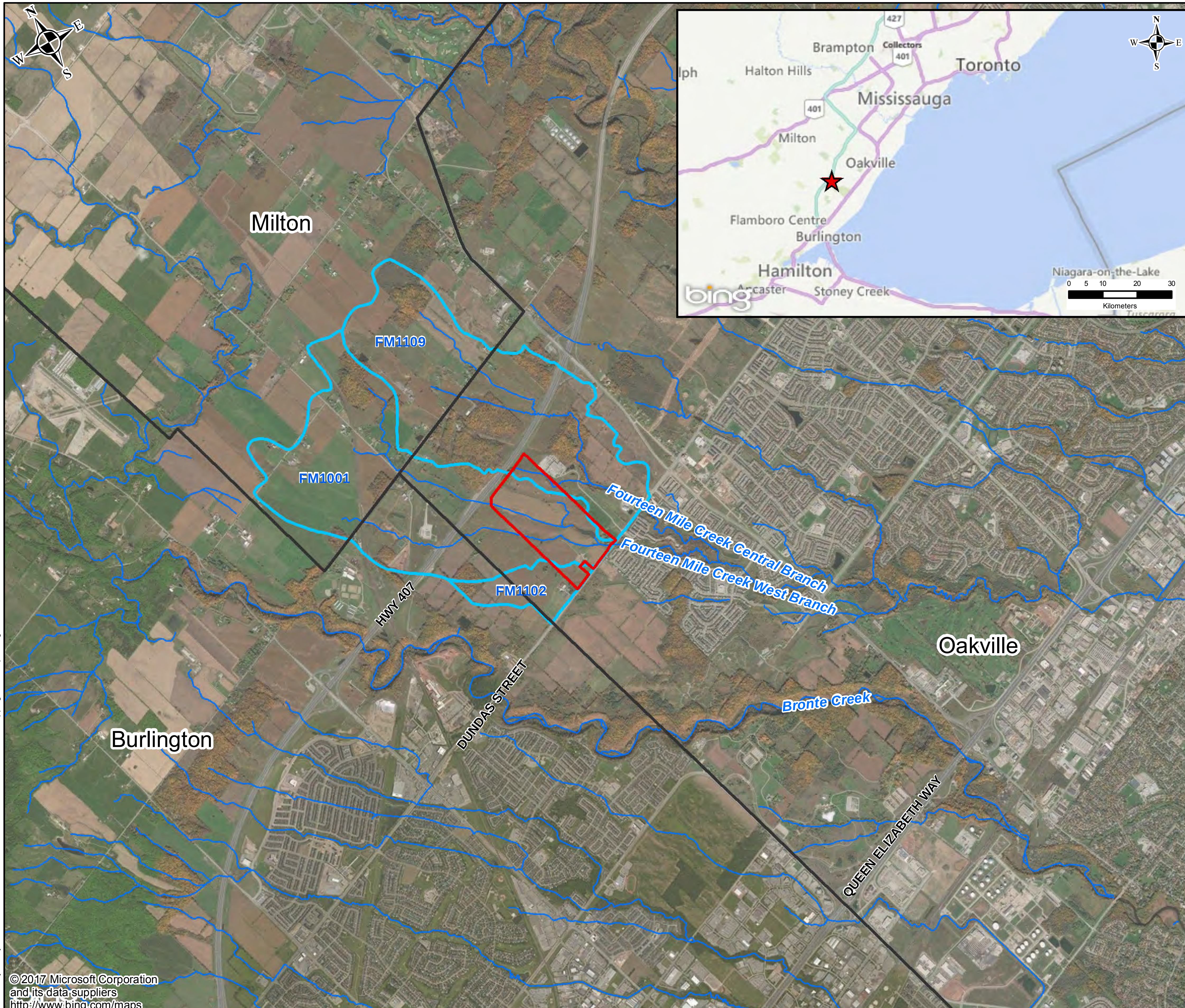
- Dewatering volumes are not anticipated to exceed 50,000 litres/day. However, dewatering potential is dependent upon a number of factors such as the proposed depth and size of excavations, the time of year and groundwater elevation. It may be later determined that a Permit to Take Water (PTTW) or an Environmental Activity and Sector Registry (EASR) from the Ministry of Environment and Climate Change will be required;

- The SWM facilities may be excavated into the Shale Bedrock, and where bedrock or sand seams within the Till are encountered, a clay liner will be required. Additional geotechnical drilling investigations should be considered at the proposed SWM facilities to better characterize the expected conditions and dewatering potential during detailed design;

- Off-site monitoring wells alongside the road allowances are recommended for decommissioning (well locations MMM-09-16 to MMM-09-20 inclusive). These monitors will need to be decommissioned as per the requirements of O.Reg. 903 (as amended);

- Continued baseline monitoring of water levels at the on-site wells is recommended. Monitors presently constructed on the bcIMC property and other adjacent developer owned lands are recommended to remain in place for future monitoring in support of these developments until such time as they are no longer needed, in which case they will also need to be decommissioned as per the requirements of O.Reg. 903 (as amended). Monitors completed to shallow depth that will be completely removed by site grading will not require decommissioning since following site grading there will be no potential contaminant pathway left in place at such locations; and,

- Groundwater monitors presently constructed within natural environment areas should be retained for long-term, post development monitoring. Additional monitors may be required to replace existing monitors to be removed by development.



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Site Location

Legend

- Municipal Boundaries
- Subject Property
- Subcatchment Areas
- Watercourse

Scale 0 0.5 1 2 3 Kilometers

Client: QuadReal

Prepared By: wsp

Date: June 2017

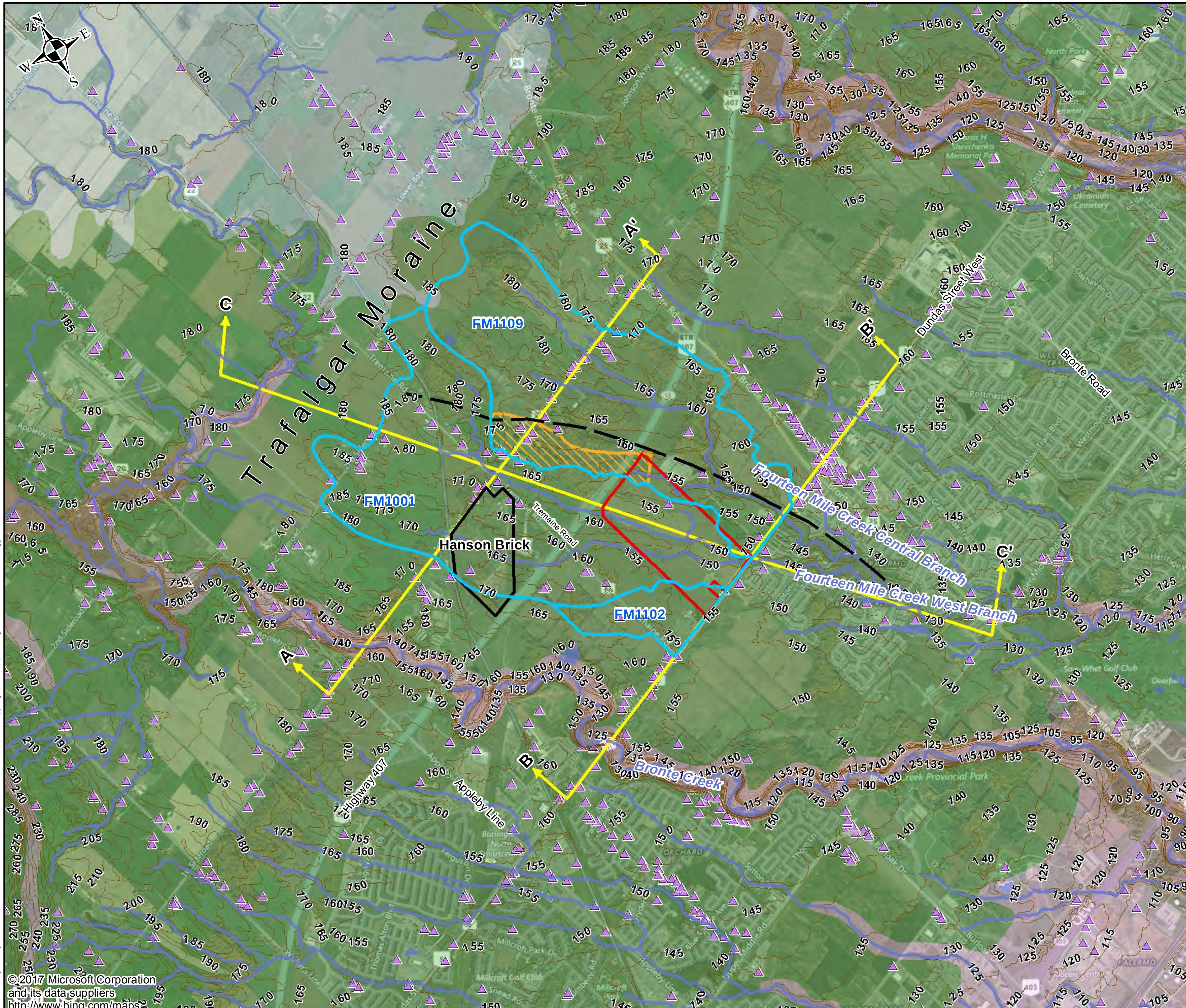
Project No. 09M-00013-01

Scale as Shown

© Queen's Printer for Ontario

Figure: 4.1

J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Figure 4.1 Site Location.mxd



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Surficial Geology

Legend

- Buried Bedrock Valley (Inferred from Water Well Records)
- Approximate Extent of Hanson Brick Tremaine Quarry Lands
- Subject Property
- Watercourse
- Waterbody
- Cross-Section
- Topographic Contour (5m Interval) (Based on OBM mapping)
- MOE Water Well Locations
- Subcatchment Areas
- (See text in section 4.4.4.1.1 of the report for explanation)

Surficial Geology

- Queenston Formation (Shale Limestone)
- Halton Till
- Peel Pond Glaciolacustrine Silt and Clay Deposits
- Modern Alluvial Deposits

Scale 0 0.5 1 2 Kilometers

Client: QuadReal

Prepared By: wsp

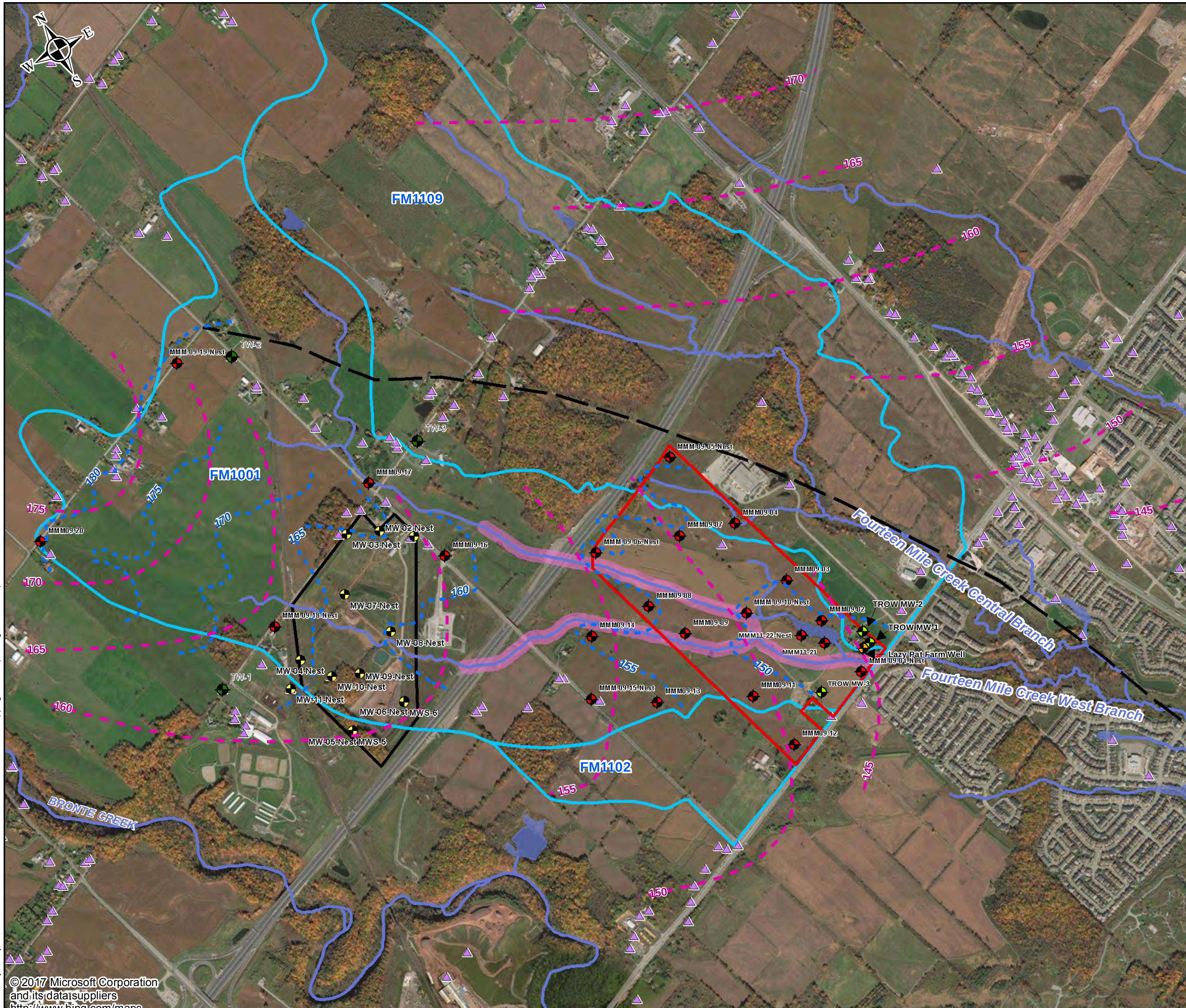
Date: June 2017

Project No. 09M-00013-01

Scale as Shown

Figure: 4.2

J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Figure 4.2 Surficial Geology.mxd



J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Figure 4.3 Interpreted Shallow and Bedrock Groundwater Contours.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Interpreted Shallow and Bedrock Groundwater Contours

Legend

- Interpreted Shallow Groundwater Contours
- Interpreted Bedrock Static Water Levels

Monitoring Locations

- MMM Monitoring Well
- TROW Monitoring Well
- Lazy Pat Farm Well
- Potential Areas with Groundwater Discharge from the Bedrock
- Buried Bedrock Valley
- Subject Property
- MOE Water Well Locations
- Watercourse
- Waterbody
- Subcatchment Areas
- Approximate Extent of Hanson Brick Tremaine Quarry Lands

Locations Not Monitored by MMM

- Hanson Brick Monitoring Well
- Hanson Brick Test Wells

Note: Interpreted bedrock groundwater contours are based on the MOE water well record data along with upper levels from MMM and Hanson Brick monitors.

Scale
0 0.25 0.5 1 1.5
Kilometers

Client: QuadReal

Prepared By: wsp

Date: June 2017

Project No. 09M-00013-01

Scale as Shown

Figure: 4.3

J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Figure 4.4 On-site Monitoring Locations.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

On-site Monitoring Locations

Legend

- Pond Logger (July 2013 - Present)
- Pond Logger (July 2011 - November 2012)
- Lost / Destroyed Mini-Piezometers
- EXP Monitoring Well (2011)
- MMM Monitoring Well (2009/2011)
- Mini-Piezometer
- TROW Monitoring Well (2001)
- Lazy Pat Farm Well
- Flow Monitoring Points
- Staff Gauge
- Surface Water Sampling Location at SG-01
- Supplemental Pond Study Cross Section
- Watercourse

Topographic Contours

- 5 m Interval
- 1 m Interval
- Subject Property

Note: FMP-3 is located offsite at the southeast corner of Tremaine Road and Number 1 Sideroad

Scale 0 100 200 400 Metres

Client: QuadReal

Prepared By: WSP

Date: June 2017

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Scale as Shown

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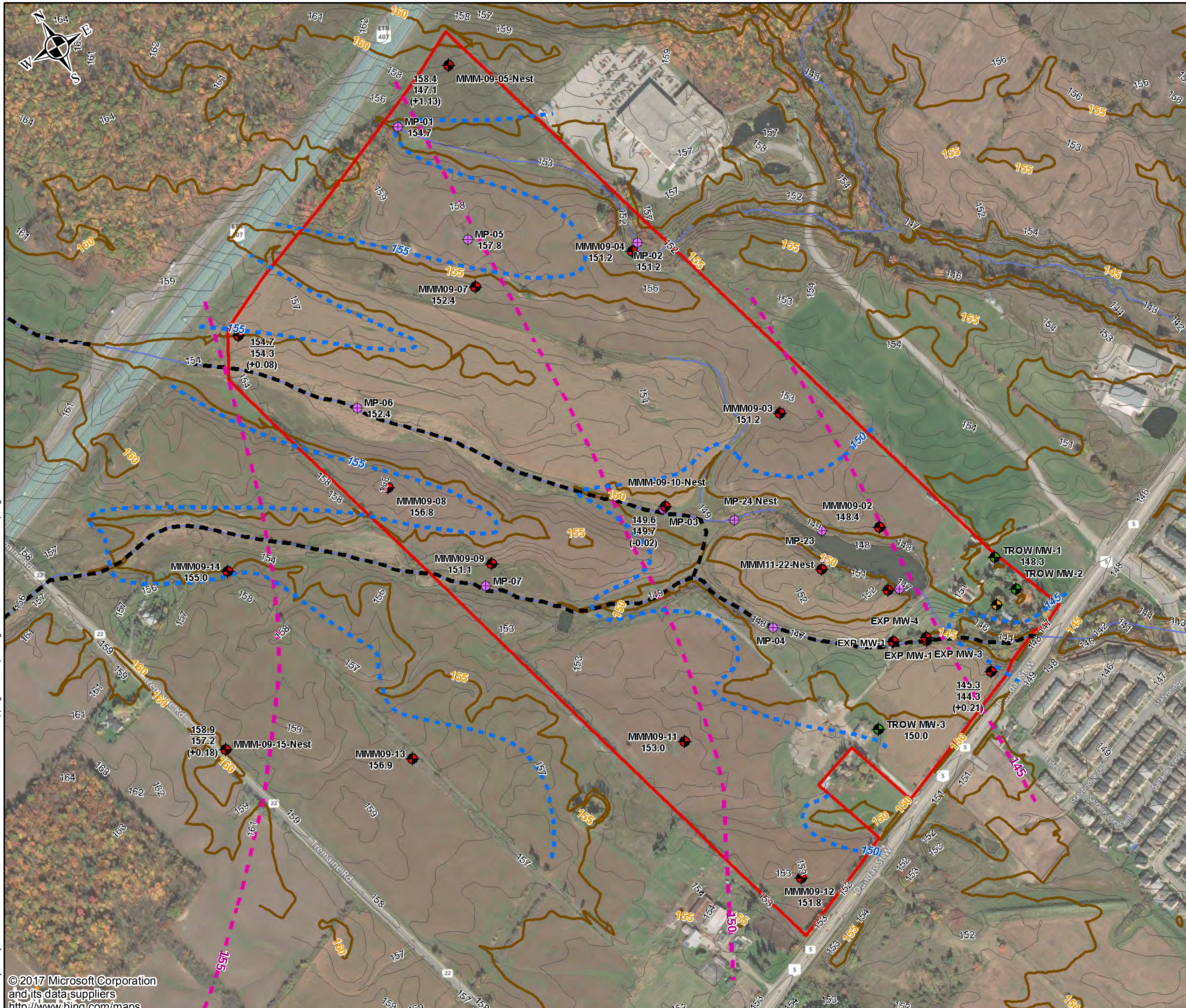
Figure: 4.4



J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Figure 4.5 Static Water Levels - Spring.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Static Water Levels - Spring

Legend

Monitoring Locations

- MMM Monitoring Well
- Mini-Piezometer
- TROW Monitoring Well
- Lazy Pat Farm Well
- Interpreted Shallow Groundwater Contours
- Interpreted Bedrock Groundwater Contours
- Interpreted Zone For Potential Bedrock Groundwater Contribution to Watercourses
- Watercourse

Topographic Contours

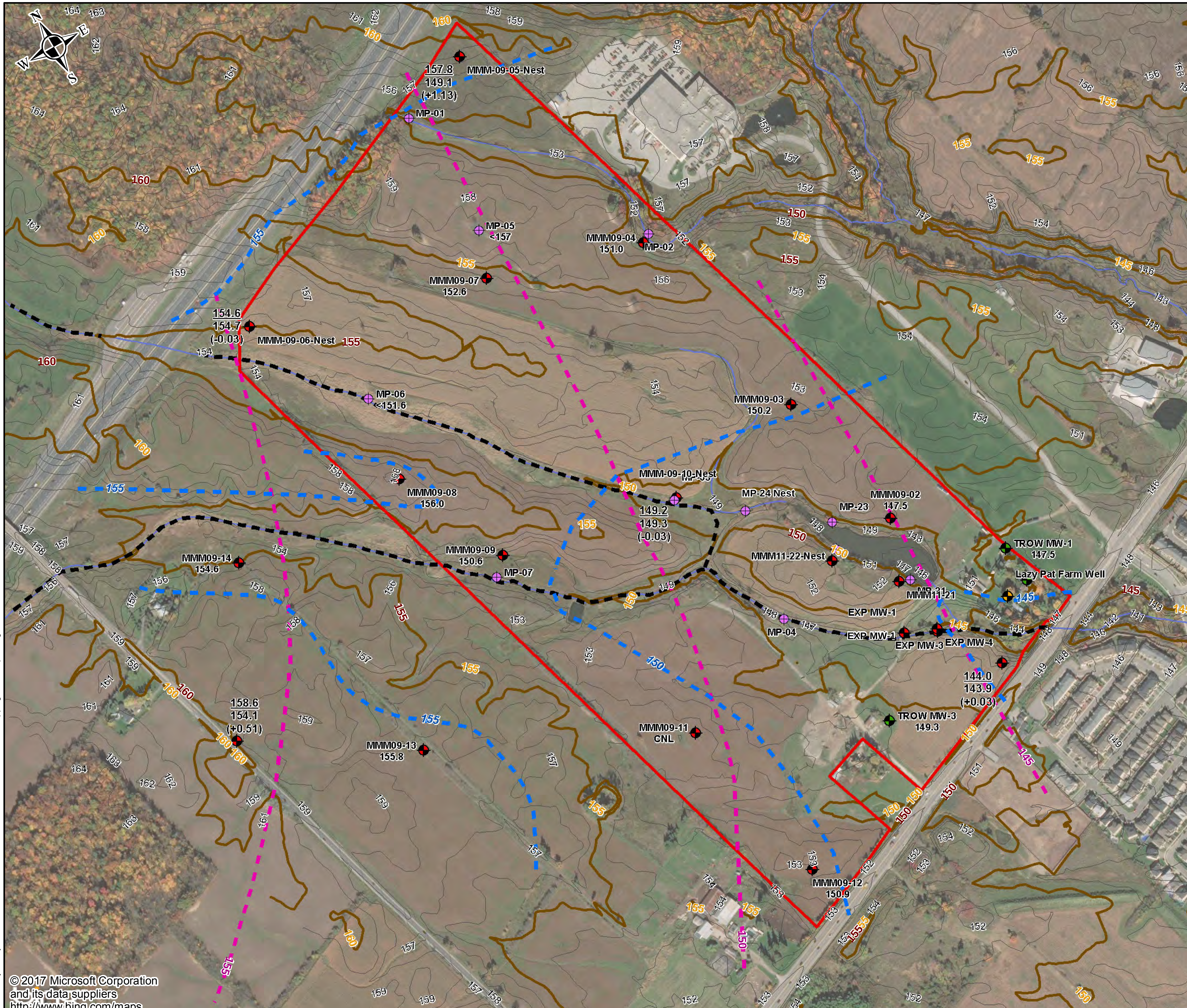
- 5 m Interval
- 1 m Interval
- Subject Property

For the nested wells: The upper value represents the shallow monitor and the lower value represents the deep monitor. The value in brackets represents the vertical gradient at the nest. Positive (+) values indicate downward flow, negative (-) values indicate upward flow.

Based on April 2010 levels. Data for MMM 09-15D is based upon Jan. 2010 levels as April 2010 values were depressed and not fully recovered from groundwater sampling in Feb. 2010.

Scale 0 100 200 400 Metres

Client	Prepared By
QuadReal	WSP
Date June 2017	Project No. 09M-00013-01
Scale as Shown	Figure: 4.5



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Static Water Levels - Summer

Legend

Monitoring Locations

- MMM Monitoring Well
- Mini-Piezometer
- TROW Monitoring Well
- Lazy Pat Farm Well
- Interpreted Shallow Groundwater Contours
- Interpreted Bedrock Groundwater Contours
- Interpreted Zone For Potential Bedrock Groundwater Contribution to Watercourses
- Watercourse

Topographic Contours

- 5 m Interval
- 1 m Interval
- Subject Property

Notes:

CNL - Could Not Locate

For the nested wells: The upper value represents the shallow monitor and the lower value represents the deep monitor.
The value in brackets represents the vertical gradient at the nest.
Positive (+) values indicate downward flow, negative (-) values indicate upward flow based on August 2010 levels.

Scale 0 100 200 400 Metres

Client: QuadReal

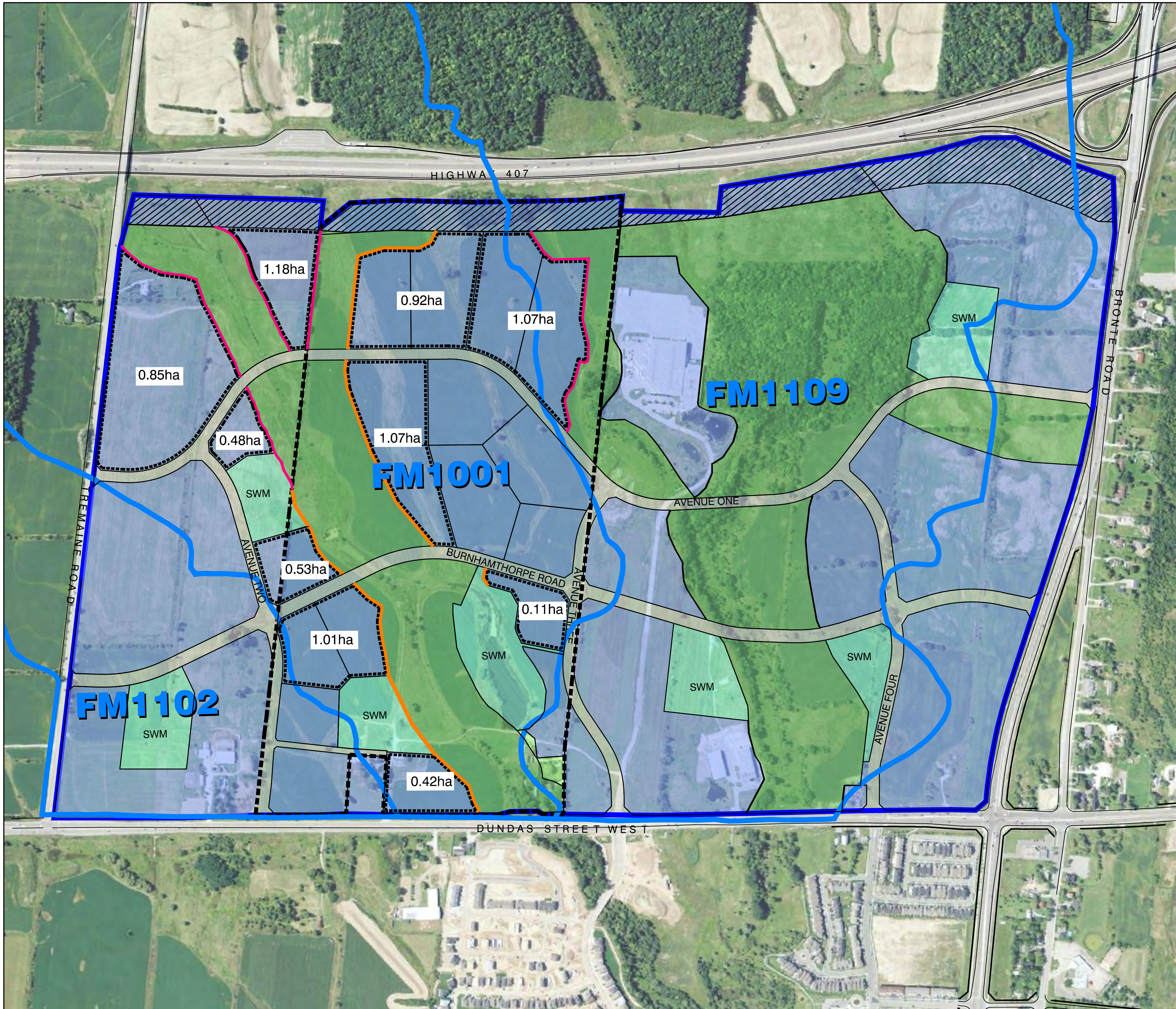
Prepared By: WSP

Date: June 2017

Project No. 09M-00013-01

Scale as Shown

Figure: 4.6



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm property

Concept Plan and Mitigation Opportunities

LEGEND

- Potential Infiltration Swales (1.1m wide)
- Potential Infiltration Swales (1.3m wide)
- Roof Area to Swale - Allocated Area in Hectares for Roof Runoff to be Conveyed to the Infiltration Swales
- Sub-catchment Areas

Note: Mitigation opportunities are identified Bentall owned lands (FM1001 and FM1109) and lands owned by others (FM1001 only)

Scale 1 : 7500

0m 50 100 150 200 250 500m

Client: QuadReal

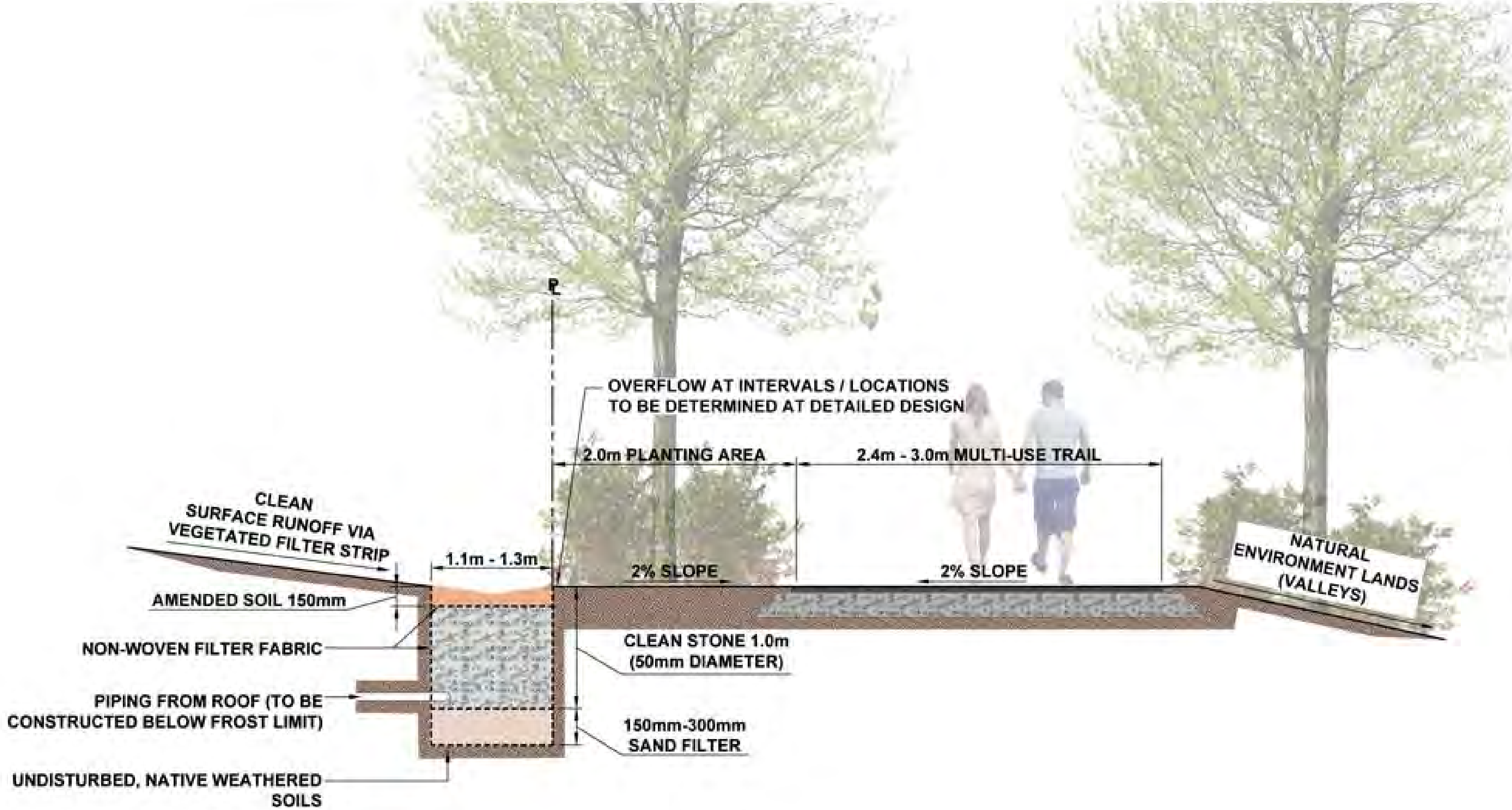
Prepared by: wsp

Date: June 2017

Proj. No. 09M-00013-01 (1409222-001)

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 4.7



NOTES:

1) CONFIRMATION OF LOCATION AND SIZING OF THESE FACILITIES TO BE CARRIED OUT AT DETAILED DESIGN THROUGH ADDITIONAL FIELD INVESTIGATIONS AND PERCOLATION TESTING.
2) INFILTRATION SWALES TO BE CONSTRUCTED AT REAR OF LOTS ADJACENT TO NATURAL ENVIRONMENT FEATURES WHERE FLAT-BOTTOMED INFILTRATION SWALES CANNOT BE BUILT.
3) CLEAN SURFACE RUNOFF DIRECTED TOWARDS THE INFILTRATION SWALES SHALL BE FROM LANDSCAPED AREAS ONLY (NO DRIVEWAY/PARKING LOT RUNOFF) AND SHALL BE DIRECTED TO THE INFILTRATION SWALES VIA SHEET FLOW THROUGH VEGETATED FILTER STRIPS

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Conceptual Infiltration Swale

Scale: N.T.S.

Client: QuadReal

Prepared by: WSP

Date: March 2018

Project No: 09M-00013-01-HG1

Figure 4.8

Figure 4.9: Monthly and Cumulative Infiltration - bcIMC Lands within FM1001
Pre-Development and Post-Development

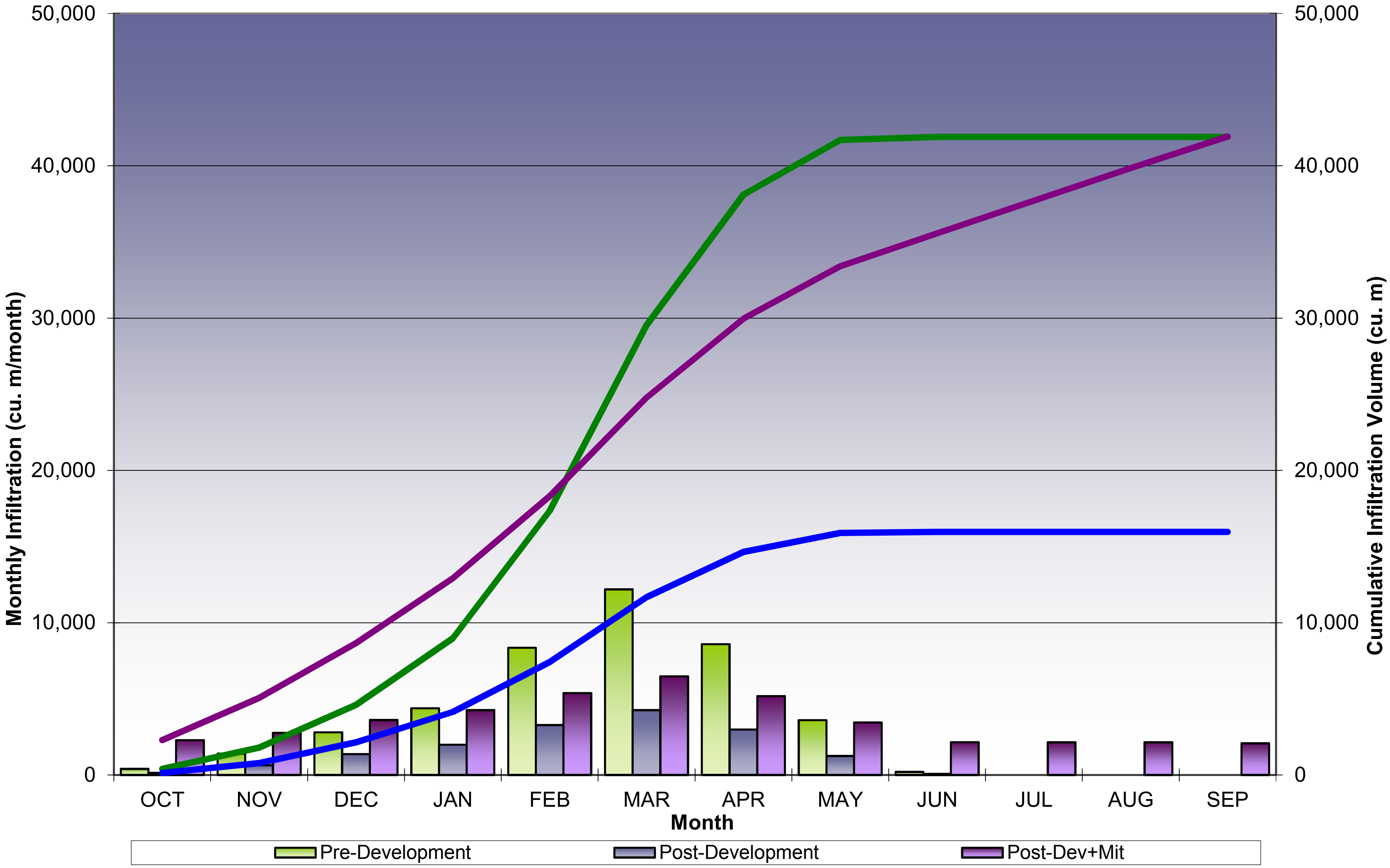
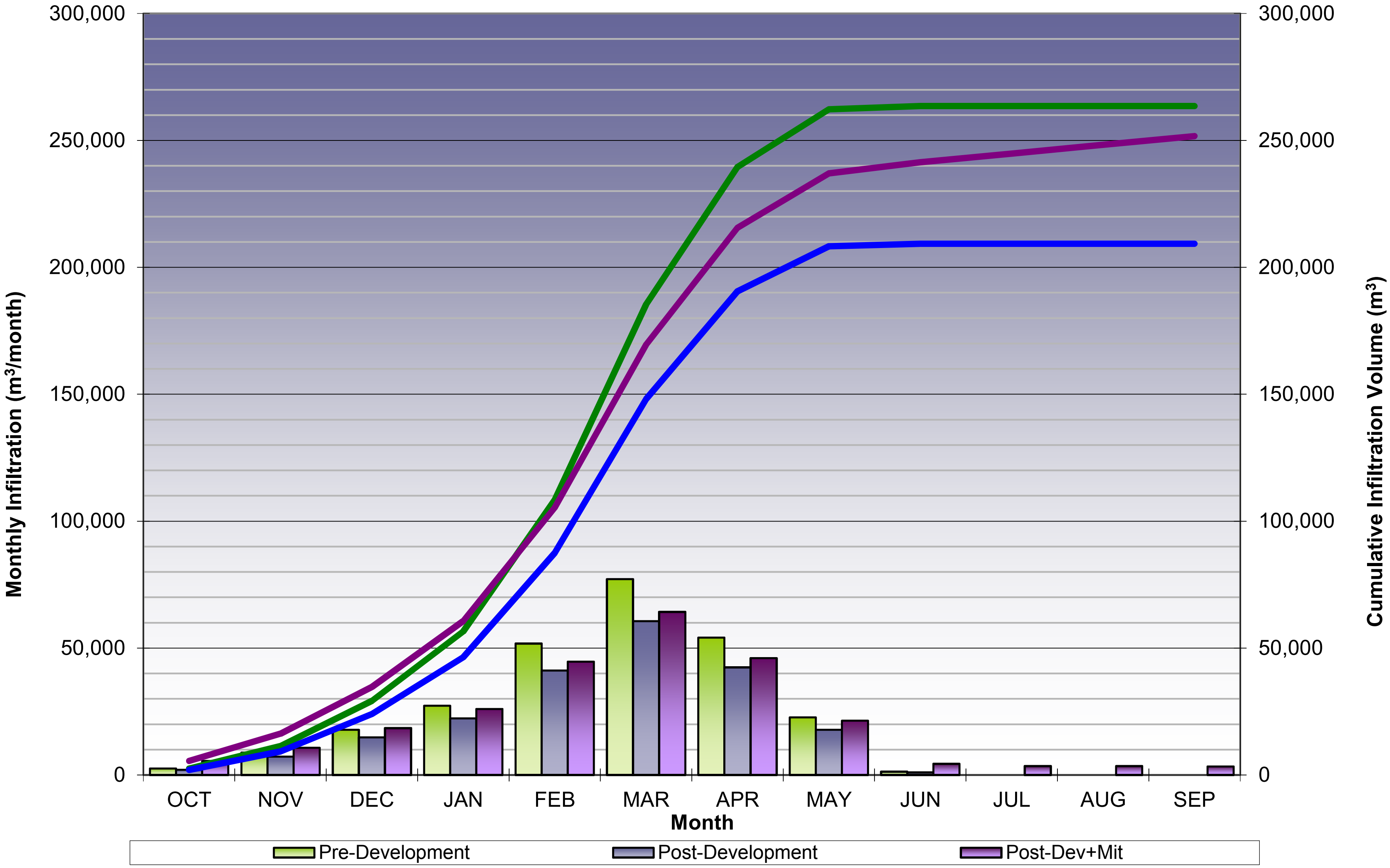
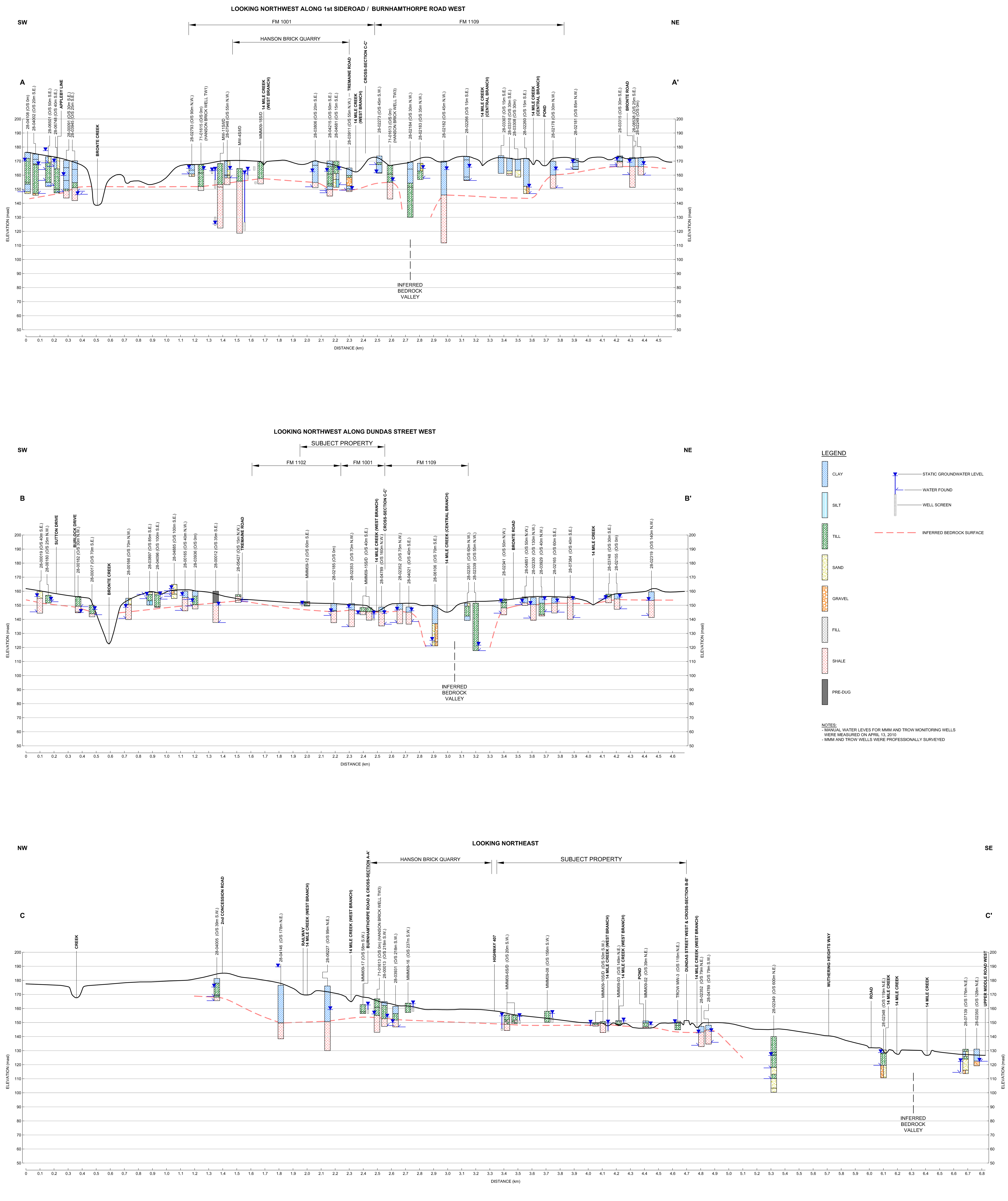


Figure 4.10: Monthly and Cumulative Infiltration - FM1001 Subwatershed
Pre-Development and Post-Development





Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Hydrogeologic Cross-Sections A-A', B-B' and C-C'

Scale

Horizontal 1 : 10000 Vertical 1 : 1000

Client: QuadReal

Prepared by: wsp

Date: JUNE 2017

Project No. 09M-00013-01 (1409222-001)

Drawing 4.1