Hydrogeological Assessment, 556, 560 and 576 Conservation Drive, Waterloo, Ontario

FINAL REPORT

December 2021

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Sign-off Sheet

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Abbreviations

AMSL	above mean sea level
ASTM	American Society for Testing and Materials
BGS	below ground surface
Client	2115881 Ontario Limited
City	City of Waterloo
GRCA	Grand River Conservation Area
LID	Low Impact Development
m	meters
m/s	meters per second
mm	millimeters
mm/hour	millimeters per hour
Meritech	Meritech Engineering
NWSSS	North Waterloo Scoped Subwatershed Study
Region	Regional Municipality of Waterloo
Site	556, 560 and 576 Conservation Drive, Waterloo, Ontario
Stantec	Stantec Consulting Ltd.
SWM	stormwater management

1.0 INTRODUCTION

Meritech Engineering (Meritech), on behalf of 2115881 Ontario Limited (Client), retained Stantec Consulting Limited (Stantec) to complete a hydrogeological assessment for the lands located at 556, 560 and 576 Conservation Drive, in the City of Waterloo, Ontario (Site) (Figure 1) in support of Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 (Figure 1). The Site is bounded to the east by the Conservation Meadows Subdivision, to the south by agricultural lands and the Green Acre Park campground, to the west by Beaver Creek and the Sunfish Lake-Laurel Creek Wetland Complex, and to the north by active agricultural fields.

The Site will be developed for single-family and multi-family units, with a school block, park block, open space, and a stormwater management (SWM) facility. Stantec identified the objectives of the hydrogeological assessment based on comments provided in the following documents (Appendix A):

- Grand River Conservation Authority (GRCA) - Integrated Planning and Public Works, 2017. Re: Zone Change Application Z-16-14, Draft Plan of Subdivision Application 30T-16402, 556, 560 and 576 Conservation Drive, City of Waterloo, 2115881 Ontario Limited / GSP Group. Dated August 11, 2017.
- Region of Waterloo (Region) - Planning, Development and Legislative Services, 2018. Post Circulation Comments, Revised Application for Draft Plan of Subdivision 30T-16402, Zone Change Application Z-16-14, 2115881 Ontario Limited / GSP Group, 556, 560 and 576 Conservation Drive (n/s Conservation Dr., e/s Roy Schmidt Rd.), City of Waterloo. Letter dated June 12, 2018.
- City of Waterloo (City) – Integrated Planning and Public Works, 2018. Second Submission Comments, Zone Change Application Z-16-1, Draft Plan of Subdivision Application 30T-16402, 556, 560 and 576 Conservation Drive.

and comments provided in the e-mail issued by Meritech titled “Cook-Mattamy hydrogeology JQ1279” dated November 8, 2018.

Based on a review of the above documentation, the identified objectives of the hydrogeological investigation are to:

1. Confirm high groundwater levels in those areas of the Site where at source infiltration measures (i.e., infiltration galleries) are proposed, including the gallery associated with the stormwater management (SWM) pond.
2. Prepare a groundwater elevation contour / flow interpretation map representing high groundwater conditions across the Site (as requested by the GRCA and Region of Waterloo).

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In 2021, as per the authorization of Meritech, Stantec performed additional field studies designed to confirm the groundwater elevation and infiltration rates for those soils located beneath the proposed footprint of the on-Site SWM facility.

The Site resides within the North Waterloo Scoped Subwatershed Study (NWSSS) area (Ecoplans Ltd. *et al.*, 2013). Stantec utilized information provided in this study together with field investigation results presented in this report to meet the previously mentioned hydrogeological assessment objectives.

This report is arranged into eight sections, including this introduction (Section 1). Section 2 presents the physical setting of the Site at a regional scale. Section 3 outlines the methods utilized to evaluate the Site hydrogeological conditions. Section 4 presents the results of the Site investigation, with Section 5 discussing the comprehensive treatment train strategy to be utilized at the Site to exceed NWSSS groundwater recharge targets. Section 6 provides a recommended program for continued groundwater monitoring at the Site, which is required for Draft Plan approvals by the City of Waterloo. Report conclusions and references are listed in Sections 7 and 8, respectively.

Appendix A provides correspondence received by review agencies, including the Region of Waterloo, City of Waterloo, and the Grand River Conservation Authority. All figures and tables referenced in this report are presented in Appendices B and C, respectively. Appendices D to L include Regional Groundwater Flow Mapping, Source Water Protection Plan Mapping, Wellhead Protection Sensitivity Area Categories, Borehole Logs, Hydraulic Conductivity Analytical Solutions, Grain Size Analysis, Photographs, SWM Treatment Train Approach, and Amended Soils Assessment Memo, respectively.

2.0 PHYSICAL SETTING

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

Most of the Site is situated within the Waterloo Hills physiographic region, with the northern portion of the Site extending into the Oxford Till Plain (Figure 2). As defined by Chapman and Putnam (1984), the Oxford Till Plain is a drumlinized till plain characterized by undulating to gently rolling topography and soils of a calcareous nature. The Waterloo Hills (also commonly referred to as the Waterloo Moraine) occupies a large portion of the Regional Municipality of Waterloo, with the surface of this physiographic feature consisting of sandy hills, ridges of sandy till, kames or kame moraines and intervening hollows of outwash sand and gravel, which all can be capped by glacial till.

As shown in Figure 2, the Site is characterized by hummocky terrain, with two topographic high points occurring in the northern portion of the property where elevations of 367 m AMSL are observed. From these topographic high points, a portion of the Site slopes to the east to northeast to an approximate elevation of 362 m AMSL along the property boundary with the Conservation Meadows Subdivision. The remainder of the Site generally slopes from the previously mentioned topographic high points to the southwest towards Beaver Creek, where elevations ranging from 353 to 348 m AMSL along the Site western boundaries are encountered.

2.2 SURFACE WATER BODIES AND WETLANDS

As shown in Figure 2, Beaver Creek is located at an approximate distance of 200 m from the north end of the western Site boundary, with the creek moving closer to the property limits towards the south until the creek eventually crosses into the Site. Beaver Creek flows south into the Laurel Creek Reservoir, which is located approximately 250 m to the southeast of the Site, before flowing east to the Grand River (approximately 8.25 km away from the Site). The Sunfish Lake - Laurel Creek Wetland Complex is a provincially significant wetland (PSW) associated with the two creeks and reservoir, with a section of this wetland occupying the southwestern portion of the Site.

Beaver Creek is a potential coldwater system, but its function as a groundwater discharge area has been degraded over the years by intensive agricultural activity in the subwatershed. Minimal groundwater-surface water interactions were interpreted along the majority of Beaver Creek in the NWSSS, except for seasonal groundwater discharge that occurs along the southern extents of this watercourse, located approximately 350 m south of Conservation Drive (Figure 5.22 as per Ecoplans Ltd. *et al.*, 2013, Appendix D).

2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

The Site is largely located within the Waterloo Moraine, a kame moraine formed in an interlobate position between ice lobes extending from the Lake Ontario-Erie, Huron, and Georgian bay areas (Karrow, 1993). Numerous advances and retreats of the ice lobes during the Wisconsinan glaciation resulted in a complex deposit of ice-contact and glacial outwash sands and gravels separated by silt- and clay-rich tills. The conceptual hydrogeologic model for the Waterloo Moraine comprises four main aquifers and aquitards after Terraqua Investigations Ltd (1995), which was broken down further into 19 hydrostratigraphic units after Bajc and Shirota (2007). The model generally does not include more recent deposits shown on surficial geology mapping such as modern alluvium (Unit 19, Figure 3), which are found in the creek/river valleys.

The four regionally based hydrostratigraphic units generally encountered in the area containing the Site, and at depths associated with the current investigation, are described below. The units are described from ground surface downward, with Bajc and Shirota (2007) unit names shown in parentheses.

Aquitard 1 (ATB1): Surficial and spatially discontinuous glacial till unit, which along the eastern flank of the Moraine consists of the Upper Maryhill Till (clayey silt to silty clay) (Unit 5d, Figure 3). Aquitard 1 is characterized by low permeability and forms a relatively impermeable barrier that effectively limits the downward movement of surface water to the deeper aquifer systems. Perched groundwater conditions are commonly encountered within this unit.

Aquifer 1 (AFB1/ATB2/AFB2): This hydrostratigraphic unit represents the main water supply aquifer in the core areas of the Waterloo Moraine. Depending on the depositional environment, the composition of Aquifer 1 varies from a layered silt and fine sand to coarse sand and gravel (Unit 6, Figure 3). Throughout the core areas of the moraine, Aquifer 1 corresponds to a thick, laterally extensive sand and/or gravel aquifer overlying Aquitard 2 and is often exposed at surface in the core areas of the moraine. In some areas, Aquifer 1 is interpreted to be bisected by the Middle Maryhill Till (ATB2), effectively separating Aquifer 1 into two units, AFB1 and AFB2. Along the flanks of the Moraine, Aquifer 1 generally thins as the ground surface elevation decreases and approaches Aquitard 2.

Aquitard 2 (ATB3): Aquitard 2 corresponds to the Lower Maryhill Till (silty to clayey till) and represents one of the primary regional hydrostratigraphic units. The Maryhill Till is broken down into Upper (ATB1), Middle (ATB2) and Lower (ATB3) units by Bajc and Shirota (2007). Along the flanks of the moraine, the Maryhill Till is often found to be discontinuous or has been re-worked and re-deposited as glaciofluvial sediments. ATB3 is present throughout most of the North Waterloo Subwatershed, except for localized areas where it has been eroded by glacial meltwater channels.

Aquitard 3 (ATC1): Aquitard 3 corresponds to the Catfish Creek Till, an olive-grey, very dense sandy to stony silt till that is often referred to as “hardpan” in the MECP water well records. This unit together with Aquitard 2 form a key stratigraphic aquitard unit throughout the Waterloo Moraine, with the Catfish Creek Till beneath the Site reported to range from 10 to 40 m in

thickness. Within the till, a thin aquifer (generally less than 3 m thick) of limited lateral extent can be found, consisting of stratified silt and sand or coarse gravel. This aquifer is referred to by Bajc and Shirota (2007) as AFC1, separating Aquitard 3 into an upper (ATC1) and lower (ATC2) aquitard.

As shown in Figure 5.22 from the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013), the interpreted direction of groundwater flow through Aquifer 1 (AFB1) is from northeast to southwest across the Site towards Beaver Creek.

2.4 SOURCE WATER PROTECTION

2.4.1 Ontario Clean Water Act

As established under the Ontario *Clean Water Act*, 2006, S.O., 2006, c. 22, source protection areas and associated land use restrictions exist for all municipal drinking water sources located throughout the Lake Erie Source Protection Area (LESPA).

The Ontario Ministry of the Environment (now the MECP) introduced the *Clean Water Act* as a means of ensuring the protection of drinking water sources within the Province. The *Clean Water Act* requires that a detailed Assessment Report be prepared for each municipal drinking water system, with this Assessment Report incorporating numerous components as outlined in the document “Technical Rules: Assessment Report, *Clean Water Act* (2006), November 16, 2009”. This legislation provides a basic framework for communities to follow in developing an approach to protecting their municipal water supplies, with the key components of this approach being as follows:

- Identification and assessment of risks to the quality and quantity of municipal drinking water sources and determine which risks are significant and require immediate action, which risks need monitoring to ensure they do not become significant, or which pose low to negligible risk. This information is presented in a detailed Assessment Report, with the content of this report consisting of (i) the defining of Well Head Protection Areas (WHPA) for groundwater drinking water sources and Intake Protection Zones (IPZ) for surface water drinking water sources, (ii) completion of a vulnerability assessment for each WHPA and IPZ, and (iii) identification of drinking water issues and threats.
- Preparation of a Source Protection Plan (SPP) that addresses identified drinking water threats, particularly significant threats.
- Carry out the SPP through existing land use planning and regulatory requirements.
- Perform ongoing monitoring and reporting to measure the effectiveness of the actions taken to protect drinking water sources and ensure that they are protected in the future.

Within the LESPA and specifically the Grand River Source Protection Area, the MECP has designated the following types of vulnerable areas that apply to drinking water sources:

Wellhead Protection Area (WHPA): an area delineated on the ground surface that represents the capture zone for the underlying aquifer in which a given municipal well draws its water. The zone represents the total amount of time it would take for groundwater to flow through the aquifer system and reach the intake of a given municipal well. The zones are defined as follows:

- WHPA-A: 100 m radius around the municipal well.
- WHPA-B: Horizontal time-of-travel to the municipal well is two years or less.
- WHPA-C: Horizontal time-of-travel to the municipal well is equal to or less than five years and greater than two years.
- WHPA-D: Horizontal time-of-travel to the municipal well is equal to or less than 25 years and greater than five years.

Based on a review of the online MECP Source Water Protection Information Atlas (2021) and as shown in Figure 4, the central to eastern portions of the Site is intercepted by WHPA-C for Waterloo North Production Well W25 (Well W25), with the remainder of the Site falling within WHPA-D of this same municipal well. The vulnerability score for the Well W25 WHPA-C that intercept the Site is 4, with the WHPA-D having a vulnerability score of 2.

Significant Groundwater Recharge Areas (SGRA): Groundwater recharge represents the proportion of precipitation and/or surface water run-off that infiltrates to the subsurface and reaches the groundwater table. Recharge areas are classified as “significant” when they supply more water to an aquifer used as a drinking water source than the surrounding area. The volume of water that infiltrates to the subsurface is largely influenced by site topography, the physical properties of the soil, and land cover characteristics. The LESPC (2021a) defines a significant groundwater recharge area (SGRA) to be an area where the annual recharge rate is greater than the average plus 15% or more across the source protection region. As per the Assessment Report (LESPC, 2021a), lands within the Grand River Source Protection Area (i.e., the Grand River Watershed) are deemed to be SGRA when the annual recharge rate is greater than 176 mm/year. Areas of the Site designated as SGRA are presented on Figure 5, with the vulnerability scoring for these areas being assigned 2 or 4.

Highly Vulnerable Aquifer (HVA): Defined as subsurface, geologic formations that are sources of drinking water, which could be easily affected by the release of pollutants on the ground surface. The HVA is identified using variables that include depth to the aquifer, physical properties of the overlying soil and/or rock, and the aquifer composition. In general, an HVA will consist of granular aquifer materials (i.e., sands and gravels) that are exposed near the ground surface and where a relatively shallow water table is present. Based on a review of the online MECP Source Water Protection Information Atlas (2021), the proposed Site development area does not occur within an area designated as HVA.

Intake Protection Zones (IPZ): A zone established around a drinking/surface water intake within which a spill or leak may get to the intake too quickly for the operators of the municipal water treatment plant to shut the intake down until the pollutant passes by. Based on a review of the online MECP Source Water Protection Information Atlas (2021) and as shown in Figure 4, the area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3. The IPZ-3 encompasses Beaver Creek and its adjacent lands (i.e., GRCA Regulation Limit or 120 m horizontal distance from the creek, whichever is greater), representing an area that may capture runoff from extreme storm events (e.g., 100-year rainfall event) and, subsequently, transport a spill or leak potentially occurring within this area downstream to the intake(s) associated with the municipal surface water drinking-water system.

Water Quantity Vulnerable Areas: Water quantity vulnerable areas are determined through a tiered process of water budget analyses as set out in the Technical Rules under O. Reg. 287/07. WHPA-Q is defined as an area where an activity can occur and pose a threat to drinking water quantities. Any activity that takes water without returning it to the same source or an activity which reduces recharge may be a threat in WHPA-Q. Based on a review of the online MECP Source Water Protection Information Atlas (2021), the Site occurs within an area designated as WHPA-Q (Figure E-1, Appendix E).

Issue Contributing Area: A delineated area identifying where activities and conditions as a result of past activities have or are likely to contribute to the elevated concentration of a substance in a muncipal well (i.e., allowing activities to be deemed significant drinking water threats in a larger portion of a WHPA than would normaly be allowed). Based on a review of the online MECP Source Water Protection Information Atlas (2021), the Site does not occur within an Issue Contributing Area.

2.4.2 Region of Waterloo Official Plan

In the Region of Waterloo, sensitivity rankings were developed for the municipal well fields, with these rankings being based on modeled time-of-travel capture zones and the vulnerability of the groundwater to contamination at each individual well head. A Sensitive Area 1 designation represented an area surrounding the well head that has the highest potential for groundwater contamination, whereas a Sensitivity Area 8 designation represents the lowest. As per the Region of Waterloo Official Plan (ROP) (2015), Wellhead Protection Sensitivity Areas (WPSA) are categorized under eight categories (WPSA 1 to WPSA 8). This range of classifications allows for varying degrees of management relative to the vulnerability of the underlying groundwater to contamination, the importance of the subject well to the capacity of the municipal drinking-water supply system, and the length of time groundwater within the WPSA will take to reach the municipal well.

As shown in Figure 6, the Site is located within the WPSA of Waterloo North Production Well W25 (Well W25). The specific WPSA is as follows:

WPSA-8: Where covering the Site, this WPSA indicates that groundwater takes greater than 10 years to flow to the intake of a given municipal production well. As per the ROP (2015) Schedule B, only Category ‘A’ (Very High Risk) land uses are not permitted in this zone, whereas Category ‘B’ (High Risk) and ‘C’ (Moderate Risk) land uses are permitted. Category ‘D’ land uses represent *preferential*

pathways or other land uses that involve soil excavation and/or the creation of subsurface facilities that contribute risk to municipal drinking-water systems by increasing *vulnerability*. Within a WPSA-8, Category 'D' land uses are permitted, except for underground parking garages, geothermal wells, and/or mineral aggregate operations, which must meet the requirements of Policy 8.A.4 before being permitted. A copy of Schedule B from the ROP (2015) that lists the various land uses associated with each Category is provided in Appendix F.

3.0 METHODOLOGY

The hydrogeological site investigation included the:

- review of historical groundwater monitoring data from previous studies
- drilling of boreholes and installation of monitoring wells
- monitoring of groundwater levels
- performing hydraulic response (hydraulic conductivity) testing
- excavation of test pits and performing infiltration testing of onsite soils.

The methodology for these tasks is described in Sections 3.1 to 3.6 below.

3.1 HISTORICAL INVESTIGATIONS

As part of the NWSSS (Ecoplans *et al.*, 2013), Stantec observed the installation of 17 monitoring wells throughout the NWSSS investigation area. Six of these monitoring wells (i.e., MW2-10, MW3-10(S), MW3-10(D), MW3-16(S), MW6-10, MW7-10) occur within the boundaries of the Site (Figure 1). The continuous monitoring of groundwater levels in these wells for the NWSSS have been ongoing since March 2010, with the most recent results presented in Stantec (2021). These groundwater level monitoring results are considered to fall under the City's Phase 1 monitoring program, given that no construction to date has started on any of the properties located within the NWSSS area. A copy of the borehole / well construction logs for the previously mentioned wells is provided in Appendix G.

3.2 BOREHOLE DRILLING

From April 11 to 12, 2019 boreholes were advanced at six locations across the Site (Figure 1) using a CME track-mounted drilling rig equipped with hollow-stem augers operated by a licensed drilling subcontractor (Aardvark Drilling Inc.). The depth of the boreholes extended to 5.2 m to 9.1 m below ground surface (BGS), with each borehole being equipped with a single monitoring well (i.e., MW1-19 to MW6-19). On May 25, 2021, Aardvark Drilling Inc. drilled one additional borehole within the footprint of the proposed end-of pipe SWM facility / infiltrating basin to a depth of 8.8 m BGS, which is also equipped with a single monitoring well (i.e., MW101-21). Soil sampling occurred using a 0.6 m long stainless-steel split spoon sampler at 0.75 m (2.5 feet) intervals for the first 3.6 m (12 feet) of drilling depth, followed by sample collection occurring at approximately every 1.5 m (5 feet) to the termination depth of the borehole. However, for MW101-21, soil sampling occurred at every 0.75 m for the entire depth of the borehole. Stantec personnel directed the drilling and soil sampling operations and logged the borehole stratigraphy. The borehole logs contain descriptions (where relevant and possible) of soil type, texture, colour, structure, consistency, plasticity, moisture content, and other visual and olfactory observations as per the procedures outlined in ASTM (2009) specification D2488-09a. Overall, the boreholes were strategically

positioned throughout the Site to confirm shallow soil conditions and seasonal groundwater depths to assist in the design of Low Impact Development (LID) stormwater management structures. Copies of the borehole logs are provided in Appendix G.

3.3 MONITORING WELL INSTALLATION AND DEVELOPMENT

Stantec observed the installation of monitoring wells in the seven boreholes advanced throughout the Site (i.e., MW1-19 to MW6-19 and MW101-21), with the wells being installed to allow for the measurement of groundwater levels and the completion of other hydrogeological testing. Installation details for each of the monitoring wells are summarized in Table 1. Each monitoring well is constructed of 50 mm inside diameter, Schedule 40 polyvinyl chloride (PVC) pipe, having a No. 10 slot screen (0.01-inch slot) measuring 3.0 m in length. Backfilling of the screened interval consisted of silica sand to a height of approximately 0.3 m above the top of screen, followed by granular bentonite to ground surface prevent a hydraulic connection from occurring between the screened formation and overlying soils. The completion of each monitoring well involved encasing the pipe stick-up within a lockable steel casing. Stantec Geomatics surveyed the ground surface and top-of-pipe elevations at each monitoring well location to a geodetic benchmark using the Can-Net GPS Survey system, having a spatial accuracy of +/- 0.03 m and +/- 0.02 m in the vertical and horizontal plane, respectively.

Following installation, Stantec personnel developed the seven monitoring wells. The purpose of developing the monitoring wells is to remove drilling fluids, solids, or other particulates that may have been introduced during drilling. Stantec personnel purged each monitoring well using dedicated 16 mm inside diameter high density polyethylene (HDPE) tubing connected to a D-25 Waterra™ foot valve. Where possible, Stantec personnel purged from eight to ten standing column volumes from the well to clear out any fine-grained sediments and, subsequently, establish a proper hydraulic connection with the native aquifer material.

3.4 GROUNDWATER LEVEL MONITORING

Groundwater levels were recorded in each of the new monitoring wells (i.e., MW1-19 to MW6-19) from May 2019 to May 2021 using a combination of automated and manual measurement methods. Solinst® Edge Leveloggers® (Leveloggers) were installed in all monitoring wells to allow automatic measurement of water levels. The Leveloggers were suspended into the water column at each monitoring well and set to record water levels at 60-minute intervals. Leveloggers are not vented to the atmosphere and therefore record total pressure (where total pressure is the sum of the atmospheric pressure and the height of water column). To obtain an accurate measurement of the groundwater level at each well, the water level data obtained from the Leveloggers were corrected for atmospheric pressure using data obtained from a Solinst® Edge Barologger® (Barologger), which was suspended in the air column at monitoring well MW1-19.

Groundwater levels were manually measured multiple times from the onsite monitoring wells between May 2019 and May 2021. The groundwater level measurements were recorded in metres to the nearest 0.01 m using a battery-operated water level indicator. Manual groundwater level measurements were used to verify data recorded by the Leveloggers. Manual water levels collected from the monitoring wells are presented in Table 2. Hydrographs presenting both the automatic and manually measured groundwater level data from MW1-19 to MW6-19 are provided in Figure 7.

As mentioned previously, continuous and manual monitoring of groundwater levels in the onsite NWSSS wells (i.e., MW2-10, MW3-10S, MW3-10D, MW3-16S, MW6-10, MW7-10) has been ongoing since March 2010 using similar methods as described above. Details of the NWSSS groundwater monitoring program are described in greater detail in Ecoplans *et al.* (2013). Hydrographs presenting groundwater level data measured from these previously mentioned monitoring wells are provided in Figure 8.

3.5 HYDRAULIC RESPONSE TESTING

To estimate the horizontal hydraulic conductivity of the deposits beneath the Site, Stantec performed in-situ hydraulic response testing on MW1-19 to MW6-19 on May 10, 2019, and MW101-21 on June 1, 2021. The testing completed on MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10 occurred as part of the NWSSS (Ecoplans Ltd. *et al.*, 2013). The testing performed for this investigation consisted of creating an instantaneous change in the monitoring well water level by removing a known volume of water from the well (i.e., rising head / bail test), followed by recording the time taken for the resulting water level to return to static conditions using a combination manual and continuous (i.e., datalogger) measurements. The testing results were analyzed using the Bouwer and Rice (1976) / Bouwer (1989) solution provided in the software package AQTESOLV™ Pro Version 4.5 (Duffield, 2014) to calculate the horizontal hydraulic conductivity of the aquifer sediments within the immediate vicinity of the screened interval of each monitoring well. Table 1 provides a summary of the calculated horizontal hydraulic conductivities, with the analytical solutions for the data being presented in Appendix H.

3.6 INFILTRATION TESTING

3.6.1 Site

Assessment of the infiltration potential for the onsite soils involved the using of a Guelph Permeameter or double ring infiltrometer.

A Guelph Permeameter is a constant head permeameter designed to measure in-situ vertical hydraulic conductivities of a given substrate. Stantec personnel used a hand auger to drill an approximately 0.6 to 0.7 m deep, 50 mm diameter cylindrical hole into the native soil at four locations for testing in May 2020 (i.e., GP101-20 to GP104-20, Figure 1). The Guelph Permeameter was then filled with water, inserted into the hole while making a concerted effort to avoid knocking debris into the excavation, and stabilized against the substrate. Stantec personnel then proceeded to record the eventual steady-state rate of water recharge into the soil at different hydraulic heads. Similar testing was completed previously at the Site as part of the NWSSS program (Ecoplans Ltd. *et al.*, 2013), with two locations being tested in the northern area of the property (i.e., GP5 and GP6, Figure 1). The infiltration rate for each soil tested was converted

from the measured vertical hydraulic conductivity using the established relationship between vertical hydraulic conductivity and infiltration rate presented in the Credit Valley Conservation and Toronto and Region Conservation (2010) Low Impact Stormwater Management Planning and Design Guideline. Table 3 presents the results of this soil infiltration testing.

Infiltration testing using the double ring infiltrometer involves driving two concentric rings into the ground, filling the rings with water, and documenting the drop in water level in the inner ring over a defined period. The observed drop in water level over time (mm/hr) yields the infiltration rate. Prior to testing, the rings are filled with water, allowing the soil to saturate for a period of 30 minutes. The outer ring acts as a buffer for the inner ring, ensuring the soils adjacent to the testing zone are saturated and thus eliminating any horizontal component of infiltration. Once the soils have been saturated, testing is performed, and the infiltration rate is recorded. Stantec personnel used the double ring infiltrometer to test the infiltration potential of the topsoil layer at the same locations where the Guelph Permeameter testing occurred (i.e., GP101-20 to GP104-20). Stantec personnel also collected samples of the topsoil at these locations, which were submitted to a laboratory for grain-size analysis. Results of the infiltration and grain-size analysis testing for the topsoil layer at the Site is provided in Table 3 and Appendix I, respectively.

Stantec also used the in-situ hydraulic response testing results obtained at MW1-19 to MW6-19, as well at the NWSSS monitoring wells MW2-10, MW5-10, MW6-10, and MW7-10, to estimate infiltration rates of the deeper overburden soils (i.e., ranging from 1.5 m to 9.1 m BGS). Since hydraulic conductivity in the horizontal direction is generally an order (potentially two orders for clay-based deposits) of magnitude higher than hydraulic conductivity in the vertical direction (Todd 1980; Freeze and Cherry 1979), the vertical hydraulic conductivities for overburden deposits surrounding the well screens were assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities. The CVC-TRCA (2010) method for converting vertical hydraulic conductivity to an infiltration rate was then applied to these data, with the results being presented in Table 3.

3.6.2 Proposed SWM Facility Infiltration Basin

On May 27, 2021, TDC Excavating Ltd. (TDC) excavated four test pits (i.e., TP1-21 to TP4-21) within the footprint of the proposed end-of pipe SWM facility. As described in the Meritech (2021) *Preliminary Stormwater Management Report*, the SWM facility design consists of a sediment forebay, filtration strip, wetland cell, and infiltrating basin. Under the supervision of Stantec personnel, the test pit excavations occurred within the footprint of the infiltrating basin and extended to the projected base elevation of the basin for the performing of soil infiltration testing. Once completing the soil infiltration testing at the proposed base elevation of the basin, the test pits were then excavated further to depths of at least 1.5 m below the base elevation, with the soils at these depths also being subjected to infiltration testing as per the protocols outlined in the Credit Valley Conservation (CVC) and Toronto and Region Conservation (TRCA) (2010) *Low Impact Stormwater Management Planning and Design Guideline*. Stantec personnel classified the soils targeted for infiltration testing using the ASTM guideline for visual-manual description and identification of soils (ASTM D2488-00) and once the test pit was no longer required, TDC backfilled the excavations to the existing grade.

Assessment of the infiltration potential for the on-Site soils involved the use of a Guelph Permeameter (a constant head permeameter designed to measure in-situ vertical hydraulic conductivities of a given substrate). At the various excavated depths of the test pits, Stantec personnel used a hand auger to drill an approximately 0.5 m deep, 50 mm diameter cylindrical hole into the native soil to be tested. The Guelph Permeameter was then filled with water, inserted into the hole while making a concerted effort to avoid knocking debris into the excavation, and then stabilized against the substrate. Stantec personnel then proceeded to record the eventual steady-state rate of water recharge into the soil. The infiltration rate for each soil tested was converted from the measured vertical hydraulic conductivity using the established relationship between vertical hydraulic conductivity and infiltration rate presented by the CVC/TRCA (2010). Table 3 presents the results of this soil infiltration testing, with photo documentation of the test pit excavation and soil permeability testing work completed being presented in Appendix J.

Using the infiltration testing results, Stantec proceeded to calculate the Design Infiltration Rate for each infiltration facility as per the approach outlined by the CVC/TRCA (2010). The calculated infiltration rate used in the design of the SWM facility infiltrating basin is 67 mm/hour (Table 4).

4.0 LOCAL GEOLOGY AND HYDROGEOLOGY

4.1 GEOLOGY AND HYDROSTRATIGRAPHY

Figure 3 presents the surficial geological conditions within the Site and surrounding area as mapped by the OGS (2010) and the locations of Cross Sections A-A' (Figure 9), B-B' (Figure 10), and C-C' (Figure 11). These cross-sections were constructed using historical borehole information and the results of onsite drilling investigations recently completed by Stantec. A summary of these drilling results is shown on the borehole logs provided in Appendix G.

As shown in Figure 3, surficial deposits of glaciolacustrine-derived silty to clayey till occupy the central portion of the Site, with these deposits extending eastward to the property boundary adjoining to the Conservation Meadows Subdivision. This deposit is interpreted to represent the Upper Maryhill Till of Aquitard 1 (ATB1), with results of the onsite drilling indicating that this unit extends from existing grades to depths ranging from 1.0 to 3.0 m below ground surface (BGS). The drilling results also suggest that the Upper Maryhill Till continues northward across the Site, with clayey silt deposits being found in the shallow subsurface at MW6-19 and MW2-10 (Figure 9).

Ice-contact stratified deposits of fine to medium-grained sand, silty sand, sandy silt, and silt cover the remainder of the Site, with these deposits extending up to 23 m beneath the property to an approximate elevation of 344 m AMSL (Figure 10). These sandy to silty soils represent deposits associated with Aquifer 1 (AFB1) / the Upper Moraine stratified sediments. Below these deposits lies the Lower Maryhill Till (silty to clayey till) of Aquitard 2 (ATB3), which in turn overlies the Catfish Creek Till (Aquitard 3, ATC1). Beneath the Site, the Catfish Creek Till is encountered at an elevation of approximately 327 m AMSL (Figure 10).

4.2 HYDROGEOLOGY

4.2.1 Groundwater Levels

Table 2 provides a summary of the manual groundwater level measurements obtained from MW1-19 to MW6-19 and MW101-21 between May 2019 and May 2021. Hydrographs presenting the continuous and manual water levels recorded within these previously mentioned monitoring wells are provided in Figure 7, with Figure 8 providing groundwater level data collected from the NWSSS monitoring wells (i.e., MW2-10, MW3-10S, MW3-10D, MW3-16S, MW6-10, MW7-10).

Groundwater contour mapping showing the historical high groundwater elevations recorded at each of the previously mentioned monitoring wells (i.e., highest water level observed in all measurements taken from a given well) is presented on Figure 12. In general, groundwater elevations are highest in the northern end of the Site, with these elevations progressively declining southward across the property towards Beaver Creek and the Sunfish Lake - Laurel Creek Wetland Complex. Overall, the high groundwater table

ranges from 357.24 m AMSL to 351.48 m AMSL across the Site, equating to depths of less than 0.1 m BGS (MW6-19) to 7.2 m BGS (MW4-19) based on existing grades.

As shown in the hydrographs (Figures 7 and 8), the groundwater table demonstrated a similar pattern in fluctuations across the Site, with high groundwater conditions predominantly occurring in the spring (i.e., early March to early June) due to lower evapotranspiration losses and a melting snowpack, which in turn provides a greater volume of water available to infiltrate and recharge the groundwater system. Moving through the summer months and into the late fall, the groundwater table declines as a response to more water being drawn from the subsurface over this period to meet evapotranspiration demands.

Groundwater level fluctuations observed at MW2-19 and MW6-19 are shown to respond more readily to climatic conditions (e.g., water table rise from precipitation events, declines from evapotranspiration losses) when compared to fluctuations occurring at the other monitoring well locations. The reason for these differences is due to these monitoring wells being largely screened in the clayey silt to silty clay deposits of the Upper Maryhill Till (Aquitard 1). The smaller pore spaces associated with these finer-grained deposits require a lower volume of water to infiltrate and/or be removed from the subsurface to illicit a rise / fall in the groundwater table compared to the monitoring well locations where the screen intervals are constructed into the coarser-grained sandy deposits of Aquifer 1. The low hydraulic conductivity associated with the Upper Maryhill Till (Aquitard 1) and portions of Aquifer 1 where finer-grained silt deposits predominate (i.e., 10^{-7} to 10^{-9} m/s; Table 1; Appendix H) also limits the ability of infiltrating water reaching the groundwater table to horizontally move through these deposits, causing a mounding effect to occur at these locations during the wetter periods of the year.

4.2.2 Groundwater Flow

Figure 12 presents groundwater elevation contours and the interpreted direction of horizontal flow through the groundwater system beneath the Site using historical high water level measurements collected from the on-site monitoring wells. In general, groundwater contours mimic the prevailing topography of the Site, with horizontal flow predominantly moving in a southwestern direction across the property towards Beaver Creek. This interpreted direction of groundwater flow agrees with flow mapping presented in the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013). However, due to localized groundwater mounding effects that can occur in areas of the Site where low permeability deposits of silt and clay characterize the subsurface, a portion of this horizontal flow may also periodically move to the north to northeast during the wetter parts of the year (i.e., late fall to spring).

Horizontal hydraulic conductivity estimates calculated from onsite hydraulic response testing completed at the monitoring wells completed within the shallow overburden deposits (i.e., 1.3 to 13.7 m BGS) ranged from 1.6×10^{-3} m/s to 1.8×10^{-9} m/s (Table 1; Appendix H), for an estimated bulk (i.e., geometric mean) horizontal hydraulic conductivity of 1.2×10^{-5} m/s (Table 1). Based on the groundwater elevation contours presented in Figure 12, groundwater is interpreted to flow across the Site at an average horizontal hydraulic gradient of 0.01 m/m. Applying Darcy's law:

$$v = \frac{K \nabla}{\theta}$$

where: v = velocity (m/yr)
K = hydraulic conductivity (8.0×10^{-6} m/s)
∇ = hydraulic gradient (0.01 m/m)
θ = effective porosity (0.35 for mixed/silty sand to silt, after Fetter 2001)

The estimated average velocity of horizontal groundwater flow through the subsurface of the Site is calculated to be approximately 13.1 m per year.

4.2.3 Infiltration Potential

4.2.3.1 Site

Estimated infiltration rates for the overburden deposits are provided in Table 3. Infiltration rates were calculated based on an established relationship between vertical hydraulic conductivity and infiltration rate presented in CVC-TRCA (2010), with vertical hydraulic conductivities being estimated based on a combination of results obtained from Guelph Permeameter and infiltrometer testing of surficial soils, and in-situ hydraulic response testing completed at selected monitoring wells (Section 3.6).

Infiltration rates calculated for the topsoil layer (tested using the infiltrometer) throughout the Site ranged from 16 mm/hour to 173 mm/hour, depending on the percentages of sand/gravel and silt/clay found in these soils. As expected, topsoil samples tested that contained a greater percentage of sand/gravel were characterized by higher infiltration rates, whereas samples containing a larger percentage of silt/clay had lower infiltration rates.

Tested vertical hydraulic conductivities for native fine to medium-grained sand deposits directly underlying the topsoil (tested using the Guelph Permeameter) ranged from 2.1×10^{-4} m/s to 7.5×10^{-6} m/s, equating to infiltration rates ranging from 79 mm/hour to 194 mm/hour (Table 3). For those native deposits of silty to clayey sand to silt, vertical hydraulic conductivities ranged from 2.3×10^{-7} m/s to 7.3×10^{-8} m/s, equating to infiltration rates ranging from 23 mm/hour to 31 mm/hour (Table 3). Stantec notes that these previously mentioned deposits were tested at depths ranging from 0.3 m to 0.7 m BGS at the Site.

Vertical hydraulic conductivities for overburden deposits screened at depths between 1.5 m to 9.1 m beneath the Site and tested via in-situ hydraulic response testing completed at the onsite monitoring wells is assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities at these locations (Todd, 1980; Freeze and Cherry, 1979) resulting in values ranging from 2.8×10^{-5} to 1.3×10^{-6} m/s and equating to infiltration rates ranging from 50 mm/hour to 113 mm/hour. For the fine sand having some silt and clay, silt, and clayey silt deposits, vertical hydraulic conductivities ranged from 8.0×10^{-8} m/s to 1.8×10^{-10} m/s, equating to infiltration rates ranging from 5 mm/hour to 23 mm/hour (Table 3).

Overall, the fine to medium-grained sand deposits present at depths ranging from 0.3 m to 9.1 m BGS across the Site are found to have infiltration rates ranging from 79 mm/hour to 194 mm/hour, equating to a geometric mean infiltration rate of 89 mm/hour. For the deposits of fine sand having some silt and clay, silt, and clayey silt, infiltration rates range from 5 mm/hour to 31 mm/hour, equating to a geometric mean infiltration rate of 16 mm/hour (Table 3).

4.2.3.2 Proposed SWM Facility Infiltration Basin

Results of the infiltration testing completed on the subsurface soils located within the footprint of the proposed SWM facility infiltrating basin are summarized in Table 3. Infiltration rates were calculated based on an established relationship between vertical hydraulic conductivity and infiltration rate presented in CVC-TRCA (2010), with vertical hydraulic conductivities being estimated from Guelph Permeameter tests completed at the proposed base elevation of the basin and approximately 1.5 m below this base elevation (Section 3.6).

Tested vertical hydraulic conductivities for predominantly native fine to coarse-grained sand deposits that lie beneath the footprint of the infiltration basin ranged from 8.1×10^{-4} m/s to 3.4×10^{-5} m/s, for a geometric mean vertical hydraulic conductivity of 1.3×10^{-4} m/s. These vertical hydraulic conductivities equate to infiltration rates ranging from 119 mm/hour to 278 mm/hour (Table 3). A tested vertical hydraulic conductivity of 6.1×10^{-6} m/s occurred at a depth of 2.9 m BGS (352.93 m AMSL) in TP4-21, equating to a calculated infiltration rate of 75 mm/hour; however, this relatively lower rate is not representative of the high infiltration rates that mostly characterize the sand deposit that lies beneath the proposed infiltration basin between the depths of 2.9 to 5.5 m BGS (353.98 to 351.43 m AMSL).

As per CVC-TRCA (2010), the calculated design infiltration rate used by Meritech (2021) for the sizing of the proposed infiltration basin is 67 mm/year (Table 4).

5.0 RECHARGE TO GROUNDWATER STRATEGY

A water balance analysis was completed as part of the NWSSS for the 31.8 ha subcatchment of the North Waterloo Subwatershed that includes the Site (Ecoplans Ltd. *et al.*, 2013). The analysis was based on the results of a hydrological model developed for the North Waterloo Subwatershed with the GAWSER modelling software. The analysis made use of regional inputs such as soils, land use, and topography, and local inputs such as meteorological data from the Laurel Dam weather station, and stream flow data from Beaver and Laurel creeks. A key recommendation coming from the NWSSS is that existing pre-development infiltration rates for land parcels located throughout the subcatchment are to be maintained or increased under the post-development condition to mitigate any potential effects to groundwater recharge function and subsequent inputs / discharge to both Laurel and Beaver Creeks. For this Site, Meritech (2021) will be employing a comprehensive treatment train approach designed to exceed NWSSS groundwater recharge targets.

Low impact development (LID) is a stormwater management (SWM) strategy that seeks to mitigate the impacts of increased stormwater runoff by managing this runoff as close to source as possible, with the implementation of such strategies also providing the residual benefit of offsetting potential infiltration losses associated with the increase in impervious surfaces associated with a given development.
The NWSSS recommends that the following LID techniques be considered in stormwater management strategies (for the Site) to meet the previously mentioned objective:

- At source infiltration measures (e.g., soak away pits / infiltration galleries) located in high density areas of the development where suitable soils are present.
- Conveyance controls with roof leader connections for single, semi-detached, and townhouses.
- End-of-pipe facilities with wetland basins and/or infiltration trenches.

As documented and discussed in the Meritech (2021) *Preliminary Stormwater Management Report*, the following post-development LID SWM measures were considered to offset potential infiltration losses associated with the increase in impervious surfaces associated with the proposed development.
A conceptual figure showing the proposed stormwater management treatment train approach that is proposed for the Site is provided in Appendix K. Specifically, this approach will include:

- Lot-level infiltration measures consisting of roof leaders from on-Site buildings being directed to side-yard swales and grassed areas (i.e., roof leader disconnection) or to rear-yard soak away pits / infiltration trenches.
- Use of amended soils in the form of a thicker topsoil layer in remaining post-development pervious areas. This technique would involve using a compacted 250 mm layer of topsoil versus the standard 100 mm used in conventional developments to promote infiltration of precipitation falling on remaining pervious areas of the development, as well as residential roof leaders not connected to the CWC systems or rear-yard infiltration galleries. However, as documented in Stantec's (2020*) Amended*

Soils Assessment (Appendix L), the proposed re-distribution of existing topsoil on-Site (i.e., topsoil moved from areas converted to impervious surfaces and used to increase the thickness of topsoil in remaining pervious areas) would have no impact on the volume of water captured and, subsequently, infiltrated by this measure. As such, Meritech concluded that the use of a thicker topsoil layer was not a necessity to meet the water balance objectives established by the NWSSS for the Site, although this LID technique may still be utilized in the treatment train approach for the purpose of enhancing the initial retention of rooftop water directed to side-yard swales and grassed areas.

- Construction of a clean water collection (CWC) “third pipe” system, consisting of a conveyance system of perforated / exfiltration pipes constructed within the roadway rights of way that will receive and infiltrate clean water captured from the rooftops of the development.

- Establishment of a SWM facility equipped with an infiltrating basin, which will receive stormwater runoff from the development via the storm sewer system and be capable of infiltrating 2-year and 5-year design storm runoff volumes. The proposed location of the SWM facility infiltrating basin is shown on Figure 1. Further details on the SWM facility sizing, depths, functionality, and other associated design parameters are discussed in Meritech (2021).

As per Meritech (2021), the design of the onsite LID post-development infiltration measures will be further developed during the detailed design stage of the project. Overall, the proposed post-development infiltration structures will be constructed largely in the permeable fine to coarse-grained sand deposits that characterize the subsurface of the Site, with these sand deposits having a geometric mean infiltration rate of 135 mm/hour (Table 3). In addition, existing grades throughout the Site will be adjusted to account for the high groundwater table condition and permit the base elevation of the proposed infiltration galleries to remain above the groundwater table and, subsequently, allow for these LID structures to function as designed.

5.1 WATER BALANCE

As per the NWSSS (Ecoplans Ltd. *et al.*, 2013), existing infiltration rates (i.e., recharge to groundwater) are to be maintained or increased to ensure that there is no reduction in base flow to Laurel Creek or Beaver Creek, no change in existing aquifer recharge, and no disruption in the pattern of groundwater recharge.

As documented in the NWSSS, the Site is divided into two major drainage areas: East and West Catchments. Under existing pre-development conditions, runoff from the East Catchment drains south to the Laurel Creek Reservoir across the Conservation Drive right-of-way and along Beaver Creek Road right-of-way. Runoff from the West Catchment drains westward across the Site, passing through the Sunfish Lake - Laurel Creek Wetland Complex before discharging to Beaver Creek. Although a surface water drainage divide characterizes the Site, a similar divide is not present for groundwater. As shown on Figure 5.22 from the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013), groundwater moves to the southwest across the Site towards Beaver Creek, with this flow direction being confirmed via the field work completed as part of the current hydrogeological assessment (Section 4.2.2; Figure 12). As such, any post-development LID infiltration measures employed across the Site, whether occurring within the

East or West Catchments, will contribute to the recharge of AFB1 and ultimately flow to the southwest towards Beaver Creek, which is identified as a potential groundwater discharge feature (Ecoplans Ltd. *et al.*, 2013).

As presented in the NWSSS, the pre-development infiltration targets required to be maintained under the post-development condition for the Site are as follows:

- East Catchment (NWSSS Catchment # 3107): 32,606 m^3/year (281.6 mm/year).
- West Catchment (NWSSS Catchment # 3913): 31,283 m^3/year (265.2 mm/year).

In total, approximately 63,889 m^3 of infiltration must occur on-Site post-development to meet the pre-development target.

As per the water balance calculations / post-development infiltration strategy proposed for the Site by Meritech (2021), the estimated infiltration volumes that will occur on-Site via the proposed treatment train approach are as follows (noting that refinements to these estimates will be further made during the detailed design stage of the project):

- Remaining Pervious Areas = 26,115 m^3/year.
- Rear-Yard Infiltration Galleries = 2,573 m^3/year.
- School Rooftop to Infiltration Gallery = 3,421 m^3/year.
- CWC Conveyance = 33,804 m^3/year.
- End-of-Pipe SWM Facility Infiltrating Basin = 18,424 m^3/year.

In total, approximately 84,337 m^3 of stormwater is expected to be returned to the Site subsurface under the post-development condition, resulting in an infiltration surplus of 20,448 m^3 and exceeding the pre-development infiltration target by approximately 30%. As mentioned previously, since there is no apparent permanent groundwater divide present on the Site, this infiltration can occur within either the East or West Catchment post-development stormwater drainage areas (refer to Figure 6 in Meritech (2021)) as all water entering the subsurface and recharging AFB1 will ultimately flow to the southwest towards Beaver Creek. Overall, the implementation of these infiltration measures is projected to at least maintain, if not enhance, pre-development infiltration volumes throughout the Site under the post-development condition.

5.2 SOURCE WATER PROTECTION

A drinking-water threat is an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water. The following activities are prescribed by the province of Ontario under O. Reg. 287/07 to be drinking water threats (i.e., Significant Drinking Water Threat Policy Categories):



1. The establishment, operation, or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act*.

    a. Untreated sewage
    b. Waste disposal
    c. Mine tailings

2. The establishment, operation, or maintenance of a system that collects, stores, transmits, treats, or disposes of sewage.

    a. Stormwater management
    b. Wastewater treatment plants/sewer systems
    c. On-site sewage systems
    d. Industrial effluent

3. The application of agricultural source material to land.

4. The storage of agricultural source material.

5. The management of agricultural source material.

6. The application of non-agricultural source material to land.

7. The handling and storage of non-agricultural source material.

8. The application of commercial fertilizer to land.

9. The handling and storage of commercial fertilizer.

10. The application of pesticide to land.

11. The handling and storage of pesticide.

12. The application of road salt.

13. The handling and storage of road salt.

14. The storage of snow.

15. The handling and storage of fuel.

16. The handling and storage of a dense non-aqueous phase liquid (DNAPL).

17. The handling and storage of an organic solvent.

18. The management of runoff that contains chemicals used in the de-icing of aircraft.

19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.

20. An activity that reduces the recharge of an aquifer.

21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.

22. The establishment and operation of a liquid hydrocarbon pipeline as per O. Reg. 385/08, s. 3.

As discussed in Section 2.4, the central to eastern portions of the Site is intercepted by WHPA-C for Waterloo North Production Well W25 (Well W25), with the remainder of the Site falling within WHPA-D of this same municipal well. Assigned vulnerability scores for the WHPA range from two (2) to four (4) (Figure 4), indicating that the threat of an activity or condition occurring at ground surface within this area and subsequently adversely affecting the quality and/or quantity of the aquifer system in which these municipal production wells draw their groundwater supply is low. The Site also falls within WHPA-Q1 and WHPA-Q2 (Figure E-1, Appendix E).

As per the SPP (LERSPC, 2021b) Map C2 (Figure E-2, Appendix E), the portion of the Site intercepted by Well W25 WHPA-C is only subject to the protection policies specified under Significant Drinking Water Threat Policy Category 16 (DNAPLs). Since the planned use for the Site will not involve the onsite handling and storage of DNAPLs, the SPP policies under Category 16 do not apply.

The area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3 (Figure 4). Since the IPZ-3 has a vulnerability score of 3.6 (as per the MECP Source Water Protection Information Atlas (2021)), these areas of the Site are subsequently not subject to the land use restrictions specified under the previously mentioned Significant Drinking Water Threat Policy Categories.

Policies in the SPP that address significant threat activities that pose a risk to the quantity of source water available for municipal well use (i.e., Significant Drinking Water Threat Policies 19 and 20) apply to WHPA-Q. Since the Site lies within a WHPA-Q, the Region of Waterloo will likely require that any groundwater taking (e.g., via dewatering or loss of infiltration) be shown to not impact the sustainability of the municipal water supply. As discussed in Section 5.1, water balance calculations indicate that pre-development infiltration volumes can be maintained throughout the Site with the use of post-development infiltration augmentation measures and, ultimately, maintain the groundwater recharge function that the Site currently provides to underlying aquifer systems (i.e., AFB1). Potential effects and mitigation strategies associated with dewatering at the Site (if required) can be addressed at the detail design stage of the development through the completion of a groundwater dewatering assessment.

Although SGRA is identified as occurring within the Site, the SPP (LERSPC, 2021b) currently contains no policies that are applicable to this source protection category. However, as mentioned above, pre-development groundwater recharge volumes at the Site will be achieved under the post-development condition via the proposed stormwater management treatment train approach.

6.0 PROPOSED GROUNDWATER MONITORING

The NWSSS (Ecoplans et al., 2013) proposes that *"in addition to typical 'during-construction' monitoring'… pre', 'during' and 'post'- construction…groundwater monitoring should be prepared as part of supporting studies for future development applications. Terms of Reference for monitoring programs should be submitted for approval by agencies having jurisdiction (e.g., GRCA, Regional Municipality of Waterloo] and City [of Waterloo]) at least two years in advance of a development application being filed on a property."*

The intent of the various stages of proposed monitoring are as follows:

Stage 1. Pre-Construction – Groundwater monitoring within and surrounding the development site to quantitatively identify, and establish a baseline for, hydrogeological site conditions. A minimum of two years of monitoring is required. Stantec notes that the monitoring of groundwater levels at MW1-19 to MW6-19 has been occurring at the Site since May 2019 (Figure 7). In addition, groundwater levels in those monitoring wells constructed throughout the Site as part of the NWSSS (i.e., MW2-10, MW3-16(S), MW3-10(D), MW6-10, MW7-10) have been continuously monitored using data loggers since 2010 as part of the North Waterloo Phase 1 Monitoring Program (Stantec, 2021) (Figure 8).

Stage 2. During-Construction – Continuation of Stage 1 monitoring, including MW1-19 to MW6-19, unless these monitoring wells require decommissioning due to their location falling within the proposed footprint of the development. Monitoring should be completed for the duration of construction.

Stage 3. Post-Construction – Monitoring, as required, to assess the efficacy of mitigation measures implemented during construction. At minimum two years of post-construction monitoring is required, with this phase beginning after 90% build-out of the development has been achieved.

Stage 2 and Stage 3 monitoring plans would at a minimum continue the continuous and manual monitoring of groundwater levels in all onsite wells installed as part of this hydrogeological assessment (i.e., MW1-19 to MW6-19 and MW101-21). Stantec also recommends that continuous water level data collected at MW2-10, MW3-16(S), MW3-10(D), MW6-10, MW7-10 as part of the North Waterloo Phase 1 monitoring program also be reviewed during these stages. The details of each monitoring phase will be confirmed by the City at each transition stage of the development.

7.0 CONCLUSIONS

The following conclusions are provided based on the completed hydrogeological assessment

1. Surficial deposits of glaciolacustrine-derived silty to clayey till, interpreted to represent the Upper Maryhill Till (Aquitard 1; ATB1), occupy the central portion of the Site, with these deposits extending eastward to the property boundary adjoining to the Conservation Meadows Subdivision. The Upper Maryhill Till extends to a depth ranging from 1.0 to 3.0 m BGS, which is underlain by fine to medium-grained sand, silty sand, sandy silt, and silt deposits of Aquifer 1 (AFB1). The deposits of Aquifer 1 occur at ground surface over the remainder of the Site, extending to depths up to 23 m beneath the property to an approximate elevation of 344 m AMSL. Below these deposits lies the Lower Maryhill Till (silty to clayey till) of Aquitard 2 (ATB3), which in turn overlies the Catfish Creek Till (Aquitard 3, ATC1). Beneath the Site, the Catfish Creek Till is encountered at an elevation of approximately 327 m AMSL.

2. The high groundwater table ranges from 357.24 m AMSL to 351.48 m AMSL across the Site, equating to depths of less than 0.1 m BGS to 7.2 m BGS based on existing grades. In general, groundwater elevations are highest in the northern end of the Site, with these elevations progressively declining as one moves southward across the property towards Beaver Creek and the Sunfish Lake - Laurel Creek Wetland Complex.

3. In general, groundwater contours mimic the prevailing topography of the Site, with horizontal flow predominantly moving in a southwestern direction across the property towards Beaver Creek. This interpreted direction of groundwater flow agrees with flow mapping presented in the NWSSS. However, due to localized groundwater mounding effects that can occur in areas of the Site where low permeability deposits of silt and clay characterize the subsurface, a portion of this horizontal flow may also periodically move to the north to northeast during the wetter parts of the year (i.e., late fall to spring).

4. The estimated average velocity of horizontal groundwater flow through the shallow subsurface of the Site is calculated to be approximately 13.1 m per year.

5. Overall, the fine to medium-grained sand deposits encountered at depths ranging from 0.3 m to 9.1 m BGS across the Site are found to have infiltration rates ranging from 79 mm/hour to 194 mm/hour, equating to a geometric mean infiltration rate of 94 mm/hour. For the deposits of fine sand having some silt and clay, silt, and clayey silt, infiltration rates range from 5 mm/hour to 31 mm/hour, equating to a geometric mean infiltration rate of 16 mm/hour (Table 3).

6. Infiltration rates calculated for the topsoil layer throughout the Site ranged from 16 mm/hour to 173 mm/hour, depending on the percentages of sand/gravel and silt/clay found in these soils. In general, topsoil samples tested that contained a greater percentage of sand/gravel were characterized by higher infiltration rates, whereas samples containing a larger percentage of silt/clay had lower infiltration rates.

7. Within the footprint of the proposed SWM facility infiltrating basin (a component of the post-development stormwater management treatment train approach), calculated infiltration rates for the fine to coarse-grained sand deposits that underlie this basin (between the elevations of 353.98 to 351.43 m AMSL) predominantly range from 119 mm/hour to 278 mm/hour.

8. Meritech (2021) will be employing a comprehensive stormwater management treatment train approach at the Site designed to exceed NWSSS groundwater recharge targets. These measures are to include lot-level infiltration measures (i.e., rear-yard infiltration galleries), a clean water collection (CWC) “third pipe” system constructed in roadway rights of way, an end-of pipe SWM facility infiltrating basin, and amended soils in remaining pervious areas of the development. Overall, these post-development groundwater recharge measures will be constructed largely in the permeable fine to medium-grained sand deposits that characterize the subsurface of the Site. In addition, existing grades throughout the Site will be adjusted to account for the high groundwater table condition and permit the base elevation of the proposed treatment train strategies to remain above the groundwater table and, subsequently, allow for these structures to function as designed. Further details on the treatment train facility sizing, depths, functionality, and other associated design parameters are discussed in the Meritech (2021) Preliminary Stormwater Management Report.

9. Water balance calculations performed by Meritech (2021) indicate that implementing the stormwater management treatment train approach will result in an infiltration surplus of approximately 20,448 m^3 occurring at the Site, exceeding the pre-development infiltration target by approximately 30%. Given that there is no apparent permanent groundwater divide present on the Site, this infiltration can occur within either the East or West Catchment post-development stormwater drainage areas (refer to Figure 6 in Meritech (2021)) as all water entering the subsurface and recharging AFB1 will ultimately flow to the southwest towards Beaver Creek.

10. The Site is intercepted by WHPA-C and WHPA-D of Waterloo North Production Well W25. The Source Water Protection (SPP) policies for DNAPLs (Category 16) apply for WHPA-C; however, since the planned use for the Site will not involve the onsite handling and storage of DNAPLs, these policies do not apply.

11. The area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3. Since the IPZ-3 has a vulnerability score of 3.6, these areas of the Site are subsequently not subject to the land use restrictions specified under the previously mentioned Significant Drinking Water Threat Policy Categories.

12. Since the Site lies within a WHPA-Q, the Region of Waterloo will likely require that any groundwater taking (e.g., via dewatering or loss of infiltration) be shown to not impact the sustainability of the municipal water supply. As discussed in Section 5.1, water balance calculations indicate that pre-development infiltration volumes can be maintained throughout the Site with the use of post-development infiltration augmentation measures and, ultimately, maintain the groundwater recharge function that the Site currently provides to underlying aquifer systems (i.e., AFB1). Potential effects and mitigation strategies associated with dewatering at the Site (if required) can be addressed at the detail design stage of the development through the completion of a groundwater dewatering assessment.

13. Although SGRA is identified as occurring within the Site, the SPP currently contains no policies that are applicable to this source protection category. However, the function of the SGRA will not be impacted by the proposed development, given that pre-development groundwater recharge volumes at the Site will be achieved under the post-development condition via the proposed stormwater management treatment train approach.

14. Most of the Site lies within WPSA-8 of Waterloo North Production Well W25. As per the ROP (2015) Schedule B, Category 'A' (Very High Risk) land uses are not permitted in this zone, whereas Category 'B' (High Risk) and 'C' (Moderate Risk) land uses are permitted. Category 'D' (Low Risk) land uses involving underground infrastructure, such as the post-development infiltration measures proposed for the Site (i.e., infiltration trenches, clean water collection (CWC) conveyance system, and SWM facilities) are also permitted in this WPSA.

15. The Site occurs in the NWSSS area and, as such, a groundwater monitoring program is proposed to document pre-, during- and post-construction hydrogeological conditions.

8.0 REFERENCES

American Society for Testing and Materials (ASTM) International. 2009. ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). West

Bajc, A.F. and Shirota, J. 2007. Three--dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, Southwestern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 3, 42p.

Bouwer, H., 1989. The Bouwer and Rice slug test--an update. *Ground Water* 27 (3): 304-309.

Bouwer, H., and Rice, R.C., 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. *Water Resources Research* 12 (3): 423-428.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. Ontario Geological Survey Special Volume 2, 270 pp.

Credit Valley Conservation - Toronto and Region Conservation Authority (CVC-TRCA), 2010. Low Impact Development Stormwater Management Planning and Design Guide – Version 1.0.

Duffield, G.M., 2014. AQTESOLV™ for Windows, Version 4.5 Professional. HydroSOLVE Inc., Reston, VA.

Ecoplans Ltd. (a member of MMM Group), MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 1. November 2013.

Environment Canada. 2021. Canadian Climate Normals 1981-2010, Waterloo International Airport Climate Station, Climate ID 6144239. [Online] http://climate.weather.gc.ca/climate_normals/index_e.html Accessed December 2021.

Fetter, C.J., 2001. Applied Hydrogeology, Fourth Edition. Upper Saddle River, New Jersey, Prentice-Hall, Inc.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice Hall, New Jersey, 604 p.

Karrow, P.F., 1993. Quaternary Geology of the Stratford-Conestogo Area, Southern Ontario. Ontario Geologic Survey Report 283.

Lake Erie Region Source Protection Committee (LESPC), 2021a. Grand River Source Protection Area, Draft Updated Assessment Report. June 17, 2021.

Lake Erie Region Source Protection Committee (LESPC), 2021b. Grand River Source Protection Area, Draft Updated Source Protection Plan. June 17, 2021.

Meritech Engineering. 2021. Preliminary Stormwater Management Report. Revised October 2021.

Ministry of the Environment (MOE). 1990. Wells. Regulation under the Ontario Water Resources Act. Regulation 903 of the Revised Regulations of Ontario, 1990.

Ontario Geological Survey (OGS). 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release -- Data 128-REV, ISBN 978-1-4435-2483-4.

Region of Waterloo. 2015. Regional Official Plan (2031). Approved with modifications by the Ontario Municipal Board on June 18, 2015.

Stantec Consulting Ltd (Stantec). 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for NorthGate Land Corporation, 2115881 Ontario Ltd., Activa Holdings Inc., and Erbsville Kartway. June 2021.

Terraqua Investigations Ltd, 1995. The Study of the Hydrogeology of the Waterloo Moraine. December 1995.

Todd, D.K. 1980. Groundwater Hydrology, 2nd Edition. Wiley, New York, 552 p.

APPENDIX A:
AGENCY CORRESPONDENCE

Grand River Conservation Authority

Administration Centre: 400 Clyde Road, P.O. Box 729 Cambridge, ON N1R 5W6

Phone: 519-621-2761 Toll free: 1-866-900-4722 Fax: 519-621-4844 www.grandriver.ca

August 11, 2017

Trevor Hawkins, M.PL, MCIP, RPP
Integrated Planning and Public Works
City of Waterloo
100 Regina Street South
Waterloo, ON
N2J 4A8

Re: Zone Change Application: Z-16-14
Draft Plan of Subdivision Application: 30T-16402
556, 560, and 576 Conservation Drive, City of Waterloo
2115881 Ontario Limited / GSP Group

Dear Mr. Hawkins,

Grand River Conservation Authority (GRCA) staff have completed their review of the following materials, submitted in support of the above noted applications:

- NRSI, ***Environmental Impact Study***, 2115881 Ontario Limited, North Waterloo (July 2016)
- Meritech Engineering, ***Preliminary Stormwater Management Report***, 556 and 576 Conservation Drive, City of Waterloo (July 2016)
- Stantec, ***Phase 1 Groundwater and Surface Water Monitoring Program***, Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings and Erbsville Kartway (May 13, 2016)
- LVM, ***Geotechnical Engineering Report***, 2115881 Ontario Limited, Proposed Residential Development, 560-576 Conservation Drive, Waterloo, Ontario (March 23, 2015)

Based on the comments provided below, GRCA staff are not in a position to recommend approval of the draft plan (30T-16042) and zone change (Z-16-14) at this time. We look forward to receiving a response and revised materials that address the following comments:

Required Comments to be Addressed:

Planning:

1. We note that a portion of the stormwater for the subject lands will be directed toward an off-site Stormwater Management (SWM) facility, the location and design of which has yet to be determined. Please note that GRCA staff are unable to provide a

comprehensive review and/or support of 30T-16402 and Z-16-14 without this information.

2. Please clarify whether any stormwater from the adjacent "Brohman lands" (620 Conservation Drive) will be directed east toward the subject site. If so, the Preliminary SWM Report will need to address whether the on-site SWM facility can adequately accommodate stormwater from the adjacent property.

3. As noted in our pre-consultation comments dated September 14, 2015, a portion of the Park Block (Block 480) is proposed within the 30 metre wetland buffer. Park is not the intended use of the buffer area; therefore, this portion should be designated as Open Space instead.

4. Section 5.4 of the Environmental Impact Study (EIS) states that "a formal trail system will be provided outside of buffers and natural areas" and GRCA staff are supportive of this approach. However, the location of any proposed trails should be illustrated directly on the Draft Plan to ensure that this recommendation is implemented.

Engineering:

5. GRCA staff agree with the target unit flow rates for discharge to Beaver Creek, as derived in the North Waterloo Scoped Subwatershed Study (NWSSS) using GAWSER modelling of event rainfall from the Guelph Arboretum and 54 years of continuous meteorological data from the Waterloo-Wellington Airport. However, in order to ensure conservative design of major system stormwater conveyance and end-of-pipe storage elements, please use the Regional Municipality of Waterloo 100-year, 3-hour IDF rainfall parameters instead of those applied by the City of Waterloo. The former has 100mm of rainfall while the latter has 90mm. For comparative purposes it is worth noting that the City of Cambridge 2011 Stormwater Management Policies and Guidelines, using AES and Shades Mill meteorological data from 1971-2008, have identified 108mm as the 100-year, 3-hour rainfall depth.

6. Please provide a section view of the proposed stormwater facility discharge controls. In particular, the nature of the 7m wide outlet control weir (as labelled in Figure 4) and its relationship to the extended detention 75mm diameter outlet control orifice is unclear.

7. Please confirm that the stormwater management facility in Block 487 will have side slopes that satisfy Ministry of the Environment (MOE) safety criteria. It would be helpful to document this in Figure 4 of the SWM Report.

Natural Heritage:

8. Section 3.3 of the EIS includes a Grand River Fisheries Management Plan which identifies the objectives for the Laurel Creek fish community as "cold water fish community in areas where geological and biophysical characteristics are present and habitat exists or has been rehabilitated." The EIS acknowledges historical brown

trout spawning in lower reaches of Laurel Creek and the confluence of Beaver Creek. The target for water quality discharging from this proposed development should be for the support of a cold water fish community.

9. Buffer and setback dimensions (EIS Section 4.9) should be identified as minimum dimensions (i.e. not fixed dimensions at this stage in the planning process).

10. EIS Section 5.4.4 should identify a thermal discharge target that will maintain water temperature supportive of the cold water fish community in Beaver Creek and Laurel Creek. Given the close proximity of the site to the confluence of Beaver Creek and Laurel Creek, the instream targets identified in the NWSSS should be used for long term monitoring.

11. Thermal discharge of surface and groundwater should be monitored and measured to assess effectiveness of mitigation measures (EIS Section 6.3).

Additional Comments to be Addressed at Detailed Design:

Further to the above, the following comments will need to be addressed at the detailed design phase in order to satisfy future GRCA permit requirements:

Engineering:

a) GRCA staff agree that the site soils, groundwater and observed ground water elevations appear to provide opportunities for maintaining and enhancing existing annual infiltration volumes. For design purposes, we suggest using site-specific water balance values provided in the NWSSS rather than the MOE Stormwater Management Planning and Design Manual generic values used in the SWM Report's appended calculations.

b) Table 6 of the SWM Report correctly uses annual infiltration values derived in the NWSSS (i.e. 188.4mm on the eastern side of a topographic divide and 222.5mm on the western side (NWSSS 2013, Fig 6.4)). However, the SWM plan uses an MOE 228mm generic for the entire development's pervious areas. As implied in the comment above, post development infiltration rates need further evaluation.

c) Unless the guidelines of the TRCA 2012 document, *Preserving and Restoring Healthy Soil: Best Management Practices for Urban Construction*, are applied, post development rates will typically be reduced due to subgrade compaction, degraded soil structure and decreased top soil depths.

d) Groundwater contour mapping is recommended using the highest observed water surface elevations from both the LVM standpipes and the Stantec monitoring wells.

Natural Heritage:

e) A detailed site grading plan will be required and a Geotechnical Engineer should assess the replacement fill material imported onto the site to ensure that it does not

interfere with surface water infiltration or groundwater movement. The importation of fill material also needs to be coordinated with the final SWM plan to ensure the intended water balance is achieved.

f) A detailed dewatering plan will be required to demonstrate how groundwater contributions to the adjacent watercourse and Provincially Significant Wetland will be maintained.

Advisory Comments for Consideration:

i. The maximum forebay velocity to prevent scour of accumulated sediment is 0.15m/s rather than the 0.5m/s identified in the design calculations. 0.5 m/s is the maximum velocity for dispersion of inflow over the forebay berm. As the proposed design achieves 0.10m/s average velocity through the forebay, this comment is advisory only.

If you have any questions or concerns regarding this letter, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner - Grand River Conservation Authority
519-621-2763 ext. 2292 | ksmith@grandriver.ca

c.c. Kristen Barisdale – GSP Group (email)
2115881 Ontario Limited, 169 Lexington Court Unit B-1, Waterloo ON, N2J 4R3

Region of Waterloo

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Kristen Barisdale, MCIP, RPP (**via email**)
Associate, Senior Planner
GSP Group Inc.
201-72 Victoria Street South,
Kitchener ON N2G 4Y9

File: D18-20/16402
C14-60/4/16014
June 12, 2018

Ms. Barisdale:

Re: Post Circulation Comments
Revised Application for Draft Plan of Subdivision 30T-16402
Zoning By-law Amendment Application Z-16-14
2115881 Ontario Limited / GSP Group
556, 560, 576 Conservation Drive
(n/s Conservation Dr., e/s Roy Schmidt Rd.)
City of Waterloo

The subject applications were received by the Region on August 20, 2016 from GSP Group; application 30T-16402 was deemed complete by the Region's Director of Community Planning on August 23, 2016. The City of Waterloo's Director of Planning Approvals has accepted Zoning By-law Amendment Application Z-16-14 as complete.

On December 21, 2017 and January 3, 2018 respectively, the Region received revised draft plans and the required Regional re-circulation fee. The Region circulated prescribed agencies with the revised draft plan on January 4, 2018. A summary of prescribed external agency comments, as well as comments from Regional staff, is provided below.

The approximately 28.64 ha (70.8 ac) site is situated on the north side of Conservation Drive immediately west of Roy Schmidt Road, in the new Beaver Creek Meadows District area of the City. The subdivision plan dated July 29, 2015 from GSP Group provides development of primarily residential uses to be developed in a single stage and on full municipal services as follows:

Residential:
a) 242 lots for single detached dwelling units;
b) 7 blocks to contain a total of 130 street fronting townhouse dwelling units;
c) 1 block to contain a total of 44 back-to-back townhouse dwelling units; and,
d) 1 block to contain 20-25 Multiple Residential units.

School:
a) 1 block to contain a 2.99 ha (7.4 ac) school site.

Park/Open Space:
a) 2 blocks (approx. 4.86 ha (12 ac) total) for Open Space; and,
b) 1 block to contain a 1.45 ha (3.6 ac) park.

The comments below pertain to review of the submitted plan titled “Draft Plan of Subdivision”, prepared by GSP Group and dated July 29, 2015 (Project No. 09009.40) (last revised November 16, 2017), and associated submitted reports. The comments below have been numbered for discussion purposes.

DELEGATED AUTHORITY COMMENTS

1. Telecon Design (Telus) and HydroOne have each provided that they have no concerns regarding the applications.

2. Rogers Cable, Ontario Power Generation Inc., Waterloo Catholic District School Board, Conseil scolaire de district catholique Centre-Sud, and Le Conseil scolaire de district du Centre-Sud-Quest have not responded to this circulation. By separate letter including a copy of these comments, these agencies are asked to respond at their earliest opportunity if they have any comments.

3. City of Waterloo
As of the date of this letter the City of Waterloo has not provided comments on the application for draft plan of subdivision.

4. Township of Woolwich Engineering and Planning Services
In an email dated January 22, 2018, the Township’s Manager of Planning stated that Township comments dated October 18, 2016 (attached as Appendix A), which were provided in response to the original draft plan circulation, continue to apply. However the Township does note the removal of the walkway on the revised/updated draft plan. The Township is of the opinion that the deletion of the walkway and public access in this area would address Bullet No. 3 of the Township’s October 18, 2016 comments concerning the potential impacts to the adjacent farm. The Township will prefer some form of fencing along the common lot line to ensure that residents backing onto the farm fields will not encroach, use and/or dump onto the abutting lands in Woolwich. The Township is further of the opinion that it would be onerous for the property owners in Woolwich to continually monitor this area to prevent this from occurring.

5. Waterloo-North Hydro Inc.
6. In an email dated April 16, 2018 (attached as Appendix B), Waterloo-North Hydro Inc. (WNH) has advised that it will require that the owner/applicant be required to comply with its requirements and/or conditions of electrical service including the establishment of necessary easements, agreement(s), and detailed engineering design and construction. Furthermore, if necessary, the Developer will be responsible for all costs associated with relocation of any existing WNH facilities as a result of this development.

7. Union Gas
In an email dated January 4, 2018, Union Gas provided that it will require the necessary easements and/or agreements for the provision of gas services for this project to the satisfaction of Union Gas.

8. Canada Post
In an email dated January 15, 2018 Canada Post provided that there are no changes needed to its comments dated September 22, 2016 (attached as Appendix C). Canada Post provided general requirements for the location and construction of centralized Community Mail Boxes. Canada Post has requirements that can be secured through conditions of draft plan approval.

9. Bell Canada
In an email dated September 6, 2016 (attached as Appendix D), Bell Canada provided that it will require the necessary easements and/or agreements for the provision of communication/ telecommunication infrastructure for this project to the satisfaction of Bell Canada.

10. Grand River Conservation Authority
The Grand River Conservation Authority (GRCA) has reviewed the revised draft plan and supporting documentation and have identified in an email dated April 26, 2018 that their original comments dated August 11, 2017 (attached as Appendix E) will continue to apply.

11. Waterloo Region District School Board
In a letter dated September 21, 2016 (attached as Appendix F), the school board provided comments on the original proposed draft plan. Although the school board has not yet provided comments in response to the revised draft plan, it has indicated that its previous comments will continue to apply. When available, comments from the school board will be provided under separate cover.

REGIONAL COMMENTS

Water Services
12. Engineering and Planning staff have reviewed the above noted revised application(s).

13. The Servicing Strategy Report prepared for this development by Meritech, dated July 2016, is generally acceptable.
    a. The report recommends that a detailed water distribution study be prepared at detailed design stage to confirm the fire flow requirements for the subdivision, specifically the higher anticipated fire demand for the school, can be achieved by the proposed water system. Alternatively, building restrictions, materials, sprinkler requirements, etc. can be recommended based on more detailed information.
    b. The applicant should be aware that the Region is currently undertaking a study on the consolidation of Waterloo Pressures Zones 4B, 4C, and 5 which has a direct impact on the application. The objectives of the study are to ensure that once the zones are consolidated that the required level of service is provided to the existing and proposed communities. The study has evaluated the fire flow conditions under future conditions and have identified the existing and proposed fire flow availability. The detailed water distribution study shall incorporate the finding of the consolidation study.

Corridor Planning
Transit Planning
14. In 2018, transit service will be operating on Pinery Trail in this subdivision with the Route 73 Northlake (busPLUS). Transit is requesting 3 transit landing pads within this subdivision with the exact locations to be confirmed in the very near future. The final routing options for the

2018 network are in the later stages of being finalized. Once the final routing is determined Transit staff can identify more exact locations. The current cost for one transit landing pad is $2,800; the total funds for three transit landing pads required from the developer will be $8,400.

Road Traffic Noise Study

15. Corridor Planning staff has reviewed the Preliminary Environmental Noise Impact Assessment for the proposed plan of subdivision at 556 & 576 Conservation Drive, City of Waterloo, prepared by Meritech, dated July 2016. The Report has assessed traffic noise from Conservation Drive.

16. Corridor Planning staff generally concur with the conclusions and recommendations. The applicant will be required to provide a Detailed Noise Impact Assessment, including the height and exact location of the required noise walls. As the subject roads are within City of Waterloo jurisdiction, the recommendations of the study (including the installation of any noise barrier(s)) should be secured through a subdivision agreement with the City. The Region notes that the location of two noise walls identified on the "Noise Assessment Plan" within Appendix C of the Preliminary Environmental Noise Impact Assessment may change through the Detailed Noise Impact Assessment as result of the revised draft plan (last revised November 16, 2017).

Source Water Protection

17. Hydrogeology and Source Water (HSW) staff have reviewed the applicable technical reports submitted for the subject applications and can provide the following comments:

18. Planning Justification Report (GSP, 2016) and Supplementary Information (GSP, 28 July 2016): No comments.

19. Servicing Strategy Report (Meritech, 2016a)
    a. Prior to DPA:
        i. Any existing private wells at the subject property will need to be decommissioned by a licensed well driller in accordance with Ontario Regulation 903 (as amended);
        ii. Any existing septic systems at the subject property will need to be decommissioned in accordance with applicable provincial legislation; and,
        iii. Any existing tile drains at the subject property will need to be decommissioned in accordance with applicable provincial legislation.
    b. Conditions of DPA:
        i. A Salt Management Plan (SMP) will be required for the proposed school block at Site Plan Control. In the event that future revised Draft Plan of Subdivision applications include multi-residential, commercial, institutional, industrial, or community use properties are proposed, a SMP will be required for those properties at Site Plan Control.

20. Geotechnical Engineering Report (LVM, 2015): No comments.

21. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program (Stantec, 2016)
    a. General Comments:
        i. Page 4.3 indicates that at MW6—10, located within the SW portion of the property, Spring 2013/2014 groundwater levels were observed to be as

much as 0.9 m higher than previous levels presented in the NWSSS. This information should be incorporated into design considerations with respect to proposed SWM infrastructure, including lot-level, conveyance, 3rd pipe, and EOP infiltration galleries.

b. Prior to DPA:
    i. An updated groundwater contour map should be generated to reflect the high water table conditions observed across the monitoring area during the Spring 2013/2014 groundwater monitoring events. This should be submitted in an updated hydrogeological report;
    ii. The maximum groundwater elevations observed at each on-site groundwater monitoring well should be reported in m ASL in the report. This data needs to be summarized in tabular format in an updated hydrogeological report for all on-site wells, including the groundwater monitoring wells installed in 2015 by LVM; and,
    iii. Groundwater monitoring wells were installed across the site during the geotechnical investigations by LVM (2015) should be incorporated into the Phase I and Phase II monitoring program until site grading requires that they be decommissioned. Of particular interest are monitoring wells BH-4-15 and BH-05-15, which are installed in the vicinity of one EOP and one conveyance infiltration gallery. Information from these groundwater monitoring wells should be incorporated into the design considerations for these infiltration galleries. The hydrogeology report should be updated to reflect these additional groundwater monitoring locations.

22. Preliminary Stormwater Management Report (Meritech, 2016b)
    a. Prior to DPA:
        i. Table 1 indicates that “Control of Roof Leaders” is not included in the SWM Plan for the proposed development. A 3rd pipe collector system is potentially being proposed as a means to infiltrate clean roof top water from residential homes; however, this has not been confirmed in the preliminary design. It is noted that the 3rd pipe system would only collect water from the front half of the roof tops, and rear-yard roof runoff would be directed towards pervious surfaces. The conceptual design details of a 3rd pipe system were not presented in the Preliminary SWM Report. HSW will require more details as to how this system will function (i.e. will it be perforated pipe that actively infiltrates water within the road right-of-way, or will it be collected in a larger infiltration gallery and discharged in a more point-source manner?). These details need to be provided in an updated Preliminary SWM Report;
        ii. The proponent should be aware that a distributed approach to groundwater recharge will be required across the proposed development, where soil conditions permit;
        iii. Page 11 of the report cites the NWSSS and Geotechnical Report (LVM, 2015) when discussing groundwater conditions at the site. The Report does not reference the higher groundwater elevation conditions noted in Stantec (2016). The Preliminary SWM Report will need to be updated to make reference to the conditions noted in the Stantec (2016) report, and provide an opinion as to whether or not the feasibility of the SWM infrastructure is impacted by these results;
        iv. Page 14 indicates that infiltration measures that receive from the streets

should be designed to bypass in the winter months. HSW agrees with this recommendation, however, was this winter by-pass taken into consideration for the post-development water balance? This needs to be confirmed, and potentially included in a new water balance in an updated Preliminary SWM Report;

v. The assumed post-development infiltration rate on pervious surfaces was 228 mm/yr for all pervious areas within the proposed development. This is higher than either of the infiltration rates used for the pre-development conditions. The proponent should provide rationale as to a) why the property wasn't broken down into east and west portions (with different infiltration rates), as it was in the pre-development infiltration calculation, and b) why the overall infiltration rate for the site was increased to 228 mm/yr. If the rationale is not to the satisfaction of HSW, the post-development infiltration volumes will need to be re-assessed and summarized in an updated Preliminary SWM Report;

vi. The post-development infiltration area for the Clean-Water-Conveyance (CWC), or 3rd pipe system, was reported as 2.46 ha. Does this area represent the total roof area of the development, or only half of the roof area for the development? It is noted that earlier sections in the report stated that a 3rd pipe CWC system would only capture runoff from the front half of residential roof tops. This should be clarified in an updated Preliminary SWM Report;

vii. Do the infiltration galleries in Catchments 504, 505 and 506 take winter by-pass shutoffs into consideration when determining post-development infiltration volumes? This needs to be clarified in an updated Preliminary SWM Report;

viii. The Preliminary SWM Report should be updated to include an analysis demonstrating, in terms of m3/yr:

$$P_{Pre\text{-}Dev} = P_{Post\text{-}Dev}$$

$$ET_{Pre\text{-}Dev} + R_{Pre\text{-}Dev} + I_{Pre\text{-}Dev} = ET_{Post\text{-}Dev} + R_{Post\text{-}Dev} + I_{Post\text{-}Dev}$$

ix. The proposed Stage II Monitoring Program should include sodium and chloride in the groundwater quality monitoring program. Manual water levels and data logger downloads should be performed quarterly. The proposed Stage II Monitoring Program needs to identify which groundwater monitoring wells are proposed to included in the Program. Groundwater elevation and quality monitoring should be performed in the groundwater monitoring wells installed by LVM (2015) (particularly in BH-04-15 and BH-05-15). These details need to be included in an updated Preliminary SWM Report. And,

x. The Preliminary SWM Report should be updated to reflect the revision to the original draft plan of subdivision. Specifically, the water balance should be revisited to adjust for Block 243 (new proposed townhomes) and Block 251(proposed multi-res block).

b. Conditions of DPA:

i. Seasonal high groundwater elevations were observed during the spring months of 2013/2014 as presented in Stantec (2016). Proposed conveyance and EOP infiltration galleries will need to be designed to have

a separation between the bottom of the infiltration gallery and the maximum groundwater elevation observed at each respective location. The high water table across the site may influence where lot-level and 3rd pipe conveyance systems are feasible. This will need to be verified prior to approval of the Final SWM Report, to the satisfaction of the Region, City and GRCA;

ii. Any proposed lot-level infiltration galleries and / or 3rd pipe collector systems will need to be oversized by 15% to account for decreased performance over time and/or private homeowner disconnection;

iii. Any EOP infiltration galleries will need to be oversized by 15% to account for decreased performance over time;

iv. Is it feasible to install a CWC system throughout the entire 503 and 701 Catchments, given the generally lower-permeability soils identified in the eastern portion of the site? This should be addressed in the Final SWM Report;

v. It is HSW's preference to see infiltration of clean roof top runoff to achieve a net zero loss of pre-development infiltration volumes. Infiltration of impervious road runoff should only be incorporated if additional infiltration volume is required to achieve a net zero loss of pre-development infiltration volumes. This should be taken into consideration during detailed design;

vi. The proposed Stage III Monitoring Program proposes to monitor the performance of infiltration trenches/galleries and soak away pits on public property within 24 hours after a rainfall event once per year. These infiltration galleries should be equipped with continuous-read data loggers to evaluate the efficacy of the infiltration infrastructure. This will allow for multiple events of different sizes and timing to be analyzed. This detail can be included in the Final SWM Report; and,

vii. Page 28 indicates that building sump pumps should be connected to the internal storm sewer system. If a 3rd pipe CWC system is utilized at the proposed development, building sump pumps should be directed towards the CWC rather than to the storm sewer, as recommended in the NWSSS. This detail can be incorporated into the Final SWM Report.

23. General Comments

a. The proposed development lies within a Wellhead Protection Area (WHPA) D-2 for the Waterloo North Well Field, and requires a Section 59 Notice to be provided in accordance with the Clean Water Act.

b. Prior to DPA:

i. Generally, the SWM plan proposed in the Preliminary SWM Report is vague with respect to what types of engineered infiltration measures will be utilized at the proposed development. HSW recognizes that detailed stormwater infrastructure designs will be completed and presented in a Final SWM Report; however, there should be more direction in an updated Preliminary SWM Report. In order to match or exceed the pre-development infiltration volumes, it is HSW's preference to see distributed infiltration of clean roof top runoff in areas where soils are conducive to infiltration. This may be via lot-level infiltration galleries and/or 3rd pipe systems, or a combination of both. The post-development infiltration volumes can be topped up with runoff from impervious road surfaces;

ii. If a significant volume of infiltration is proposed from runoff originating from paved surfaces (via conveyance and/or EOP infiltration galleries), HSW will require a Chloride Impact Assessment to be completed prior to DPA, which can be included as a new section within an updated Preliminary SWM Plan; and,
iii. Alternatively, if winter by-pass valves are proposed on conveyance and EOP infiltration galleries, HSW would re-consider the need for a Chloride Impact Assessment.

Environmental Planning

24. Environmental planning staff has reviewed the reports and revised plans related to the proposed residential subdivision by Cook Homes at Conservation Drive and Beaver Creek Road in Waterloo. Environmental Planning staff have the following comments for your consideration:

25. Draft Plan of Subdivision

a. What is meant by the area identified as “Not included in dripline setback” (Block 256)? This area is identified as Significant Woodland and afforded a 10-metre buffer on Map 6 of the EIS but not identified as a Significant Natural Feature on Map 7 of the EIS. Please clarify.

26. Environmental Impact Study

a. Editorial note – Parts of the report do not have page numbers.

b. The Region’s Greenlands Network Implementation Guideline was endorsed by Regional Council in June 2016 (p.2). Please ensure that the EIS references the 2016 version of this document.

c. 4.6 Ecological Linkages (p.43) – While staff agrees that the Beaver Creek corridor is the primary existing ecological linkage, does the NWSSS not identify a linkage to be enhanced along the northern property limit (see NWSSS Figure 14.4)? Please clarify. Staff raised this issue at the October 2016 agency site walk and recommended considering enhancements to this linkage through removal of invasive species and planting a mix and range of trees/meadow species similar to the existing trail to the east of the subject lands.

d. 5.4.1 Encroachment into Buffers (p.53) – First bullet states “the buffer provided always meets or exceeds the minimum Region of Waterloo recommended buffer of 10m from dripline for Core Environmental Features.” Please note that a 10-metre buffer is a requirement under ROP Policy 7.C.11 and not a “recommendation.” In addition, the Conceptual Grading Plan and Figure 4 of the SWM Report (Meritech, July 2016) appears to show grading in the SWM block up to/within the dripline of the Core Environmental Feature (Significant Woodland). However, the encroachment is difficult to determine since the woodland dripline and buffer are not shown on the grading plan. Please clarify with respect to how site alteration in this area would comply with ROP Policy 7.C.6.

e. 5.6.1 Wetland/Woodland Edge Buffer (p.62) – The last sentence of this section makes reference to a “farm dump area”. Where is this area located and could it be identified on one of the maps (i.e. EIS Map 7)?

f. 6.3 Post Construction Monitoring (p. 66) – How long will post construction monitoring continue following 90% buildout of the subdivision? Please note that the Region typically requires 2 years of post-construction monitoring.

27. Stormwater Management Report

a. Figure 4 – The limit of grading for the SWM facility appears to be coincident/within with the boundary of the Significant Woodland. The minimum buffer for Regional Core Environmental Features is 10 metres according to the ROP. Please clarify.

b. Quantity (p. 15) – For Catchment 504, if a bioswale is to be used (instead or oil/grit separator), where would it be located? The last sentence of this section is somewhat vague in this regard. Please clarify.

Archaeology

28. Staff have received the Archaeological Assessment Report Entitled, "Original Report” Archaeological Assessment (Stages 1 & 2) by Archaeological Research Associates Ltd. dated June 17, 2016, and acknowledge that a Stage 3 site-specific assessment is recommended for two locations of archaeological materials: Euro-Canadian Findspots 3 and 4. Such assessment, as well as an acknowledgement letter from the Ministry of Tourism, Culture and Sport (with two (2) copies of assessment provided to Region) that such report has been entered into the Ontario Public Registrar of Archaeological Reports, will need to be completed prior to Draft Plan Approval.

General

29. If any part of the development may potentially create a Non-Municipal Year-Round Residential System (NMYRRS) under the Safe Drinking Water Act (SDWA), 2002, such must be confirmed prior to draft plan approval and in consultation with the City of Waterloo; additional requirements may be applicable under the SDWA if a NMYRRS is confirmed.

30. Pursuant to the Region’s standard conditions for Draft Plans of Subdivision and Condominium, a development is required to contain a permanent secondary access if more than 26 units are developed with only one point of access. The north-west portion of this plan would exceed this maximum requirement, and, depending on when/how lands to the east are ultimately developed, all lands north of Street ‘E’ could also exceed this maximum. Additional information showing how this issue can be resolved will be required prior to issuing a decision.

31. Regional staff has no objection in principle at this juncture with the proposed draft plan of subdivision, and associated zone change application. As stated in the aforementioned comments, Regional staff will require additional information prior to granting draft approval, and will consider additional comments (including the City’s) as they are received.

Region Planning Fees

32. Regional staff acknowledges receipt of the application fees for the plan of subdivision, and zone change and EIS review. The developer should be advised of the following fees and charges (subject to annual change by By-law):

Subdivision Plans:

Draft Approval - $4,025.00 Registration Release - $2,000.00

If you have any questions, please don't hesitate to contact the undersigned.

Yours truly,



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Principal Planner
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(519) 575-4757 ex. 3120

cc. N. Hardacre, MCIP, RPP, City of Waterloo Planning (via email)
J. Scarfone, Manager of Planning, Township of Woolwich (via email)
R. Wei, Waterloo North Hydro (via email)
J. Bere, Canada Post Corp. (via email)
M. Palynchuk, Access Networking Provisioning (Bell) (via email)
Grand River Conservation Authority (via email)
Waterloo Region District School Board (via email)
Region of Waterloo – Water Services; Corridor Planning; Source Water Protection; Environmental Planning; and, Cultural Heritage (all via email)

THE CITY OF Waterloo | **Integrated Planning & Public Works**

Planning Approvals

August 31, 2018

Mrs. Brenna MacKinnon
Planning, Development and Legislative Services
Regional Municipality of Waterloo
150 Frederick Street
Kitchener, ON N2G 4J3

Mrs. Kristen Barisdale, MCIP, RPP
Associate, Senior Planner
GSP Group Inc.
72 Victoria Street South, Suite 201
Kitchener, ON N2G 4Y9

Mrs. MacKinnon & Mrs. Barisdale:

Re: Second Submission Comments
Zone Change Application Z-16-14
Draft Plan of Subdivision 30T-16402
556, 560 and 576 Conservation Drive

Please accept this correspondence in relation to Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 and as a formal response to two submissions made by GSP Group on November 30, 2017 and June 15, 2018. Details of the materials provided in each submission are outlined as follows:

Submission of November 22, 2017:

- Revised Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised November 16, 2017, annotated with changes.

Submission of June 15, 2018:

- Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised February 23, 2018
- Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018
- Conceptual Erosion & Sediment Control Plan, dated February 2018
- Servicing Strategy Report, prepared by Meritech, dated May 2018
- Preliminary Stormwater Management Report (revised), prepared by Meritech, dated May 2018

City of Waterloo staff has completed a preliminary review of the information listed above and provides the listed comments below, in response. Prior to the City being in a position to recommend Draft Approval of the subdivision to the Region, or approval of the Zone Change application to Waterloo City Council, the following must be addressed and responded to in writing, with supporting studies and/or plans where necessary.

PART A – PLANNING COMMENTS

Density

1. Based on the current Draft Plan, the density of the proposed development is between 44 and 50 residents and jobs per hectare (rj/ha). The planned density of the Beaver Creek Meadows District Plan (BCMDP) area is 58 rj/ha as per OPA 15, which applies to the entire BCMDP area. Any shortfalls in the density of this subdivision area will impact, and need to be made-up in, other areas of the BCMDP. Please confirm the total density (in rj/ha) to be generated by this development

2. The density of the Mixed-Use Node appears under capacity compared to the land uses and density contemplated in the Official Plan and BCMDP. Density targets included within Table 3 of the District Plan for Mixed-Use Medium Density Residential is between 60 to 100 units per hectare. The proposed Draft Plan is showing approximately 53 units per hectare for the Mixed-Use Medium Density Residential lands. Please demonstrate how the density of the Node is consistent with the planned density outlined in the BCMDP and the Official Plan. Consider increasing density, in particular Block 251 (Multiple Residential).

Park Block and Open Space Block

3. Block 253 (Park) must be a minimum dedication of 5% of the Draft Plan lands. All natural features and associated buffers must not be included within this calculation. Land within buffers will not be considered as contributing to the parkland dedication requirements (Official Plan policy 8.2.4(12)).

4. A portion of Block 253 (Park) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 253 (Park). All natural features and associated buffers should be within Block 254 (Open Space). All lands within Block 253 (Park) should be unencumbered.

5. A portion of Block 256 (SWM) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 256 (SWM). All natural features and associated buffers should be within Block 254 (Open Space). All SWM features (including infiltration galleries) and trails/maintenance access should be located within the limits of Block 256 (SWM). Please also refer to the Environmental comments below.

6. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the south side of the park frontage is limited and partially blocked by Block 244 (Street Townhouses). While the park frontage has been slightly increased from previous versions of the proposed Draft Plan, the frontage to the park still remains limited due to the location of Block 244 (Street Townhouse). Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Furthermore, street townhouses were not contemplated in the BCMDP in this location (Block 244).

7. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the north side of the park frontage is limited and partially blocked by Lot 154 and Lot 155. Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Please remove Lot 154 and Lot 155.

School Block

8. As per the BCMDP, the subject lands are planned to include an elementary school in a central location and north of the Mixed-Use Node. Block 252 (School) is 2.99 ha in size, consistent with policy 3.7.5(b) of the BCMDP. Final site design and layout of the school site should be coordinated with the School Board, in accordance with policies 3.7.5 of the BCMDP.

Single Detached Lots (Lots 1-242)

9. Additional information is required in support of the requested site specific reductions. Please provide a Lot Plan(s) showing a typical single detached dwelling on a typical lot (both internal and corner lots) with the requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

10. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard setback of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. A front yard depth of 4.0 metres is insufficient for a car to park in the driveway. In addition, a 2.0 metre wide easement is required along the frontage of each lot.

11. Lot depths shown are a minimum of 28 metres (with the exception of Lot 108 and Lot 109 which has a depth of 27.8 m). This is below the typical lot depth of 30 m. Consider increasing lot depths to achieve required front yard and rear yard setbacks, and to provide appropriate amenity area in the front and rear yards.

12. Staff have concerns with the request to reduce side yard setbacks. Reduced side yard setbacks will increase the need for easements to access the rear yard, provide insufficient space to maintain the house and side yard, and provide insufficient space for infrastructure (i.e., meters, air conditioning units). The need for easements to access private single detached backyard does not seem reasonable. This indicates the house is too large for the lot. Side yard setbacks should comply with zoning standards.

13. Lot 138 and Lot 242 appear to be very small corner lots. Ensure lot dimensions are such that minimum flankage yard setbacks can be accommodated along the entire length of the flankage façade (i.e., both front and back corners of the dwelling). Consider increasing the size of these lots or provide Lot Plans for each lot to show how required setbacks will be met.

14. The requested maximum porch encroachment into the side yard of 1.5 metres is greater than either of the minimum side yard setbacks requested (0.6 metres and 1.2 metres). This is not reasonable.

15. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

16. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

<u>Townhouse Blocks (Blocks 243-250)</u>

17. Additional information is required in support of the requested site specific reductions to the various forms of dwelling units. Please provide Lot Plan(s) showing typical street townhouse dwelling and requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

18. Provide additional information related to the Back-to-Back Townhouse dwellings proposed on Block 250 in the form of a concept plan showing building form and setbacks. Additional rationale and/or justification is also required for the requested setbacks, including encroachments.

19. Provide a conceptual lot layout for all townhouse blocks. Are the townhouse dwellings intended to be condominium units? Lotted on the final plan to be registered?

20. Please remove Block 244 (Street Townhouses). Townhouse dwellings are not contemplated in this location in the District Plan (refer to #6).

21. Please increase the depth of Block 248 and 249 (Street Townhouses). A depth of 25.1 to 26.2 metres does not appear to be sufficient for the intended units while still providing appropriate outdoor amenity area.

22. Block 250 (Back-to-Back Townhouses) is only 28 metres deep, while Block 246 (Street Townhouses) is 27 metres deep. Confirmation is required that a depth of 28.0 metres is sufficient for back-to-back townhouse units without negatively impacting the streetscape and still providing adequate outdoor amenity area. Please demonstrate how this design would be achieved with such a narrow block depth (see also #18).

23. It is not clear how uses along Conservation Drive will address the street while avoiding backing onto interior blocks. Policies 3.2.10 and 3.2.19(b) of the BCMDP discourage back-lotting onto municipal streets such as Conservation Drive and Beaver Creek Road. Block 248 and 249 (Street Townhouses) are proposed to front Conservation Drive and Street A, and back onto Street F. Having Block 248 and 249 'back' onto the front yards of the townhouse units in Block 250 (Back-to-Back Townhouse) is not an appropriate configuration. Please consider revising the configuration of the townhouse blocks. Staff have reviewed possible configurations for this area and are available to meet to discuss these options, should you wish.

24. Please confirm if commercial is proposed within any of the Townhouse Blocks. This is strongly encouraged within the Mixed-Use Medium Density Residential lands and within the Mixed-Use Node. Blocks 245, 246 and 250 could contain a mixture of street townhouses and live/work style townhouses to achieve density targets and design priorities of the BCMDP.

25. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

26. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard depth of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. In addition, a front yard depth of 4.0 metres is insufficient for a car to park in the driveway. A 2.0 metre wide easement is required along the frontage of each lot.

27. A maximum height of 10.5 metres is being requested for townhouse dwellings. A height of greater than 10 metres will require an Official Plan Amendment for Blocks outside the Mixed-Use Node (i.e., Block 243 (Street Townhouse)).

28. Block 243 has been modified from single detached units to townhouse units. This is consistent with the direction of the BCMDP.

29. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

30. Have stacked townhouse dwellings been considered?

Multiple Residential Block (Block 251)

31. Please confirm built form proposed for Block 251 (Multiple Residential). Show conceptual plan(s) for the proposed / possible development of this block.

32. Please show dimensions (i.e., frontage) on the Draft Plan for Block 251 (Multiple Residential).

33. Density targets included in the BCMDP for the Mixed-Use Medium Density Residential lands within the Mixed-Use Node is between 60 to 100 units per hectare. The proposed density of Block 251 (Multiple Residential) is 30 to 37 units per hectare. Consider increasing the density of Block 251 (Multiple Residential).

34. Additional land will be required along the eastern boundary of Block 251 (Multiple Residential) which will form part of the ultimate road allowance and future road construction of Roy Schmidt Road (refer to 'Roy Schmidt Road' comments below).

35. Commercial is strongly encouraged to be included as part of the development of Block 251 (Multiple Residential). This aligns with the policies of the BCMDP.

36. The Draft Plan has been revised from previous versions to include Multiple Residential on Block 251 instead of townhouse units. This change is consistent with the BCMDP.

37. It is recommended that the land uses of Block 251 (Multiple Residential) be coordinated and compatible with the lands to the east which also form part of the Mixed-Use Node.

Mixed-Use Node

38. Special Provision Area 37 (SPA 37) of the Official Plan applies to a portion of the subject lands identified as the Beaver Creek Node, which allow for higher densities and building heights, as well as a wide range of uses to create a mixed-use centre with a concentration of neighbourhood-oriented retail, service commercial uses, institutional employment and residential uses. The extent of the node has been determined through the BCMDP. Blocks 245 to 251 are within the identified node area. Development within these blocks is permitted to be as high as 20 metres and permitted to have a density of up to 300 bedrooms per hectare.

39. SPA 37 of the Official Plan encourages a mix of uses. Staff recommends that a wide range of uses be considered for Blocks 245 to 251 including commercial, and to develop these blocks as a mixed-use area, consistent with SPA 37.

40. Policy 3.4.14 of the BCMDP outlines a range of commercial uses both permitted and encouraged within the Mixed-Use Node. Staff recommends commercial uses and live/work style units within the Mixed-Use Node (refer to policy 3.4.13 of the BCMDP). The inclusion of limited commercial uses and live/work units, well integrated with residential uses within the Node, is an important component of the overall vision and structure of the BCMDP.

41. The heights of the buildings within the Mixed-Use Node should be a minimum of 9.0 metres and should not exceed six storeys. The BCMDP contemplates a range of uses within the Node, with a high degree of pedestrian orientation. Policy 3.6.2 of the BCMDP encourages a range of residential uses to provide accommodation for a broad income and social mix. The proposed development should be consistent with policies 3.6.3 and 3.6.4, which require high quality urban design and visually interesting spaces that consider pedestrian movement and streetscapes.

42. At a minimum, buildings along Conservation Drive should be designed to accommodate future main floor commercial uses (minimum ground floor height will be recommended).

<u>Roy Schmidt Road</u>

43. Roy Schmidt Road shall have a road allowance width of 18.0 metres, to be measured at 9.0 metres on either side of the historic centre line of the road.

44. The developer shall coordinate the design of Roy Schmidt Road and cost-share on the reconstruction with the owner/developer of the lands on the east side of the road (Draft Plan 30T-17403), including a new multi-use trail extending from Conservation Drive to the City of Waterloo boundary north of Pinery Trail.

45. The width of Roy Schmidt Road south of Street E does not appear to be 18 metres, specifically along the eastern property line of Block 251 (Multiple Residential). The configuration of Block 251 (Multiple Residential) should be modified to allow sufficient road width.

46. The Draft Plan shows Roy Schmidt Road to be closed between Rideau River Street and Pinery Trail. Roy Schmidt Road is only proposed to be closed at the intersection of Conservation Drive. The remainder of Roy Schmidt Road is to remain open. The width of Roy Schmidt Road north of Pinery Trail shall be 18.0 metres. Lot 211 and Lot 212 will need to be revised to allow sufficient road width.

47. Registration of Lots 226 to 242 will be conditional upon the construction of Roy Schmidt Road.

48. Roy Schmidt Road is to be closed at Conservation Drive. A trail connection is required from Roy Schmidt Road to Conservation Drive in the location of the shared boundary between this development and the adjacent lands (Draft Plan 30T-17403), in the form of a 4.0 metre walkway block for a multi-use trail. If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process.

49. Show accurate lot lines of adjacent / surrounding lands on the Draft Plan, including lands owned by the City in the area of Roy Schmidt Road.

Street Alignment

50. Staff support the accesses provided to the future development lands to the west (Brohman lands), through the extension of Pinery Trail and Street B. The precise location of these streets should be coordinated with the adjacent land owner throughout the Draft Plan process. The final location of Pinery Trail and Street B are to be located in such a way as to permit, and not hinder, the appropriate development of the adjacent lands (Brohman lands).

51. Show and dimension daylight triangles where streets intersect, particularly in the location of Street H, at Conservation Drive. How will reduced flankage affect visibility on corner lots? Daylight triangles shall be provided as per TAC guidelines.

52. The configuration of Street corners should be curved. Ninety degree angles are not desirable and create driveway issues (Street E).

53. Consider revising Street E and Street F as one Street name (as a future crescent). The current configuration of Street E and Street F creates confusion – where does one end and the next begin? Street G and Street H could remain with separate names.

54. Temporary cul-de-sacs will be required at the terminus of Street B, Pinery Trail and Street E.

55. Include 0.3 metre reserves between Conservation Drive and proposed residential Blocks to restrict driveway access.

56. Street H alignment / functioning is to conform with correspondence dated July 7, 2017 *(Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services – Update to Transportation Forecasts and Left Turn Lane Requirements, Stantec, 2017)*, which was provided to the Beaver Creek Meadows Developer's Group on July 14, 2017.

57. A Traffic Management Plan is required to be submitted with all subdivision applications, as per Policy 3.9.1(f) of the BCMDP. Traffic calming measures are to be recommended, reviewed and implemented as the subdivision is built, rather than retrofitted after the fact. Such measures will be included as conditions of Draft Approval, to be implemented as the subdivision is built out. For additional information refer to Part D.

Pedestrian Connectivity

58. There is a lack of pedestrian connections between streets. Please show walkways in strategic locations throughout the Draft Plan to increase pedestrian connectivity and to reduce walking distances.

59. In previous versions of the Draft Plan an east-west walkway was proposed between Street B and Rideau River Street. This connection has since been removed. It is recommended this connection be retained as limited east-west connections exist in this area. Maintaining this connection is consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

60. A pedestrian connection should be included between Street B and Street D to improve north south pedestrian connections, consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

61. The Draft Plan shows very limited active transportation connections. This is inconsistent with policy 3.9.4 of the BCMDP, which requires the active transportation network to be designed to ensure convenient and safe travel throughout the community. Proposed lots along the north limit of the Draft Plan have no direct access to key areas such as the school, park, Mixed-Use Node, or transit services. Policy 3.9.5 of the BCMDP requires an active transportation network that provides multiple options for pedestrians and cyclists to travel within the community.

62. Map 5 of the BCMDP shows a proposed trail connection running north-south including a route along the buffer area on the west side of the plan. Staff recommends that a pedestrian connection along the buffer be implemented, subject to environmental sensitivities. The EIS submitted as part of this proposal should confirm the feasibility of implementing a trail in this buffer area prior to final development approval. All trails should be developed in accordance with policies 3.9.7- 3.9.15 of the BCMDP.

63. A continuation of the Avon Trail was previously shown along the north boundary of the Draft Plan, as per policy 4.4.8 of the BCMDP and has since been removed. This is an important community trail connection.

64. Consider including a walkway connection from the roundabout at Beaver Creek Road and Conservation Drive to Street E / Street F through Block 249 (Street Townhouse).

65. Overall, the proposed Draft Plan does not meet the intent of Policy 3.9.2 to 3.9.6 for an active transportation system. Please refer to Map 5 of the BCMDP.

Phasing

66. If phasing of the development is proposed, please submit a Phasing Plan. Also, confirm how the phasing of the development will relate to the availability and timing of the broader stormwater management plan.

Retaining Walls

67. All proposed retaining walls throughout the plan (i.e., at west property limit, within SWM Blocks, etc.) shall be removed or minimized to the extent possible.

Noise

68. The Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018 recommends a 1.8 metre high noise wall along Conservation Drive and Street A, along with noise warning clauses for lots within 20 metres and 40 metres of Conservation Drive. Staff do not support the use of noise walls to mitigate noise levels generated by traffic along Conservation Drive. Acceptable measures include building orientation / site layout, berms, and setbacks (physical separation).

Design Considerations

69. Development of the subject lands should be consistent with urban design policies of the BCMDP (Section 4). Generally, the Draft Plan should reflect a complete community with high quality design, a high degree of connectivity, well designed and attractive streetscapes, and a sense of identity. Good urban design principles should also be incorporated into the built form, including each dwelling unit type. In particular, townhouses should be consistent with policies 3.4.17-19 of the BCMDP.

70. The development as a whole should be consistent with the City's Urban Design Manual.

71. An Urban Design Brief was not submitted. Subdivision Urban Design Guidelines will be required as a condition of draft approval.

PART B – ENVIRONMENTAL PLANNING COMMENTS

72. When compared to the previous submission, the wetland limits shown on the Draft Plan of Subdivision (last revised February 23, 2018) have changed. The rationale for the new limits needs to be confirmed, as does GRCA's acceptance of the new limits. Also, the wetland limits shown on the Draft Plan differ from those shown on the Conceptual Erosion and Sediment Control Plan (dated February 2018). The wetland limits on the Conceptual Erosion and Sediment Control Plan match those from the previous version of the Draft Plan. Further, the dripline shown in the northwest corner of the site on the Draft Plan is different than that shown on the Conceptual Erosion and Sediment Control Plan.

73. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) includes a note that reads "Dripline knob to be removed". Through the EIS, the "knob" is mapped as Significant Woodland (Core Natural Feature) and Significant Wildlife Habitat (Supporting Natural Feature). Official Plan policies 8.2.4(2) and 8.2.5(2) require the form and ecological function of such features to be maintained, enhanced or, where feasible, restored. Policies 8.2.4(3) and 8.2.5(3) also restrict development and site alteration within such features to a limited range of uses/activities. As per the Official Plan and the North Waterloo Scoped Subwatershed Study (NWSSS), the feature should remain intact and be afforded a 10 metre buffer. In terms of that buffer, as set out in Official Plan policy 8.2.4(9), buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands.

74. It is unclear whether the constructed wetland will include a cooling trench. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) shows a level spreader but a cooling trench is referenced on page 29.

75. While the Preliminary Stormwater Management Report (Revised May 2018) sets out recommendations for the during-development and post-construction monitoring programs, the Terms of Reference for each phase will need to be finalized at the time of transition. This comment also applies to the monitoring recommendations put forward in the EIS. Further, while the 2016 and 2017 Pre-development Biological Monitoring Reports were submitted in early 2017 and 2018 respectively, the 2016 Groundwater and Surface Water Monitoring Report and subsequent reports are still outstanding. These reports should be submitted together and as soon as possible following the end of the monitoring year.

76. Based on the direction provided in the District Plan, a trail, that would have to be supported through the EIS if it is in the buffer, should be incorporated into the plan that extends from Block 256 (Stormwater Management) down to Conservation Drive. Further, approximate trail locations should be shown.

77. Section 5.4.7 of the EIS states that the wet cells of the pond have been placed outside of the Category 2 habitat of the Blanding's turtle which will avoid the need for registering any maintenance works for an exemption under the ESA. However, in MNRF's comments, it was noted that the stormwater management pond could become Blanding's Turtle habitat in the future and would therefore require any maintenance of the pond to proceed in consultation with MNRF to ensure the species is not negatively impacted. This needs to be clarified and City Engineering staff need to be made aware of the requirements.

78. The Preliminary Stormwater Management Report (Revised May 2018) and the Conceptual Erosion and Sediment Control Plan (dated February 2018) show part of an infiltration gallery within the wetland buffer (to varying degrees, as different wetland limits are used on each plan). Official Plan policy 8.2.4(9) states that buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands. It has not been demonstrated that these criteria are met. If it can be shown that the criteria are met, details on the design of the infiltration galleries are needed, as they may be incompatible with a naturalized buffer. Potential areas of incompatibility include whether access to the galleries needs to be maintained, whether the vegetation over top of the galleries need to be maintained/manicured, whether tree roots will interfere with gallery function as the buffer matures from a meadow community to a treed one, and whether the galleries will need to be maintained in the short or long term, since accessing them would disrupt the buffer and remove any habitat that has been created, the provision of which is identified as a key ecological enhancement in the NWSSS.

79. Sections 3.2 and 5.4.3 of the EIS note that Stantec is preparing a hydrogeological study as part of the application. A Terms of Reference for a hydrogeological assessment was submitted to the City on November 9, 2016. Has that assessment been completed and submitted?

80. Given the required removal of the suitable bat habitat features (residential buildings and isolated landscape trees), is there opportunity to create bat habitat in the buffer areas?

81. Figure 14.4 of the NWSSS shows the northern edge of the property as an area to enhance in terms of its linkage function. While the EIS notes the lack of linkage connection/corridor function the hedgerow currently provides (page 41 and 50), the feasibility of enhancement has not been evaluated or addressed.

82. The Draft Plan of Subdivision (last revised February 23, 2018) shows encroachment into buffers in three locations – a) in the residential lots that back onto the northern hedgerow, b) in the stormwater management block, and c) in the park block.

    a) With respect to the residential lots that back onto the hedgerow, while a 5 metre buffer is shown on the Draft Plan, both the hedgerow and buffer are, to varying degrees, within the lots. Could the lots be graded without interfering with the hedgerow? What is to prevent removal of the hedgerow by future homeowners if it is within the lot lines? Further, the Preliminary Stormwater Management Report (Revised May 2018) shows both a maximum 2 metre high retaining wall and infiltration gallery along that boundary. It is presumed such infrastructure would require the removal of the hedgerow. The previous comment dealing with the linkage function of the hedgerow needs to be addressed to inform how the hedgerow will be managed. In addition to the

impact the retaining wall and infiltration gallery would have on the hedgerow, their location would also pose significant challenges in terms of infrastructure maintenance. Access to the retaining wall would be severely restricted and the infiltration gallery would be on a number of private properties, with limited access and no opportunity to ensure functionality or prevent removal.

b) With respect to the stormwater management block, the criteria listed in Official Plan policy 8.2.4(9) needs to be fully addressed in order to contemplate the location of the constructed wetland and infiltration gallery as currently proposed. Specific concerns regarding the infiltration gallery in the buffer are previously noted. In addition to these concerns, the proposed maximum 1.7 metre high retaining wall would pose a significant challenge in terms of maintenance and buffer functionality, as the buffer would need to be cleared to enable access.

c) With respect to the park block, Official Plan policy 8.2.4(9) states that permitted uses within buffers are to be limited to low impact uses consistent with those permitted within designated features. Active park land is not one of those uses. Further, the policy states that buffers are to remain in or be restored to a primarily natural state. The buffer lands are therefore to be removed from the Park Block. This is consistent with Official Plan policy 8.2.4(12) which states buffers will not be considered as contributing to parkland dedication requirements. The situation is further complicated because a trail is to be potentially built within the buffer (as per an earlier comment). The combination of an infiltration galley and a trail could result in very little naturally-vegetated buffer.

83. The EIS recognizes that the timing of construction activities must have regard for the breeding bird season. Consistent with the Westside Subdivisions, a timing window of April 1 to September 10 should be used. All land clearing, earthen works, servicing works, infrastructure work and tree removal between April 1 and September 10 should be prohibited unless a nesting survey is undertaken that demonstrates the activities will not have the potential to disturb or destroy migratory birds or their active nests.

84. The EIS notes that there will be an increase of 11-46% in post-development infiltration (page 56), with the Preliminary Stormwater Management Report (Revised May 2018) providing further details (page 25). While the NWSSS recommends existing infiltration rates be maintained or increased, a potential increase of 46% seems significant. Section 4.2 of the EIS notes that the wetlands' primary hydrologic function appears to be the storage of surface water and the storage and expression of groundwater. Would increasing the rates this substantially result in impacts to the wetlands? Is groundwater mounding a risk?

85. As per the direction provided by the NWSSS and the EIS, a condition of draft plan approval will require the distribution of an environmental stewardship brochure. The City has a universal one available for purchase entitled "Naturally Your Waterloo". Experience has shown that requiring builders to distribute the brochure to new

homeowners is challenging because of the time span over which the development occurs. Given this, the applicant should either be required to purchase all of the brochures needed for the subdivision upfront from the City and distribute them as appropriate or provide the funds necessary to print all the required brochures but rely on the City to distribute them as the subdivision builds out (e.g. it could be given out alongside the Building Permit). Further discussion is needed to determine the preferred approach.

86. The environmental lands and their buffers (i.e. the Open Space blocks) are to be dedicated to the City free of charge and without any encumbrances.

87. Under section 5.6.1 of the EIS, a historic farm dump is noted. This area will need to be cleaned up as a condition of approval.

88. Invasive Phragmites is discussed under section 5.6.3 of the EIS. An invasive species management plan will need to be provided as a condition of approval.

89. City-standard chain link fencing needs to be installed along the private-public interface.

PART C – LANDSCAPE COMMENTS

90. Block 253 (Park) cannot include buffer lands within the lands calculated toward the 5% parkland dedication. Likewise, areas of the park encumbered with infrastructure such as stormwater management facilities and infiltration galleries cannot be included in the 5% parkland calculations.

91. Why is the Avon Trail link deleted? This is an important community trail connection.

92. The hedgerow at the north and its 5.0 metre buffer are now incorporated into the rear lots of homes. This is not a viable way to protect, conserve and enhance this hedgerow. Regionally significant bird species are noted in this hedgerow therefore measures to preserve and enhance this feature should be undertaken. There is very limited protection for hedgerows when located within private property.

93. The servicing plan indicates that infiltration infrastructure is proposed in the lots at the north end of the site, between Rideau River Street and Street B. They seem to indicate water will flow off site, which is not permitted.

94. The servicing submission from Meritech (dated May 2018) shows the proposed locations for infiltration galleries. Most of these are inaccessible for future maintenance. Please revise or confirm how maintenance will be addressed.

95. The proposed development to the east (Draft Plan 30T-17403) does not show a vehicular connection at the end of Street E as indicated on this Draft Plan. Coordination between plans and consulting firms is required.

96. The stormwater management pond maintenance access road is typically designed to form part of the overall pedestrian trail system. Linkages to the park and to the north-south trail system on the west edge of the property should be incorporated into the access road.

97. It is recommended that a 2.0 metre wide (minimum) flat area be designed behind the residential lots that back onto the stormwater management pond rather than the 3:1slope beginning at property line.

98. The location of the infiltration gallery proposed within Block 252 (School) must be accepted by the School Board, to not encumber the development potential of this block.

99. The EIS does not speak to the north-south trail connection through the buffer lands or other trails. The trail system should be shown conceptually. This trail connection should be provided within the buffer from Conservation Drive to the stormwater management pond. The City standard 3.0 metre wide asphalt trail with supporting buffer plantings is required.

100. The trail/linkage system should be designed holistically so that walkway blocks connect to major points of attraction such as the park and the school. Although the BCMDP shows this conceptually, the Draft Plan does not create these linkages. Linkages are not linking street to street in a linear fashion. Future residents should be able to use a walkway block from Street B to connect to Street D, and then to the park, etc.

101. Block 253 (Park) must be unencumbered and for recreational purposes only. Portions of the park that do not provide useable parkland should be eliminated from the overall park calculation and/or moved out of the park block. These include the infiltration gallery and the sanitary service. These facilities are typically not permitted in parkland.

102. Block 253 (Park) should be 80% flat tableland with grades no steeper than 2%. Areas of steep slopes will not be accepted.

103. City standard 1.5 metre high black vinyl chain-link fencing shall be provided at all public private interfaces where private lands abut wetlands, buffer lands, environmental lands, woodlots and open spaces meant to be naturalized to minimize encroachment. In all other areas, the City standard property demarcation posts and living fence shall be provided.

104. The City is interested in discussing the School Board proposals for layout of the new school and associated green space. Given the size and layout of Block 253 (Park), it is perhaps not conducive to sharing sporting facilities and therefore the School Board may need to provide these 100% on their lands.

105. Sufficient deterrents need to be designed into the shared property line between Block 253 (Park) and Block 256 (SWM) to maintain safety given the slopes of the pond and the proximity of the park.

106. Please confirm the design intentions of Blocks 254 and 255 (Open Space) and who is to maintain it. If it is Open Space, the developer must enter into an agreement to maintain these lands until the subdivision is build out.

107. The design and incorporation of a layby for bus drop-off for Block 252 (School) should be considered.

108. Walkway blocks shown on previous iterations of the plan have been removed. Interconnectivity throughout the neighbourhood must be provided. Walkway blocks are 4.0 metres wide, unless additional services are required which may warrant a width of 6.0 metres to 9.0 metres.

109. A 6.0 metre high retaining wall is proposed along the west property limit. This is significant. Why does the west property limit not meet existing grades? How does the retaining wall work at future road extension (i.e., Pinery Trail and Street B)?

110. A Vegetation Management Plan will be required as part of the first engineering submission.

111. A Hedgerow Enhancement Planting Plan is required.

112. An Invasive Species Control Plan is required.

113. An infiltration gallery cannot be located within buffers. Buffers can contain trails and naturalized plant material and some minor re-grading only.

114. Block 252 (Park) will require stormwater, hydro and water stubs for playground and for a future rink area.

115. Infrastructure shall not be in parks unless required by the park.

116. Any garbage in the buffer, wetland, woodlands shall be removed by the developer to the satisfaction of the City of Waterloo. This includes any farm dump, old fences, building materials, etc..

117. Educational signage is required to be designed, approved and installed in the buffer area to educate property owners regarding encroachment and dumping, ownership, etc. Signage plan to be submitted for approval.

118. The plan for the restoration and enhancement measures to protect wildlife and cut down invasive species along Conservation Drive is required.

119. The plan for the animal crossing/ecological linkage enhancement crossing is required.

120. Park, SWM, OS, buffer, naturalization, living fence and property demarcation, fencing, signage plans are required to estimate the Letter of Credit requirements in Schedule B of the Subdivision Agreement. Developer to submit street tree planting plan OR to confirm with Parks and Environment to have the City undertake the street tree planting.

121. Topsoil is not permitted to be stockpiled within Block 253 (Park).

PART D – TRANSPORTATION AND ACTIVE TRANSPORTATION COMMENTS

Road Widenings and Lands to be Conveyed to the City

122. The existing road allowance of Roy Schmidt Road appears to be 12 metres wide. A road widening on the west side of Roy Schmidt Road shall be conveyed to the City for the entire length of Roy Schmidt Road to establish the new property line at 9.0 metres from the historic centreline of Roy Schmidt Road. A similar widening has been requested from the developer of the proposed subdivision on the east side of the road (Draft Plan 30T-17403).

123. Roy Schmidt Road is to be closed at Conservation Drive but the City will retain a 4.0 metre wide walkway block for a MUT in this location (between Roy Schmidt Road and Conservation Drive). If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process;

124. The developer shall confirm that the north limit of Conservation Drive is 13 metres from the historic centreline of the road, to facilitate the ultimate road allowance of 26 metres as per the City's Official Plan.

125. 4.0 metre* wide walkway blocks are required:
    a. Inside the west limit of the plan from Pinery Trail to Block 255 (Open Space).
    b. Adjacent to the rear of Lot 46 to Lot 71 on Street B.
    c. Adjacent to the rear of Lot 7 to Lot 23 on Rideau River Street to connect to the existing trail at the east limit of the Draft Plan and the trail on the west limit of the Draft Plan.
    d. Between Lot 45 and Lot 46 on Street B, between Lot 23 and Lot 24 on Rideau River Street, and between Lot 6 and Lot 7 (or Lot 7 and Lot 8) on Rideau River Street to connect the public sidewalks to the trail inside the north limit of the Draft Plan.

126. The trail within the plan is to be designated The Avon Trail:
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.

b. Inside the west limit of the Draft Plan from Pinery Trail to Block 255 (Open Space).
c. Along the south limit of Block 255 (Open Space) to the north limit of the Draft Plan.
d. Inside the north limit of the Draft Plan from Block 255 (Open Space) to the existing trail along the east limit of the Draft Plan.

*__Note:__ *where detailed engineering determines that grading and drainage of trails, walkways or park facilities require additional land or easements, such transfers must be conveyed to the City at the time of engineering approvals.*

Transportation Study and Implementation

127. The Developer shall submit a Transportation Study prepared by a qualified Transportation Engineer, for the review and approval of the City's Director of Engineering, to address the needs of all road users: pedestrians, cyclists, transit users, and drivers.

128. The Transportation Study will use as background information the transportation studies for Conservation Drive and Beaver Creek Road, and provide projected peak hour and AADT volumes for each transportation mode on the following streets (which are considered to be feeder roads):
    a. Street H
    b. Pinery Trail
    c. Street A, from Conservation Drive to Pinery Trail
    d. Street E, from Roy Schmidt Road to Street A

129. Above feeder roads should have a Multi-Use Trail (MUT) on one side, and the study should provide options for enhanced crossings at all intersections on these roads.

130. The Transportation Study shall determine the sight daylighting requirements at all roads intersecting with Conservation Drive. Lands to accommodate daylighting requirements shall be conveyed to the City.

131. The Transportation Study shall include options and recommendations for enhanced pedestrian and cycling safety, and shall design and construct any traffic calming facilities and road safety features recommended by the Transportation Study.

Multi-Use Trails (MUTs) and Sidewalks

132. All design and construction to be undertaken by the developer shall be to the satisfaction of the City's Director of Engineering Services.

133. The detailed design of City sidewalks, trails and parks shall address all grading and drainage issues to meet AODA requirements. Should additional land or easements be

required to accommodate City infrastructure needs, the developer shall convey such transfers to the City at the time of engineering approval.

134. A MUT is required within the Roy Schmidt Road right of way. The City preferred location for this 3.0 metre wide MUT is on the west side of the road (due to a fewer number of driveways). This MUT will extend from Conservation Drive, up to and along Roy Schmidt Road, to the existing trail at the north limit of the Draft Plan. A 1.8 metre sidewalk is required along the entire length of Roy Schmidt Road, within the right of way on the east side of the road. The developer shall coordinate the design of Roy Schmidt Road with the developer of the lands to the east.

135. While the City is constructing a MUT on the east side of Beaver Creek Road south of Conservation Drive, and on the south side of Conservation Drive, the preferred location of the MUT is on the west side of Street A adjacent to Block 252 (School). This will require enhanced crossings on the east and north legs of the roundabout at Street A and Conservation Drive.

136. The developer shall design and construct the following 3.0 metre* wide Multi-Use Trails (MUT):
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.
    b. Inside the west limit of the Draft Plan from Pinery Trail to the south limit of Block 255 (Open Space).
    c. Between Block 255 (Open Space) and the rear of Lot 63 to Lot 71 on Street B.
    d. Inside the north limit of the Draft Plan from the MUT on Block 255 (Open Space) to connect to the existing trail at the north-east limit of the Draft Plan.
    e. Along the east limit of Block 256 (SWM) connecting the MUT on Block 254 (Open Space) to the MUT at the north limit of Block 256 (SWM).
    f. Along the north limit of Block 256 (SWM) connecting Pinery Trail to the MUT on the east side of Block 253 (Park).
    g. Along the south and east limit of Block 253 (Park) connecting the MUT on Block 254 (Open Space) to Pinery Trail.
    h. On the west side of Street A from Conservation Drive to Pinery Trail.
    i. On the north side of Street E from Roy Schmidt Road to the property line between Block 252 (School) and Block 244 (Street Townhouse).
    j. Along the south limit of Block 252 (School) from the MUT in (i.) above, to the MUT on Block 253 (Park).

Note: *where Block 244 (Street Townhouse) is removed, the MUT on the north side of Street E should connect from Street A to Block 253 (Park).*

137. The developer shall design and construct 1.8 metre concrete sidewalks on the following streets:
    a. On both sides of all streets with the exception of Street D and streets with a 3.0 metre MUT on one side.

b. On streets with a 3.0 metre MUT on one side, a 1.8 metre sidewalk is required on the opposite side of the street.
c. On Street D, a 1.8 metre sidewalk is required on one side only, in front of Lots 108 to Lot 128.

Bike Lanes

138. The developer shall design and prepare a pavement marking plan showing 1.5 metre painted bike lanes with a 0.3 metre painted buffer on Pinery Trail, and on Street A from Conservation Drive to Pinery Trail.

139. In accordance with the Transportation Study, the developer shall prepare a detailed design of the Pinery Trail and Roy Schmidt Road intersection to safely connect the MUT on Roy Schmidt to the buffered bike lanes on Pinery Trail.

Transportation Operations

140. Streets with bike lanes may not be able to accommodate on-street parking, due to the width of the road. Bike lanes on Street A will restrict on-street parking for the school and Block 243 (Street Townhouse). Bike lanes on Pinery Trail will restrict on-street parking at the park.

141. Please provide additional information with respect to the type of traffic control and traffic calming measures planned for the proposed Draft Plan.

142. How will school traffic be accommodated? The area around the school will have limited on-street parking to assist with student drop-off and pick-up.

143. The radius elbow corner on Rideau River Street presents a challenge for winter operations. Please consider modifying this design.

144. Driveway access to Block 251 is recommended from Street A and/or Street E, not from Roy Schmidt Road. The City intends to minimize the number of driveways on Roy Schmidt Road, because the preferred location for the MUT is on the west side of Roy Schmidt Road from Conservation Drive to the existing trail at the north limit of the subdivision; the driveways that conflict with the MUT are limited to Lots 226-242.

145. The developer shall design and construct a pedestrian refuge island and crossing within Conservation Drive at Street H, and at the MUT on Block 254 (Open Space). These are required to facilitate connections to facilities being constructed by the City, including bike lanes on both sides of Conservation Drive, and the MUT on the south side of Conservation Drive.

146. The Street H connection with Conservation Drive is located just west of the proposed roundabout at Beaver Creek Road. Stantec completed a turn lane analysis for all subdivision entrances onto Conservation Drive and Beaver Creek Road. There were

four recommendations made from the analysis. In its current location, Street H, will be limited to right-in/right-out (RIRO) movement only based on the recommendations outlined in the *Update to Transportation Forecast and Left Turn Lane Requirements Technical Memo* (Stantec, July 7, 2017). Should the developer maintain the location of Street H an analysis of the RIRO configuration and resulting reassignment of traffic for the proposed operations of the roundabout will need to be completed. Should RIRO not be desirable for Street H, please review the July 7, 2017 Turn Lane Analysis Memo for more intersection spacing options. Options may be investigated to remove Street H and extend Street E from Street F to Conservation Drive.

147. Please ensure appropriate coordination between the lighting plan for the proposed Draft Plan and the lighting plan for Conservation Drive.

PART D – ENGINEERING COMMENTS

148. The Beaver Creek Road Sewage Pumping Station must be in place prior to final registration of the Draft Plan and the issuance of any building permits.

149. The Communal SWM facility must be constructed prior to servicing of the subdivision for water quality control.

150. The SWM report indicates an additional SWM Report will be submitted for the "off-site" stormwater management. City staff would not be in a position to accept this dual management proposal without further details of the off-site facility as well as securities/assurances that it will be built and available to this development.

151. Several discussions have been held about the off-site SWM pond concept. A letter has been sent offering options.

152. If it is determined that the external facility is not feasible or it does not materialize, all SWM controls would be required within the development, requiring significant revisions to the design and layout of the plan.

153. The servicing strategy report indicates that matching elevations along the neighbouring properties is a design consideration. The conceptual grading plan includes some significant deviations from existing elevations on adjacent lands, namely a 6.0 metre high retaining wall in the northwest corner of the site and a 2.0 metre high retaining wall along the north property line. This will not be accepted by staff. This grading strategy will effectively preclude development of the adjacent property, and will incur significant costs for retaining walls and importing fill. A realistic proposal needs to be provided. Development of the Draft Plan lands must be completed in a way that will not to negatively impact or encumber the adjacent lands.

Please note that City staff reserves the right to provide additional comments, or modify the above noted comments subject to further review and/or additional information as may be provided.

I trust the foregoing is satisfactory, however should you have any questions please do not hesitate to contact the undersigned.

Sincerely,



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Development Planner
Planning Approvals
Integrated Planning & Public Works
City of Waterloo
P: 519.514.0225
F: 519.747.8523
TTY: 1.866.786.3941
E: natalie.hardacre@waterloo.ca

APPENDIX B:
Figures



Stantec

Legend

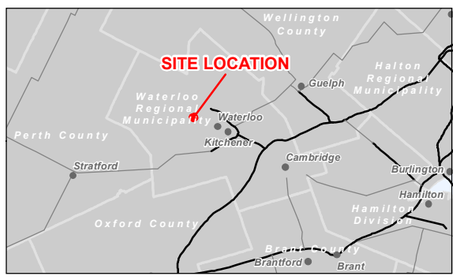
- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Proposed Draft Plan
- Proposed SWM Facility Infiltration Basin
- Watercourse
- Wetland - Evaluated (Provincial)

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2020.
3. Orthoimagery © First Base Solutions, 2021. Imagery Date, 2020.



Project Location
Waterloo, ON

160900921 REVA
Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

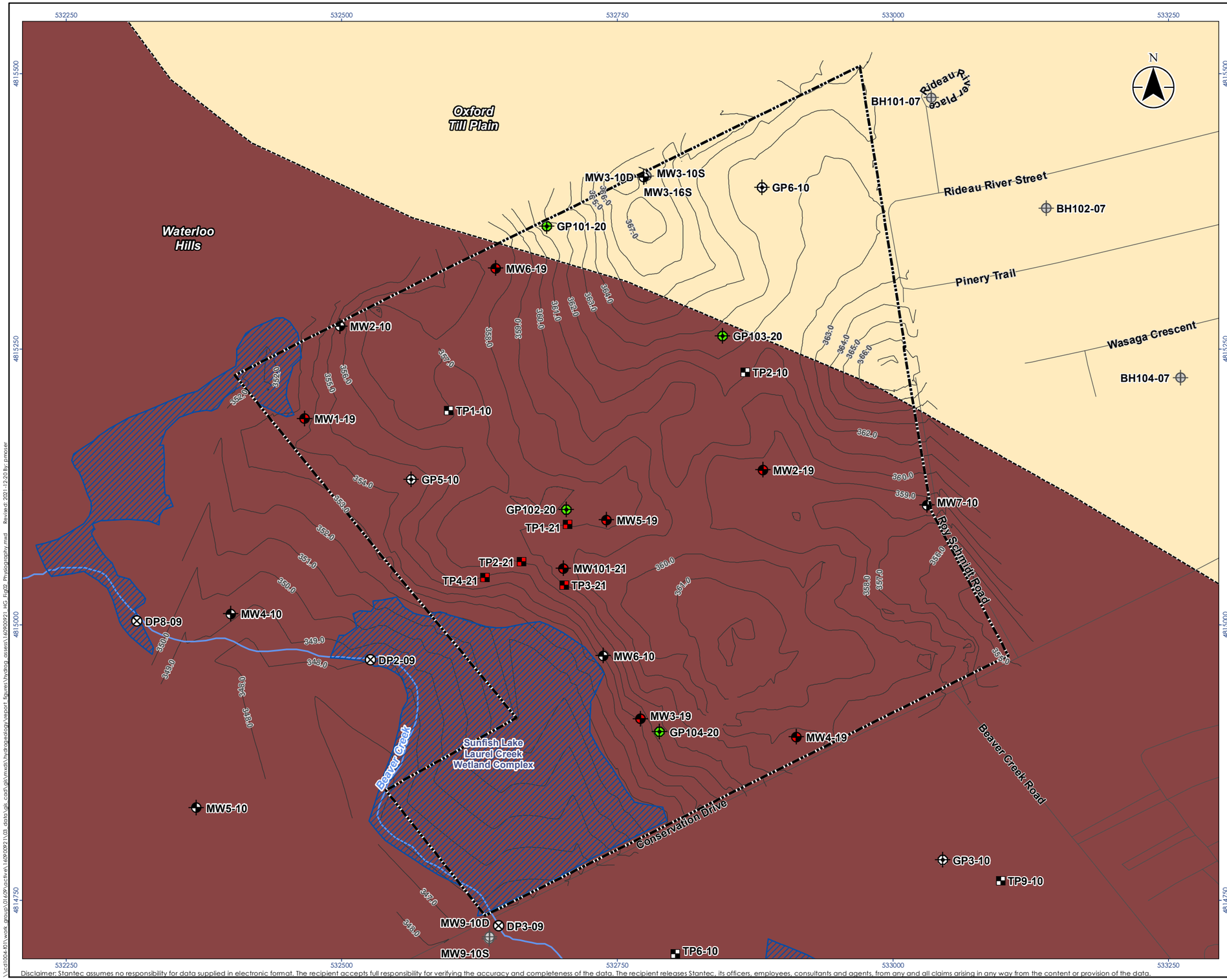
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Topographic Contour (mAMSL)
- Watercourse
- Wetland - Evaluated (Provincial)
- Physiographic Region Boundary

Physiography

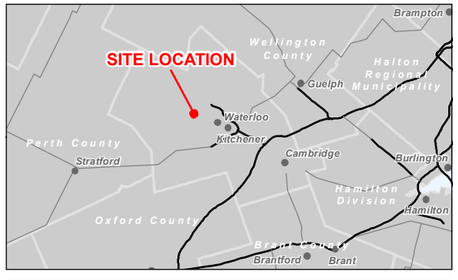
- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

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3. Orthoimagery © First Base Solutions, 2019. Imagery Date, 2018.
4. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



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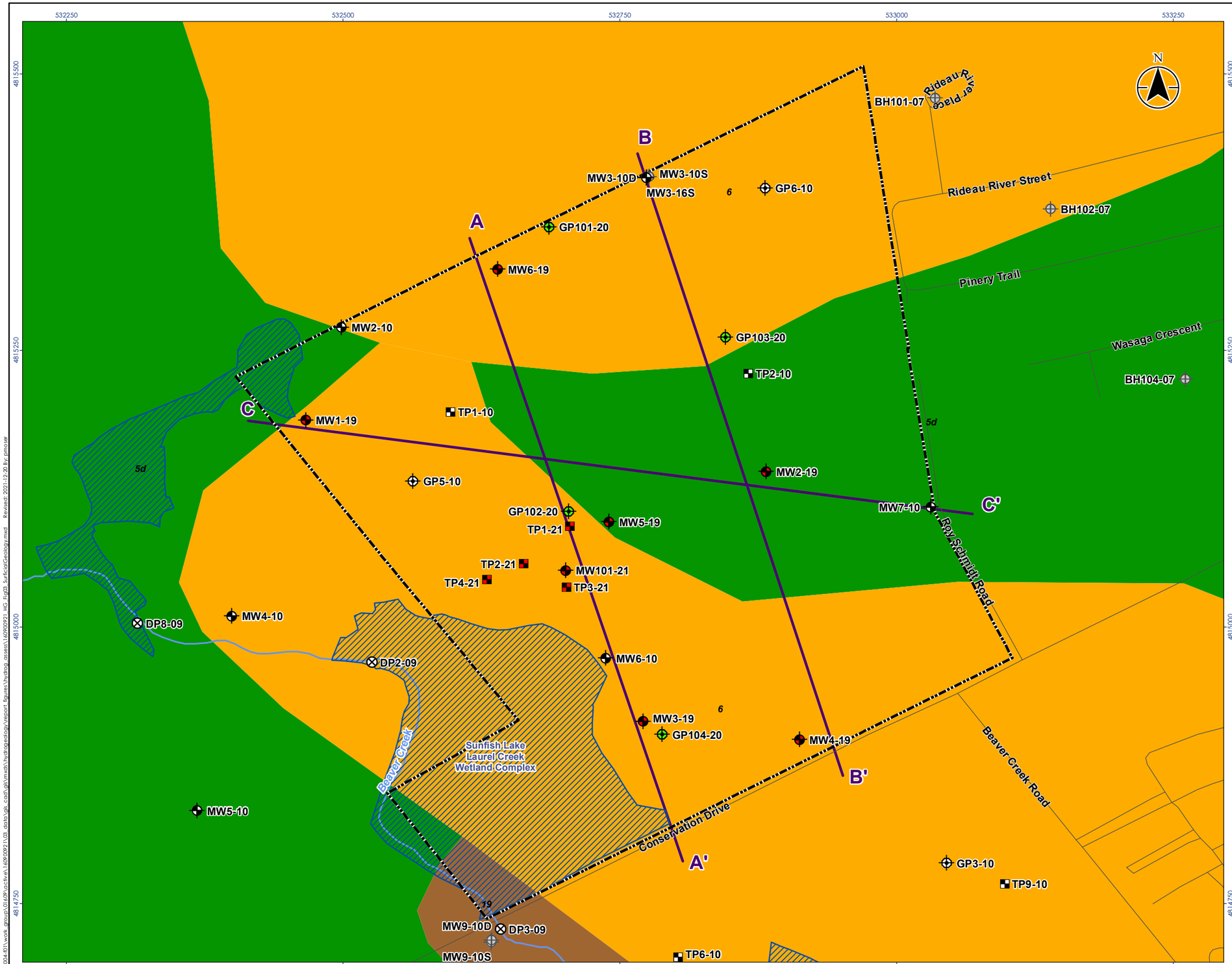
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography and Topography

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Cross-Section Location
- Watercourse
- Wetland - Evaluated (Provincial)

Surficial Geology

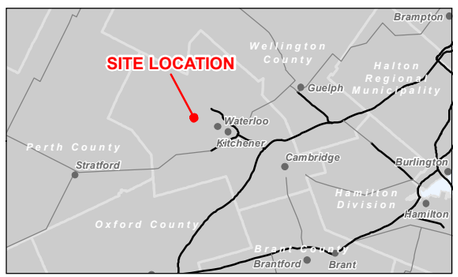
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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3. Ontario Geological Survey 2010. Surficial geology of Southern Ontario: Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4



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Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

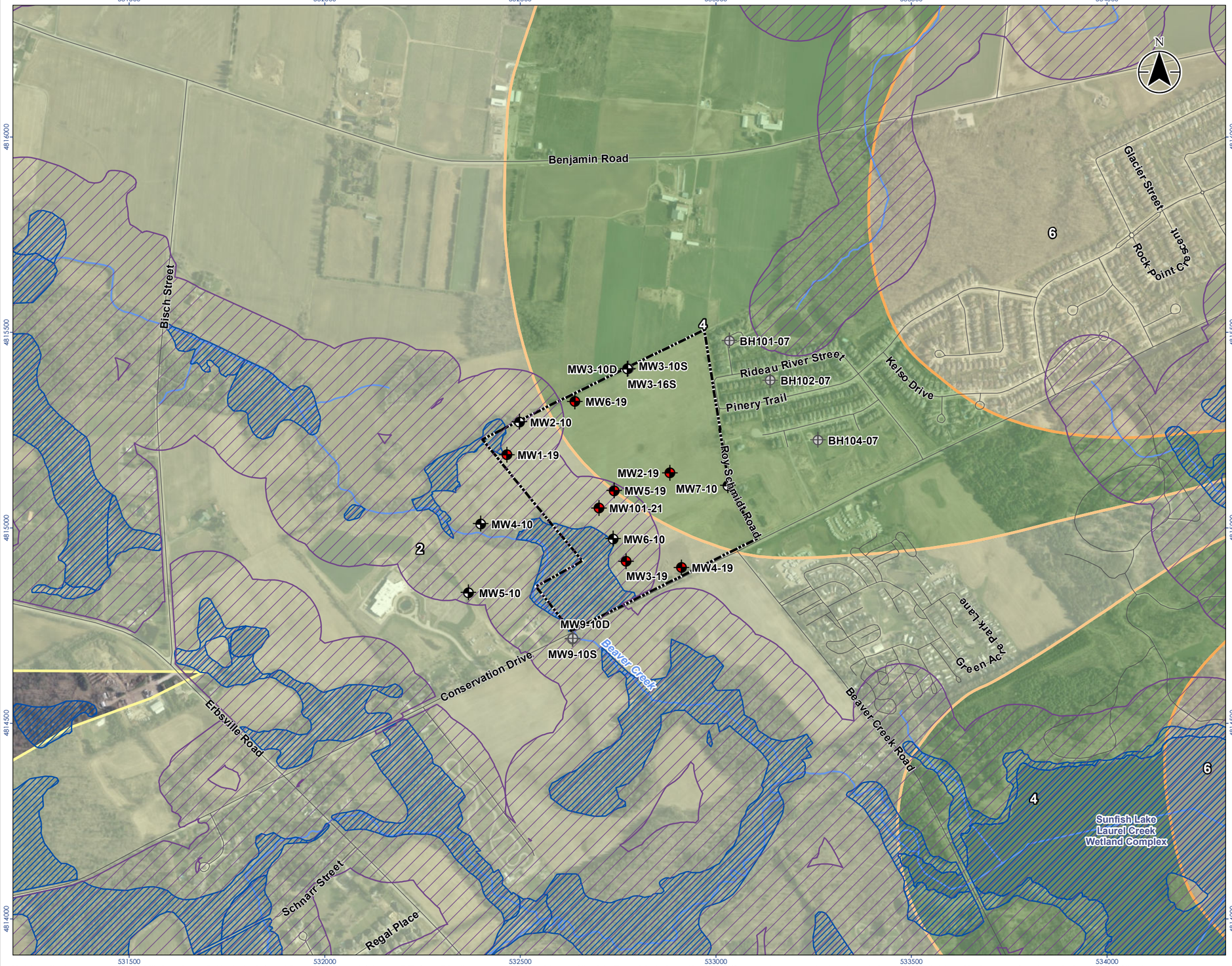
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
3

Title
Surficial Geology

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Intake Protection Zone

- IPZ-3

Wellhead Protection Areas

- WHPA-A
- WHPA-B
- WHPA-C
- WHPA-D

Wellhead Protection Areas Vulnerability

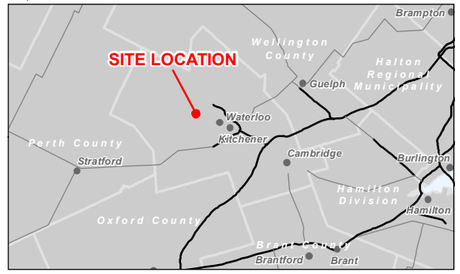
- 10
- 8
- 6
- 4
- 2

0 250 500 metres

1:10,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Orthoimagery © First Base Solutions, 2021. Imagery Date, 2020.
4. Contains Information made available under Grand River Conservation Authority's Open Data Licence v2.0.



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Waterloo, ON

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Technical Review by GW on 2021-12-12

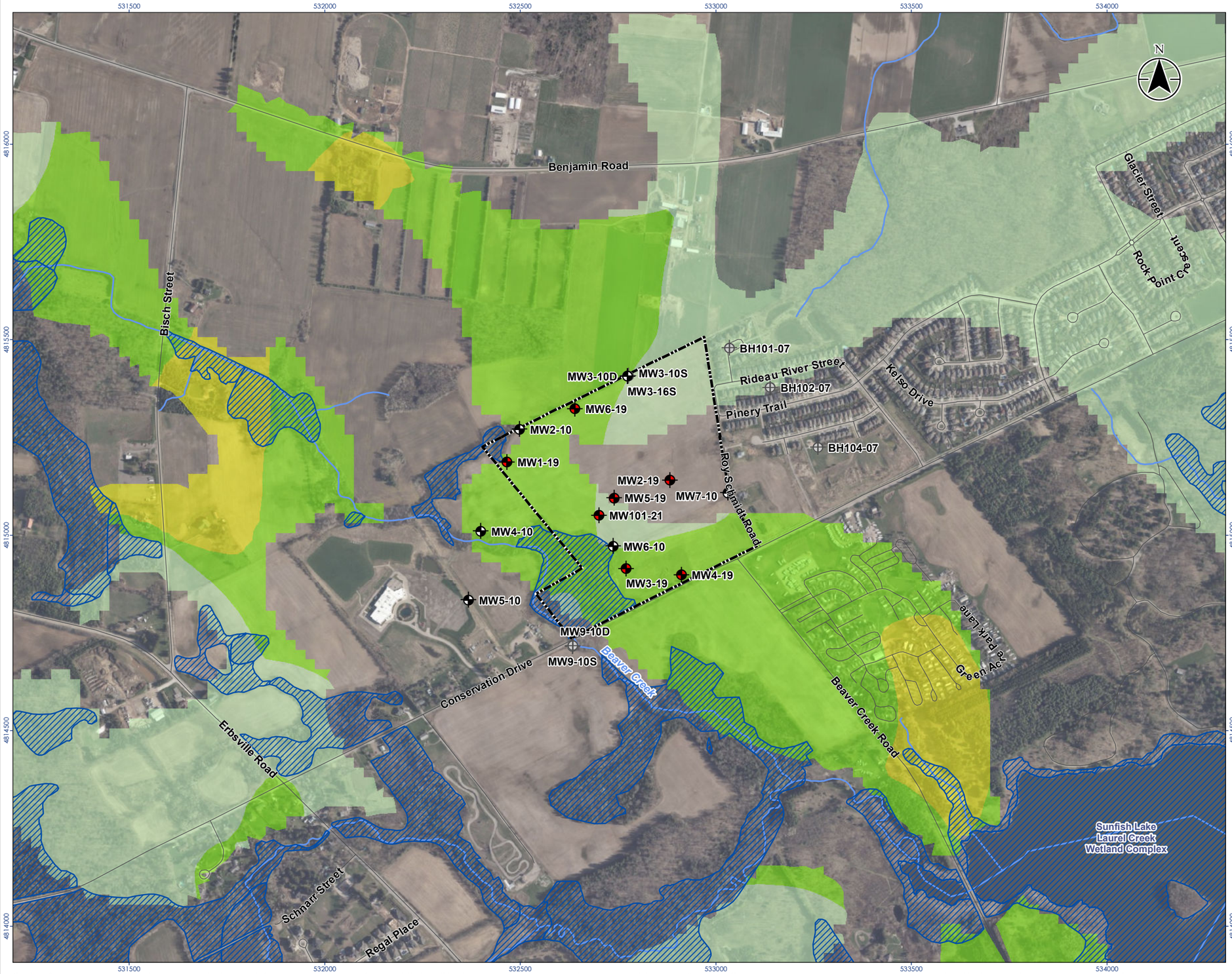
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
4

Title
Source Water Protection – Wellhead Protection Areas

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Significant Groundwater Recharge Area Vulnerability

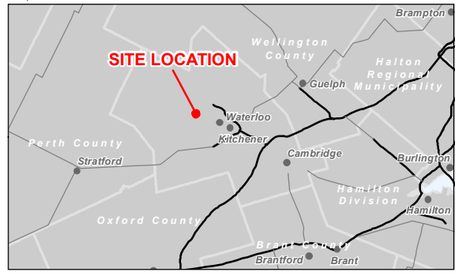
- 2
- 4
- 6

0 250 500 metres

1:10,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
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Project Location
Waterloo, ON

160900921 REVA
Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

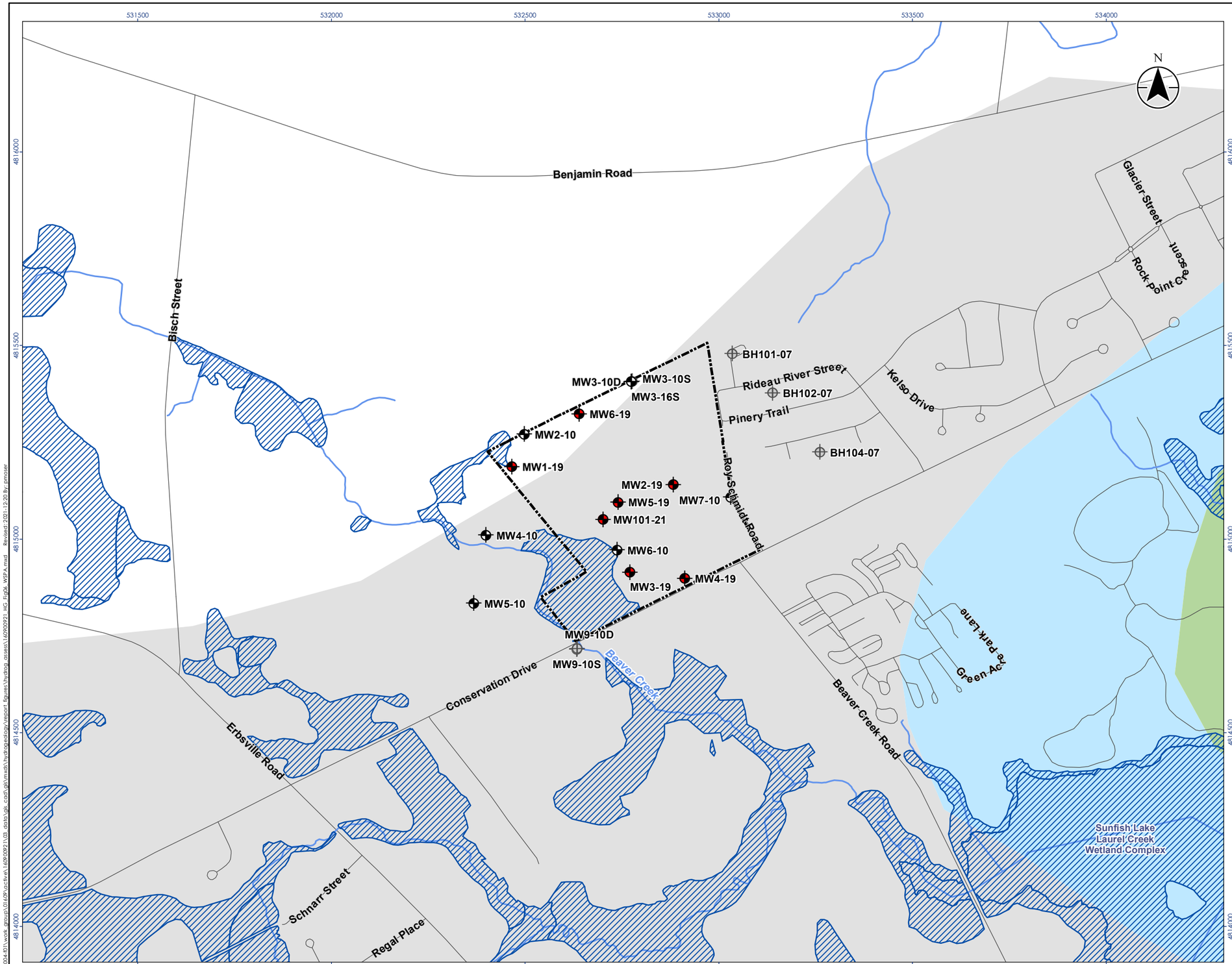
Client/Project
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HYDROGEOLOGICAL ASSESSMENT

Figure No.
5

Title
Source Water Protection – Significant Groundwater Recharge Area

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\\cd1004-f01\work_group\01\609\active\160900921\03_data\gis_cad\gis\mxds\Hydrogeology\report figures\Hydrogeology Report Figures\Hydrogeology Report Figure 5 Source Water Protection_Signif_GW_Recharge.mxd Revised: 2021-12-20 By: pmorse



Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Wellhead Protection Areas

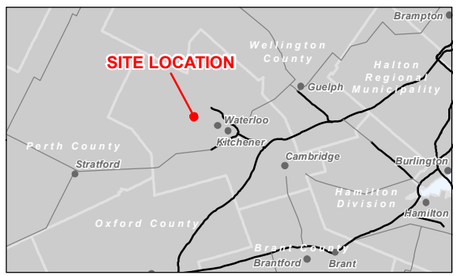
- WPSA-4
- WPSA-6
- WPSA-7
- WPSA-8

0 250 500 metres

1:10,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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3. Wellhead Protection Areas © Region of Waterloo Official Plan, 2015.



Project Location
Waterloo, ON

160900921 REVA
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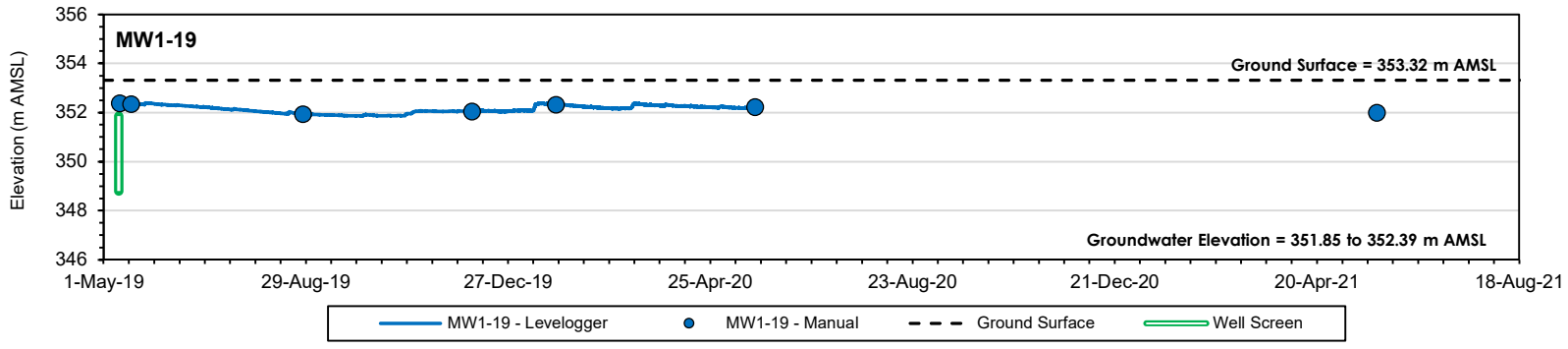
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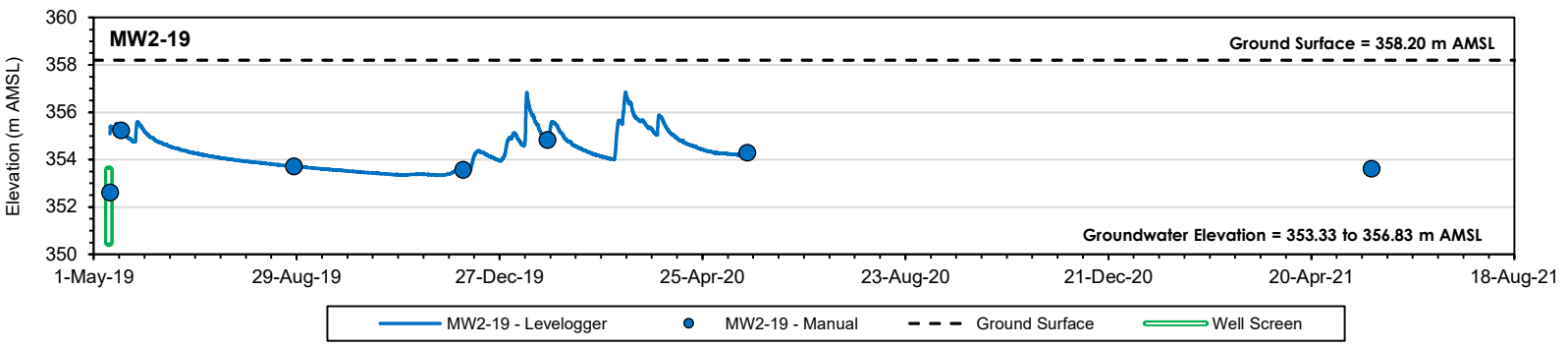
Figure No.
6

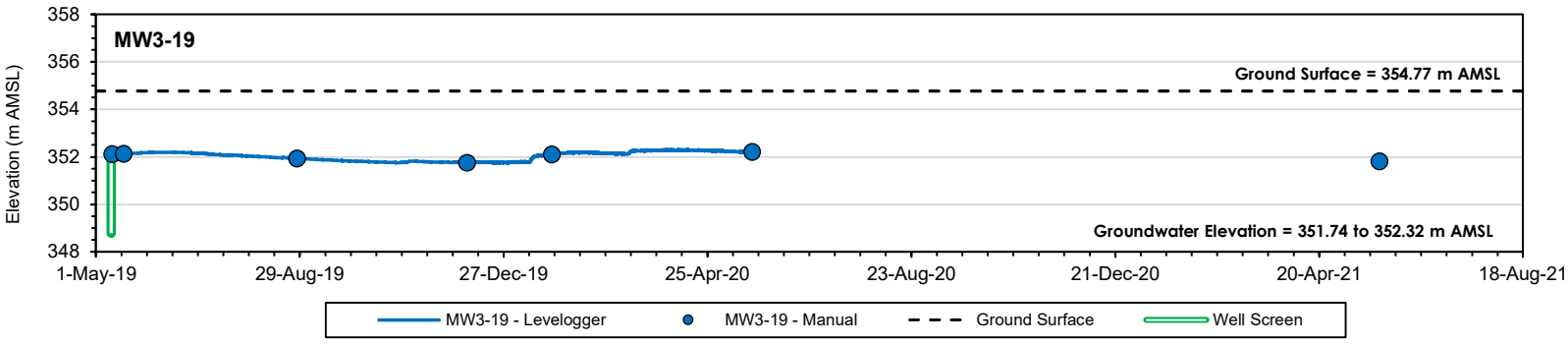
Title
Wellhead Protection Sensitivity Areas

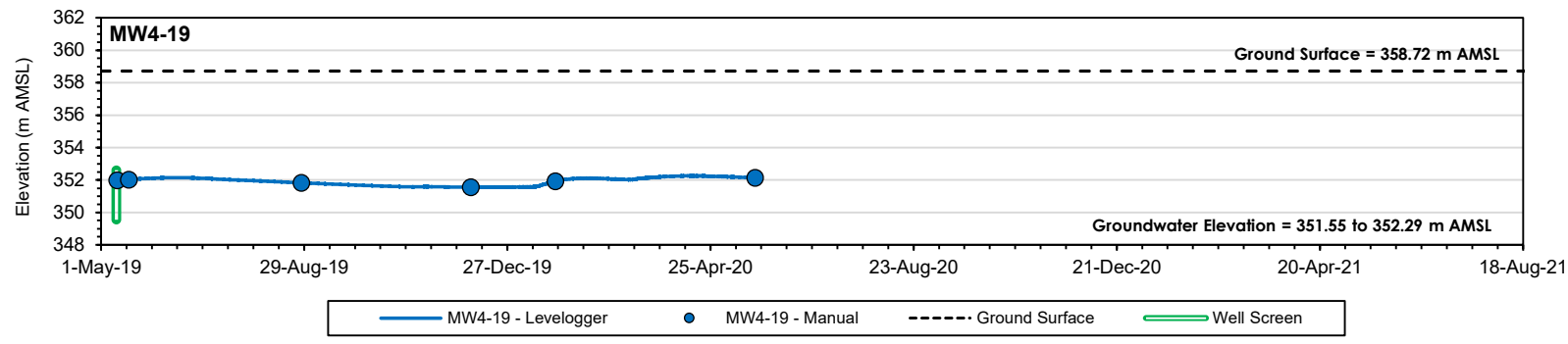
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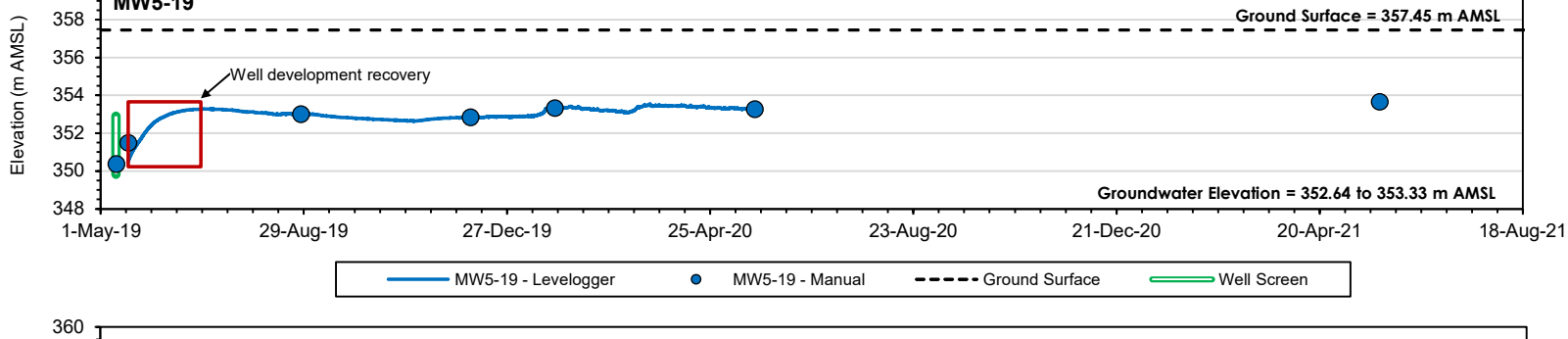
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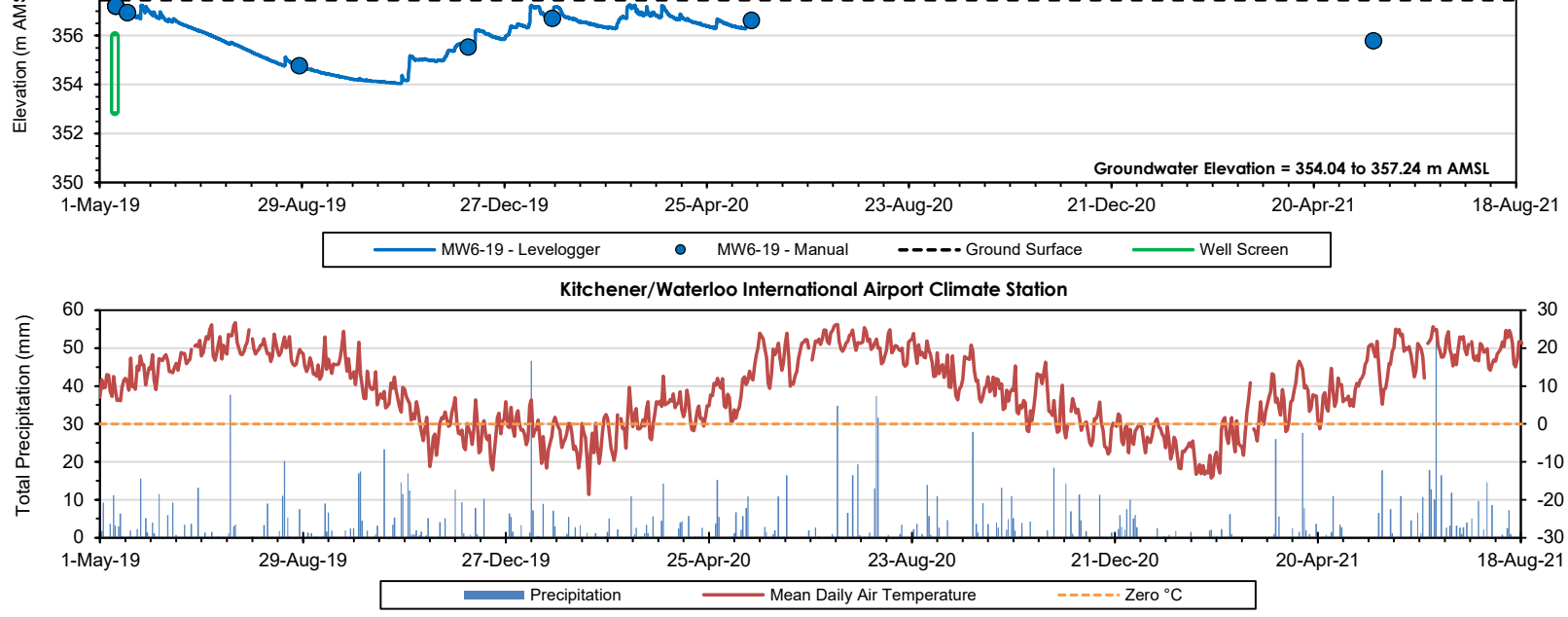












Notes

(1) Precipitation and temperature data were obtained from Environment Canada for the Region of Waterloo International Airport (ID 6144239), accessed December 2021.

(2) Data range for MW5-19 does not include water levels recorded during recovery from hydraulic conductivity test.

Stantec

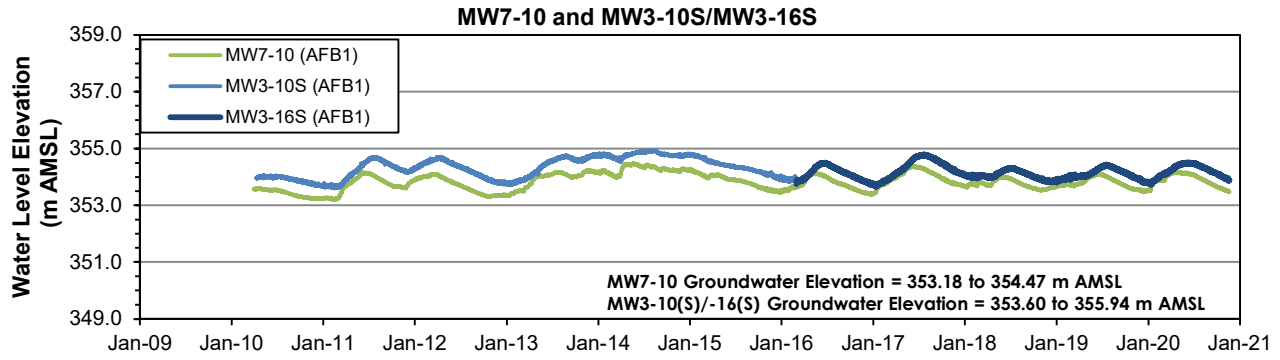
Client/Project

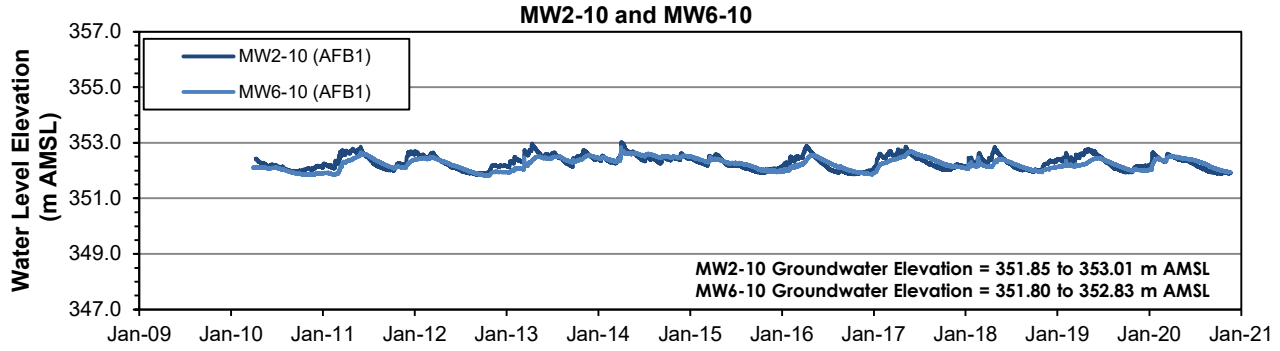
2115881 Ontario Limited
556, 560, and 576 Conservation Drive
Hydrogeological Assessment

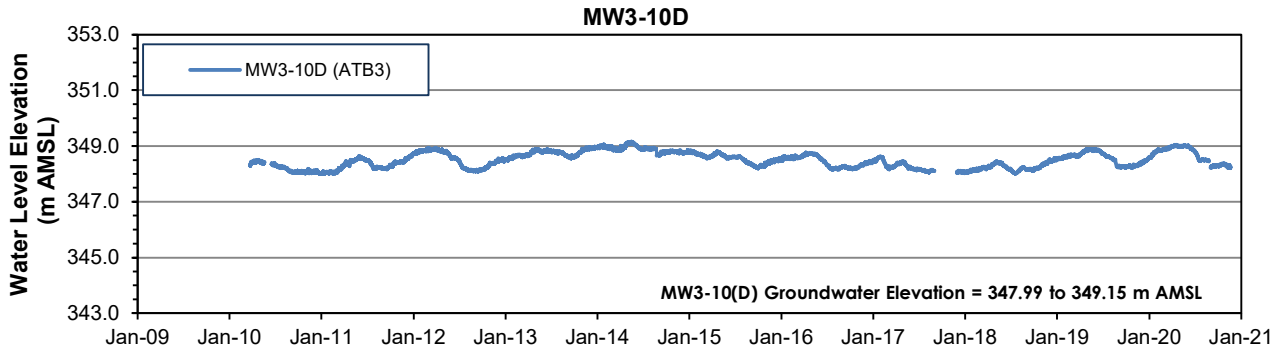
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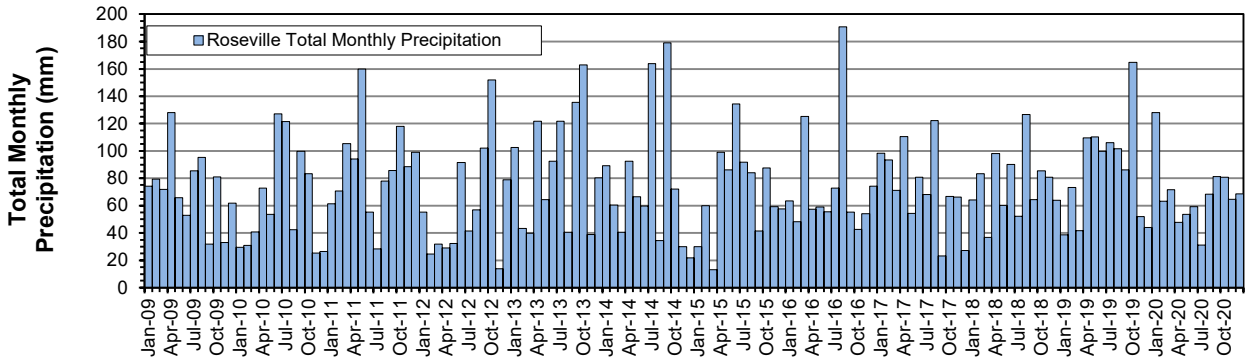
7

Title **HYDROGRAPHS**
MW1-19 to MW6-19









Source

Stantec Consulting Limited. 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program.

Client/Project

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HYDROGEOLOGICAL ASSESSMENT

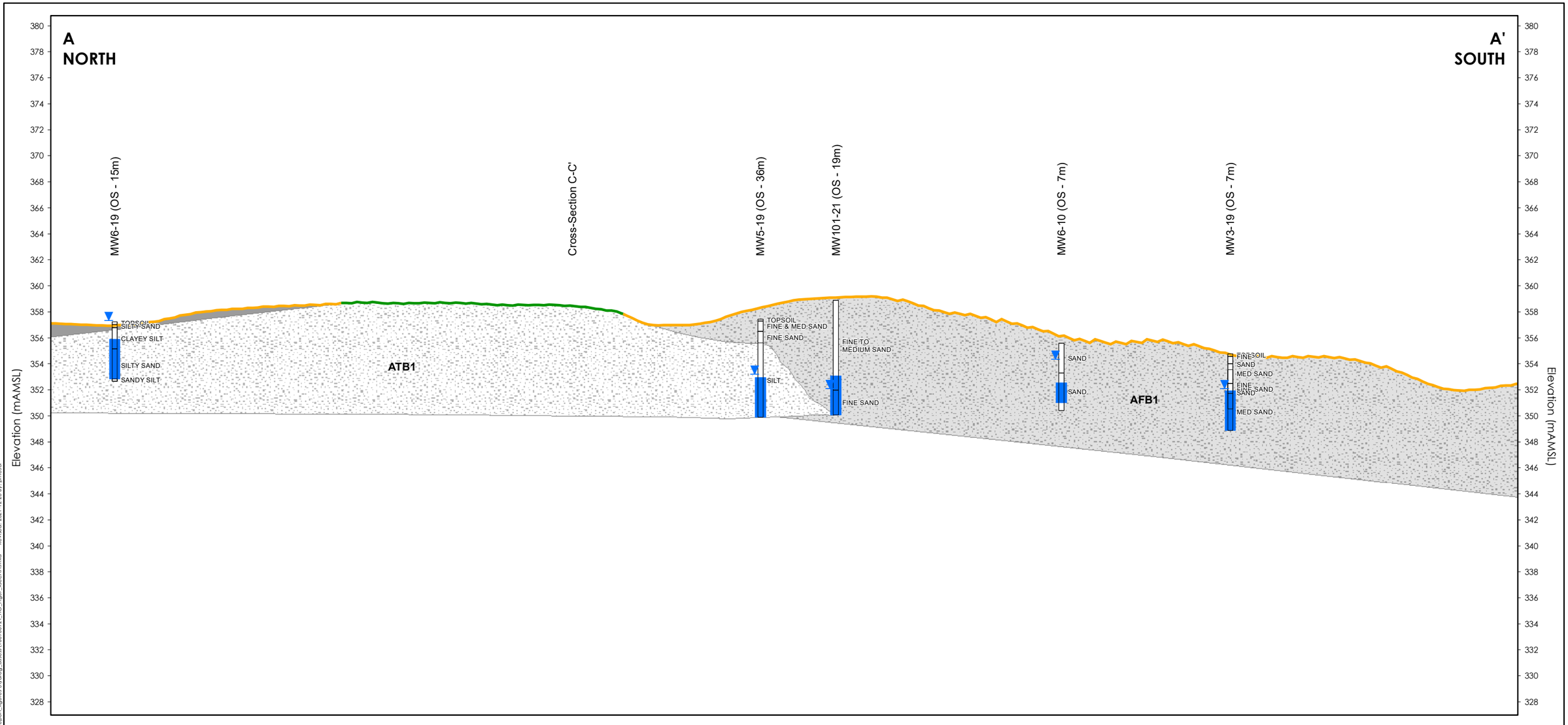
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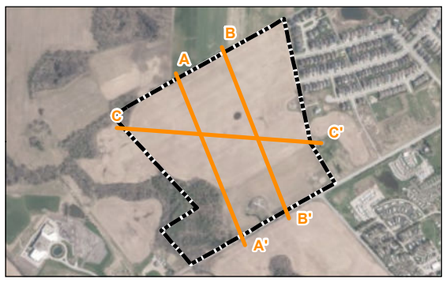
8

Title

HYDROGRAPHS
MW2-10, MW3-10(S)/-16(S), MW3-10(D), MW6-10, AND MW7-10

Stantec





MW1-15 (OS m)
Sand

Well ID (Offset)

Stratigraphy

Water Level (High Groundwater Conditions)

Well Screen

Surficial Geology

- 5d: Glaciolacustrine-derived silty to clayey till
- 6: Ice-contact stratified deposits
- Fill / Topsoil
- ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1
- AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1

5x Vertical Exaggeration

0 25 50 metres

1:1,500 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

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Project Location
Waterloo, ON

160900921 REVA
Prepared by pmoser on 2021-12-20
Technical Review by GW on 2021-12-20

Client/Project
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HYDROGEOLOGICAL ASSESSMENT

Figure No.
9

Title
Cross-Section A-A'

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B
NORTH

B'
SOUTH

MW3-10 (OS-1m)
GP103-20 (OS-24m)
TP2-10 (OS-33m)
MW2-19 (OS-20m)
Cross-Section C-C'
MW4-19 (OS-27m)

Elevation (mAMSL)

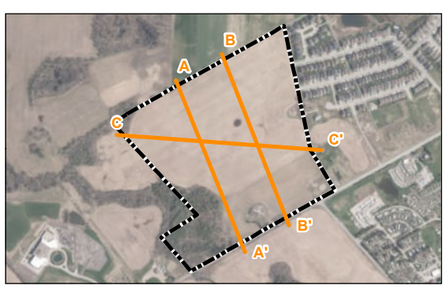
TOPSOIL
SAND
SILT
SAND
SILT & SAND
SILTY CLAY
SILT
SILTY CLAY TILL
SAND & SILT
SILTY SAND TILL

TOPSOIL
SILT
SILTY CLAY
SILT

TOPSOIL
CLAYEY SILT
SILTY CLAY
SANDY SILT

FINESOIL
SAND
FINE & MED SAND
MED SAND
FINE SAND

ATB1
AFB1
ATB3
ATC1



MW1-15 (OS m)
Sand

Well ID (Offset)

Stratigraphy

Water Level (High Groundwater Conditions)

Well Screen

High Groundwater Table

Surficial Geology

- 5d: Glaciolacustrine-derived silty to clayey till
- 6: Ice-contact stratified deposits
- ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1
- AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1
- ATB3 Lower Maryhill Till (silty to clayey till) - Aquitard 2
- ATC1 Catfish Creek Till (sandy to stoney silt till) - Aquitard 3

5x Vertical Exaggeration

0 25 50 metres

1:1,500 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

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Waterloo, ON

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Technical Review by GW on 2021-12-20

Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
10

Title
Cross-Section B-B'

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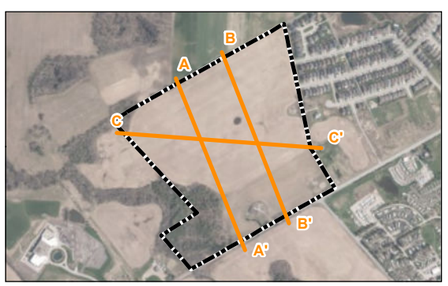
C
WEST

C'
EAST

Elevation (mAMSL)

MW1-19 (OS - 7m)
TP1-10 (OS - 31m)
Cross-Section A-A'
GP102-20 (OS - 44m)
MW5-19 (OS - 49m)
Cross-Section B-B'
MW2-19 (OS - 14m)
MW7-10 (OS - 2m)

TOPSOIL
FINE SAND
MED SAND
TOPSOIL
SAND
SILT
SAND
SILTY CLAY
AFB1
TOPSOIL
FINE & MED SAND
FINE SAND
SILT
ATB1
TOPSOIL
CLAYEY SILT
SILTY CLAY
SANDY SILT
TOPSOIL
CLAYEY SILT
SAND
SILT
SAND



MW1-15 (OS m)
Sand

Well ID (Offset)

Stratigraphy

Water Level (High Groundwater Conditions)

Well Screen

High Groundwater Table

Surficial Geology

5d: Glaciolacustrine-derived silty to clayey till

6: Ice-contact stratified deposits

ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1

AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1

5x Vertical Exaggeration

0 30 60 metres

1:1,750 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

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Figure No.
11

Title
Cross-Section C-C'

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Stantec

Legend

- Site Boundary
- 357.54 Groundwater Elevation (m AMSL)
- Monitoring Well (Stantec, 2020 - 2021)
- Monitoring Well (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Topographic Contour (m AMSL)
- Proposed SWM Facility Infiltration Basin
- Groundwater Contour (m AMSL)
- Interpreted Groundwater Contour (m AMSL)
- Interpreted Direction of Groundwater Flow
- Watercourse
- Wetland - Evaluated (Provincial)

Surficial Geology

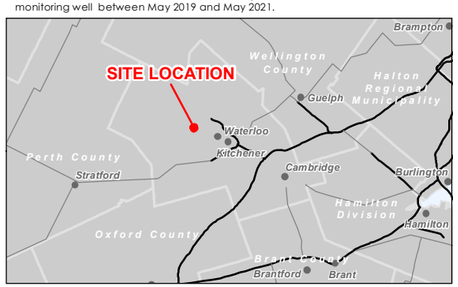
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Ontario Geological Survey 2010. Surficial geology of Southern Ontario: Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4
4. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.



Project Location
Waterloo, ON

160900921 REVA
Prepared by PRM on 2021-12-21
Technical Review by GW on 2021-12-21

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Figure No.
12

Title
High Groundwater Elevations

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APPENDIX C:
Tables

TABLE 1
MONITORING WELL CONSTRUCTION DETAILS

Well ID	UTM Coordinates		Elevations		Well Stick-up (m)	Well Depth (m BTOC)	Well Depth (m BGS)	Well Base Elevation (m AMSL)	Screened Interval				Screened Material Description [a] (% of screened interval)	Probable Hydrostratigraphic Unit	Hydraulic Conductivity [b] (m/s)
	Northing	Easting	Top of Casing (m AMSL)	Ground Surface (m AMSL)					Top Elevation (m BGS)	Top Elevation (m AMSL)	Bottom Elevation (m BGS)	Bottom Elevation (m AMSL)			
MONITORING WELLS															
MW101-21	4815051	532701	359.87	358.88	0.99	9.79	8.80	350.08	5.75	353.13	8.80	350.08	SAND, trace silt	Aquifer 1	1.6E-03
MW1-19	4815187	532466	354.10	353.32	0.78	5.20	4.42	348.90	1.37	351.95	4.42	348.90	Medium SAND (100%)	Aquifer 1	2.8E-04
MW2-19	4815140	532882	358.92	358.20	0.72	8.38	7.66	350.54	4.61	353.59	7.66	350.54	Fine SAND, some silt/clay (100%)	Aquifer 1	8.0E-07
MW3-19	4814915	532771	355.59	354.77	0.82	6.70	5.88	348.89	2.83	351.94	5.88	348.89	Medium SAND (100%)	Aquifer 1	1.8E-04
MW4-19	4814898	532912	359.49	358.72	0.77	9.85	9.08	349.64	6.03	352.69	9.08	349.64	Fine SAND, trace silt/clay (100%)	Aquifer 1	1.9E-04
MW5-19	4815095	532740	358.23	357.45	0.78	8.33	7.55	349.90	4.50	352.95	7.55	349.90	SILT, some clay (100%)	Aquifer 1	1.8E-09
MW6-19	4815323	532640	358.02	357.24	0.78	5.18	4.40	352.84	1.35	355.89	4.40	352.84	Clayey SILT (20%) / Silty SAND (80%)	Aquitard 1 / Aquifer 1	1.6E-07
MW2-10	4815271	532498	356.52	355.56	0.96	5.53	4.57	350.99	3.05	352.51	4.57	350.99	Fine to Medium SAND (100%)	Aquifer 1	6.6E-05
MW3-10S	4815407	532776	367.62	366.81	0.81	14.53	13.72	353.09	12.20	354.61	13.72	353.09	Fine to Medium SAND (100%)	Aquifer 1	3.4E-06
MW3-10D	4815406	532774	367.60	366.84	0.76	42.37	41.61	325.23	40.09	326.75	41.61	325.23	Sandy SILT TILL (100%)	Aquitard 2	8.4E-08
MW3-16S	4815406	532774	367.70	366.84	0.86	14.58	13.72	353.12	12.20	354.64	13.72	353.12	Fine SAND (100%)	Aquifer 1	-
MW4-10	4815010	532399	348.64	347.87	0.77	3.82	3.05	344.82	1.53	346.34	3.05	344.82	Silty SAND (60%) / Clayey SILT (40%)	Aquifer 1 / Aquitard 1	2.2E-06
MW5-10	4814834	532368	351.91	351.08	0.83	5.10	4.27	346.81	2.75	348.33	4.27	346.81	Silty SAND (100%)	Aquifer 1	1.3E-05
MW6-10	4814972	532737	356.48	355.58	0.90	5.47	4.57	351.01	3.05	352.53	4.57	351.01	Medium SAND (100%)	Aquifer 1	5.1E-05
MW7-10	4815108	533031	359.67	358.74	0.93	8.25	7.32	351.42	5.80	352.94	7.32	351.42	Fine to Medium SAND (100%)	Aquifer 1	8.7E-05
														GEOMEAN (Aquitard 1 / Aquifer 1) =	**1.2E-05**

Notes:

(a) Refer to **Appendix G** for borehole and well construction logs
(b) Refer to **Appendix H** hydraulic conductivity analytical solutions

m AMSL = meters above mean sea level
m BGS = meters below ground surface
m BTOC = meters below top of well casing
- = data not available

TABLE 2
GROUNDWATER LEVEL DATA - MONITORING WELLS

Well ID	Date	Time	Well Depth			Screen Length	Top of Casing Elevation	Ground Surface Elevation	Pipe Stick-up	Groundwater Level		
			(m BTOC)	(m BGS)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	(m)	(m BGS) [1]	(m BTOC)	(m AMSL)
MW1-19	10-May-19	1:23 PM	5.20	4.42	348.90	3.05	354.10	353.32	0.78	0.93	1.71	352.39
	17-May-19	9:13 AM								0.97	1.75	352.35
	27-Aug-19	9:05 AM								1.38	2.16	351.94
	5-Dec-19	-								1.27	2.05	352.05
	24-Jan-20	10:55 AM								1.00	1.78	352.32
	20-May-20	12:21 PM								1.09	1.87	352.23
	25-May-21	12:40 PM								1.33	2.11	351.99
MW2-19	10-May-19	9:33 AM	8.38	7.66	350.54	3.05	358.92	358.20	0.72	2.77	3.49	355.43
	17-May-19	8:53 AM								2.96	3.68	355.24
	27-Aug-19	9:25 AM								4.48	5.20	353.72
	5-Dec-19	1:04 PM								4.63	5.35	353.57
	24-Jan-20	10:20 AM								3.36	4.08	354.84
	20-May-20	1:26 PM								3.90	4.62	354.30
	25-May-21	12:52 PM								4.58	5.30	353.62
MW3-19	10-May-19	4:20 PM	6.70	5.88	348.89	3.05	355.59	354.77	0.82	2.65	3.47	352.12
	17-May-19	8:31 AM								2.64	3.46	352.13
	27-Aug-19	9:45 AM								2.84	3.66	351.93
	5-Dec-19	12:22 PM								3.01	3.83	351.76
	24-Jan-20	9:46 AM								2.67	3.49	352.10
	20-May-20	8:39 AM								2.55	3.37	352.22
	25-May-21	1:30 PM								2.96	3.78	351.81
MW4-19	10-May-19	3:14 PM	9.85	9.08	349.64	3.05	359.49	358.72	0.77	6.73	7.50	351.99
	17-May-19	8:40 AM								6.69	7.46	352.03
	27-Aug-19	9:50 AM								6.89	7.66	351.83
	5-Dec-19	12:10 PM								7.16	7.93	351.56
	24-Jan-20	9:39 AM								6.79	7.56	351.93
	20-May-20	8:23 AM								6.57	7.34	352.15
	25-May-21	-								-	-	-
MW5-19	10-May-19	10:30 AM	8.33	7.55	349.90	3.05	358.23	357.45	0.78	4.53	5.31	352.92
	17-May-19	8:59 AM								5.97	6.75	351.48
	27-Aug-19	9:35 AM								4.45	5.23	353.00
	5-Dec-19	12:36 PM								4.62	5.40	352.83
	24-Jan-20	9:39 AM								4.12	4.90	353.33
	20-May-20	10:16 AM								4.18	4.96	353.27
	25-May-21	11:48 AM								4.58	5.36	352.87
MW6-19	10-May-19	12:19 PM	5.18	4.40	352.84	3.05	358.02	357.24	0.78	0.02	0.80	357.22
	17-May-19	9:23 AM								0.31	1.09	356.93
	27-Aug-19	8:54 AM								2.47	3.25	354.77
	5-Dec-19	12:36 PM								1.72	2.50	355.52
	24-Jan-20	10:49 AM								0.54	1.32	356.70
	20-May-20	12:34 PM								0.62	1.40	356.62
	25-May-21	12:45 PM								1.45	2.23	355.79
MW101-21	26-May-21	8:15 AM	9.79	8.80	350.08	3.05	359.87	358.88	0.99	6.63	7.62	352.25

Notes:

(1) A negative value indicates that the water level measured within the pipe is located above ground surface

m BGS = meters below ground surface
m BTOC = meters below top of casing
DRY = no groundwater or surface water was observed in the piezometer or watercourse, respectively
- = measurement not available

TABLE 3
INFILTRATION TESTING RESULTS

Testing Location ID	Source	Ground Surface Elevation [3] (m AMSL)	Horizontal Hydraulic Conductivity (m/s)	Vertical Hydraulic Conductivity[2] (cm/s)	Vertical Hydraulic Conductivity[2] (m/s)	Infiltration Rate[1] (mm/hr)	Testing Depth (m BGS)	Testing Depth (m AMSL)	Screened Interval (m BGS)	Soil Substrate Tested (% of screened interval)	Topsoil Thickness (m)	Grain Size Proportions (%)
Guelph Permeameter Testing (Site)												
GP5-10	Ecoplans (2013)[a]	-	-	7.5E-04	7.5E-06	79	0.36	-	-	Medium SAND	-	-
GP6-10	Ecoplans (2013)[a]	-	-	8.0E-04	8.0E-06	81	0.28	-	-	Medium SAND	-	-
GP101-20	Stantec (2020)	-	-	-	-	66	0.03	-	-	TOPSOIL	0.35	Gravel (0.1), Sand (30.0), Silt (42.9), Clay (27.0)
GP101-20	Stantec (2020)	-	-	2.3E-05	2.3E-07	31	0.57	-	-	SILT, trace fine sand and clay	-	Gravel (0.0), Sand (25.8), Silt (41.7), Clay (32.5)
GP102-20	Stantec (2020)	-	-	-	-	173	0.03	-	-	TOPSOIL	0.35	Gravel (3.5), Sand (81.1), Silt (8.9), Clay (6.5)
GP102-20	Stantec (2020)	-	-	1.0E-03	1.0E-05	86	0.70	-	-	Silty SAND, trace clay and fine gravel	-	-
GP103-20	Stantec (2020)	-	-	-	-	16	0.01	-	-	TOPSOIL	0.45	Gravel (0.2), Sand (37.7), Silt (45.1), Clay (17.0)
GP103-20	Stantec (2020)	-	-	7.3E-06	7.3E-08	23	0.70	-	-	Silty SAND, trace clay and fine gravel	-	-
GP104-20	Stantec (2020)	-	-	-	-	107	0.02	-	-	TOPSOIL	0.25	Gravel (15.2), Sand (71.2), Silt (9.1), Clay (4.5)
GP104-20	Stantec (2020)	-	-	2.1E-02	2.1E-04	194	0.55	-	-	Fine SAND	-	-
In-situ Hydraulic Response Testing (Site)												
MW1-19	Stantec (2019)		2.8E-04	2.8E-03	2.8E-05	113	-		1.5 - 4.5	Medium SAND, trace silt/clay	-	-
MW2-19	Stantec (2019)		8.0E-07	8.0E-06	8.0E-08	23	-		4.6 - 7.6	Fine SAND, some silt/clay	-	-
MW3-19	Stantec (2019)		1.8E-04	1.8E-03	1.8E-05	100	-		2.9 - 5.9	Medium SAND, trace gravel	-	-
MW4-19	Stantec (2019)		1.9E-04	1.9E-03	1.9E-05	100	-		6.1 - 9.1	Fine SAND, trace silt/clay	-	-
MW5-19	Stantec (2019)		1.8E-09	1.8E-08	1.8E-10	5	-		4.6 - 7.6	SILT, some clay	-	-
MW6-19	Stantec (2019)		1.6E-07	1.6E-06	1.6E-08	15	-		1.5 - 4.5	Clayey SILT (20%) / Silty SAND (80%)	-	-
MW101-21	Stantec (2021)		1.6E-03	1.6E-02	1.6E-04	180	-		5.7 - 8.8	SAND, trace silt	-	-
MW2-10	Ecoplans (2013)[b]		6.6E-05	6.6E-04	6.6E-06	77	-		3.1 - 4.6	Fine to Medium SAND	-	-
MW5-10	Ecoplans (2013)[b]		1.3E-05	1.3E-04	1.3E-06	50	-		2.8 - 4.3	Silty SAND, fine to medium-grained	-	-
MW6-10	Ecoplans (2013)[b]		5.1E-05	5.1E-04	5.1E-06	71	-		3.1 - 4.6	Medium SAND, trace gravel	-	-
MW7-10	Ecoplans (2013)[b]		8.7E-05	8.7E-04	8.7E-06	82	-		5.8 - 7.3	Fine to Medium SAND	-	-
			AVERAGE (TOPSOIL) =		**-**	**91**						
			GEOMEAN (Fine to Medium SAND) =		**1.4E-05**	**94**						
			GEOMEAN (Silty to Clayey SAND, SILT to Clayey SILT) =		**2.1E-08**	**16**						
Guelph Permeameter Testing (Proposed SWM Facility Infiltration Basin)												
TP1-21 (GP1)	Stantec (2021)	357.94	-	6.1E-03	6.1E-05	139	4.40	353.54	-	SAND, trace silt	-	Gravel (0.6), Sand (96.7), Silt (2.7)
TP1-21 (GP2)	Stantec (2021)	357.94	-	3.4E-02	3.4E-04	220	4.50	353.44	-	SAND	-	-
TP1-21 (GP3)	Stantec (2021)	357.94	-	2.5E-02	2.5E-04	203	5.50	352.44	-	SAND, trace silt	-	Gravel (1.9), Sand (90.5), Silt (7.6)
TP2-21 (GP1)	Stantec (2021)	356.77	-	2.6E-02	2.6E-04	205	2.90	353.87	-	SAND, trace gravel and silt	-	Gravel (3.8), Sand (95.1), Silt (1.1)
TP2-21 (GP2)	Stantec (2021)	356.77	-	1.0E-02	1.0E-04	160	2.90	353.87	-	SAND	-	-
TP2-21 (GP3)	Stantec (2021)	356.77	-	2.4E-02	2.4E-04	200	4.30	352.47	-	SAND, trace gravel and silt	-	Gravel (3.0), Sand (93.9), Silt (3.1)
TP3-21 (GP1)	Stantec (2021)	357.98	-	5.0E-03	5.0E-05	132	4.00	353.98	-	SAND, some silt	-	Sand (90.0), Silt (10.0)
TP3-21 (GP2)	Stantec (2021)	357.98	-	1.3E-02	1.3E-04	170	4.00	353.98	-	SAND	-	-
TP3-21 (GP3)	Stantec (2021)	357.98	-	3.4E-03	3.4E-05	119	5.50	352.48	-	SAND	-	-
TP3-21 (GP4)	Stantec (2021)	357.98	-	4.1E-02	4.1E-04	232	5.50	352.48	-	SAND, trace gravel and silt	-	Gravel (1.5), Sand (96.9), Silt (1.6)
TP4-21 (GP1)	Stantec (2021)	355.83	-	6.1E-04	6.1E-06	75	2.90	352.93	-	SAND, trace gravel and silt	-	Gravel (5.7), Sand (92.1), Silt (2.2)
TP4-21 (GP2)	Stantec (2021)	355.83	-	8.1E-02	8.1E-04	278	4.40	351.43	-	SAND, trace gravel and silt	-	Gravel (6.7), Sand (92.3), Silt (1.0)
TP4-21 (GP3)	Stantec (2021)	355.83	-	3.4E-02	3.4E-04	221	4.40	351.43	-	SAND	-	-
			GEOMEAN (Fine to Coarse SAND) =		**1.3E-04**	**170**						
All Testing Locations												
			GEOMEAN (Fine to Coarse SAND) =		**5.4E-05**	**135**						

Notes:

(1) Infiltration rate calculated based on established relationship between vertical hydraulic conductivity and infiltration rate presented in *Credit Valley Conservation and* Toronto and Region Conservation (2010) Low Impact Stormwater Management Planning *and Design Guideline - Version 1.0.*

(2) Vertical hydraulic conductivities assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities.

(3) Stantec Geomatics surveyed the ground surface elevations at each test pit to a geodetic benchmark using the Can-Net GPS Survey system, having a spatial accuracy of +/- 0.03 m and +/- 0.02 m in the vertical and horizontal plane, respectively.

References:

(a) Ecoplans Ltd (a member of MMM Group), MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 3B (Table B1). November 2013.

(b) Ecoplans Ltd (a member of MMM Group), MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 3A (Table A1). November 2013.

TABLE 4 - DESIGN INFILTRATION RATE CALCULATION

Proposed Infiltration Facility															
	Calculated Vertical Hydraulic Conductivities (m/s)													Geomean	Infiltration Rate (mm/hr)
Test Location	TP1-GP1	TP1-GP2	TP1-GP3	TP2-GP1	TP2-GP2	TP2-GP3	TP3-GP1	TP3-GP2	TP3-GP3	TP3-GP4	TP4-GP1	TP4-GP2	TP4-GP3		
Base of Facility	6.1E-05	3.4E-04		2.6E-04	1.0E-04		5.0E-05	1.3E-04						1.2E-04	168
~1.5 m below Base			2.5E-04			2.4E-04			3.4E-05	4.1E-04		8.1E-04	3.4E-04	2.5E-04	203
Ratio (Base / 1.5 m)															*0.8*
Safety Factor															2.5
Design Infiltration Rate															***67***

=168/203

Notes:

(1) Infiltration rate calculated based on established relationship between vertical hydraulic conductivity and infiltration rate presented in *Credit Valley Conservation and Toronto and Region Conservation (2010) Low Impact Stormwater Management Planning and Design Guideline - Version 1.0.*

(2) Table C2 provided on Page C8 (Appendix C) of the *CVC/TRCA (2020) Low Impact Stormwater Management Planning and Design Guideline - Version 1.0.*

Table C2: Safety correction factors for calculating design infiltration rates

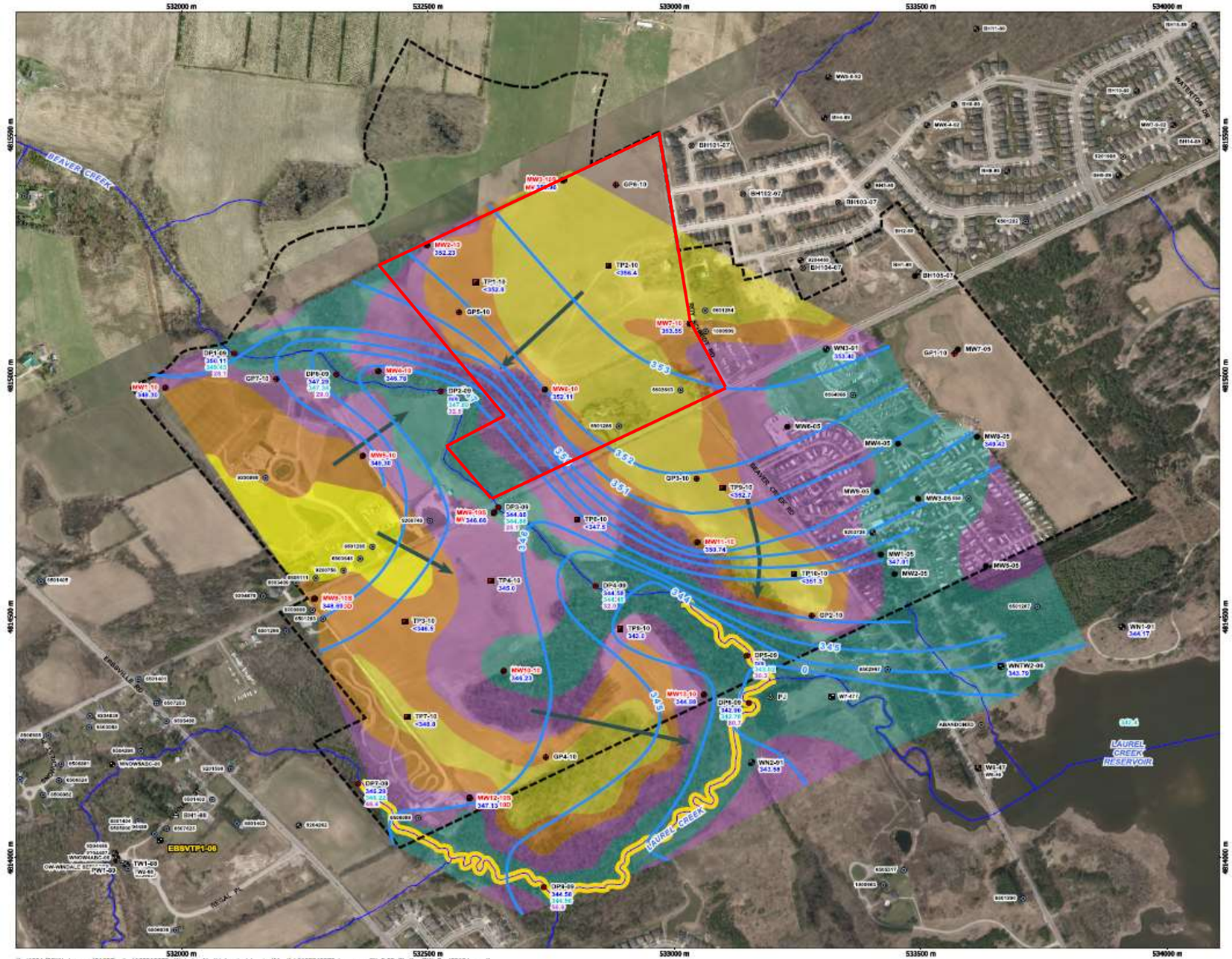
Ratio of Mean Measured Infiltration Rates[1]	Safety Correction Factor[2]
≤ 1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

Source: Wisconsin Department of Natural Resources. 2004. Conservation Practice Standards. Site Evaluation for Stormwater Infiltration (1002). Madison, WI.

Notes:

1. Ratio is determined by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the geometric mean measured infiltration rate of the least permeable soil horizon within 1.5 metres below the proposed bottom elevation of the BMP.
2. The design infiltration rate is calculated by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the safety correction factor.

APPENDIX D:
North Waterloo Scoped Subwatershed Study – Groundwater Flow Mapping



NORTH WATERLOO SCOPED SUBWATERSHED STUDY

SHALLOW GROUNDWATER FLOW SEPTEMBER 2010

FIGURE 5.22

- Monitoring Well (Stantec, 2010)
- Drive-Point Piezometer (Stantec, 2010)
- Guelph Permeameter (Stantec, 2010)
- Test Pit (Stantec, 2010)
- Abandoned Monitoring Well (Naylor, 2007)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (CH2MHill, 1991)
- Monitoring Well (Terraqua, 1991)
- Piezometer Location
- Monitoring Well (Other)
- Test Hole
- Water Supply Well
- Well (Other)
- Abandoned Well
- 349.30 Groundwater Elevation (mAMSL)
- 342.50 Surface Water Elevation (mAMSL)
- 342.50 Surface Water Flow (L/s)
- Groundwater Contours within AFB1
- Groundwater Flow Direction
- Interpreted Groundwater Discharge Area
- Primary Study Area
- Site Location

0 250 m

1:7500

NOTES
1. Coordinate System: UTM NAD 83 - Zone 17 (N).
2. Groundwater level data for monitoring wells and drive-point piezometers from September 3, 2010 at 12:00pm.
3. At multi level wells, groundwater level data presented based on the shallow well screen.
4. Surface water flow data from August 30, 2010.

NORTH

October 2013

Stantec

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE

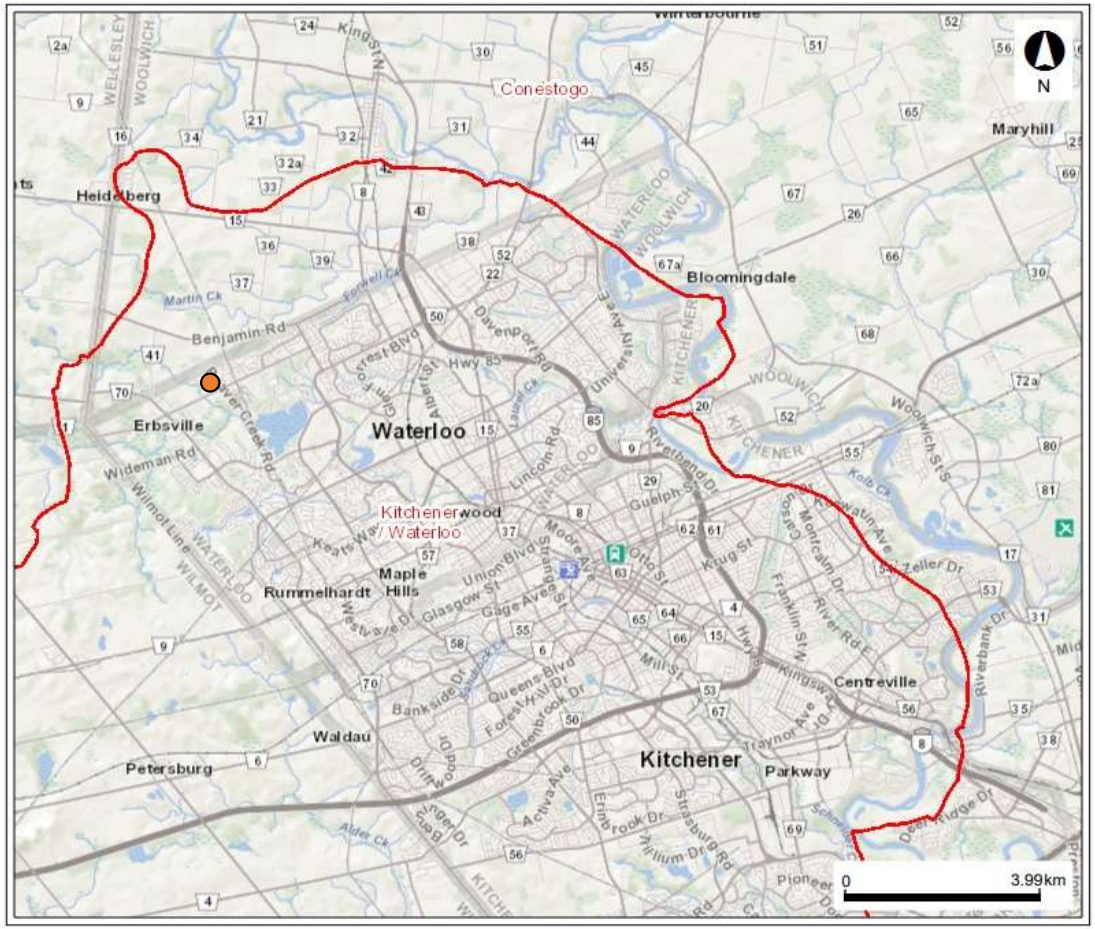
ecoplans

160330675

Source: Ecoplans Ltd., MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 1. November 2013.

APPENDIX E:
Source Water Protection Plan Mapping

WHPA-Q1 and WHPA-Q2



Legend

- Source Protection Areas
- Wellhead Protection Area Q1
- Wellhead Protection Area Q2
- **Site Location**

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Environment, Conservation and Parks (MECP) shall not be liable in any way for the use or any information on this map. of, or reliance upon, this map.

Ontario

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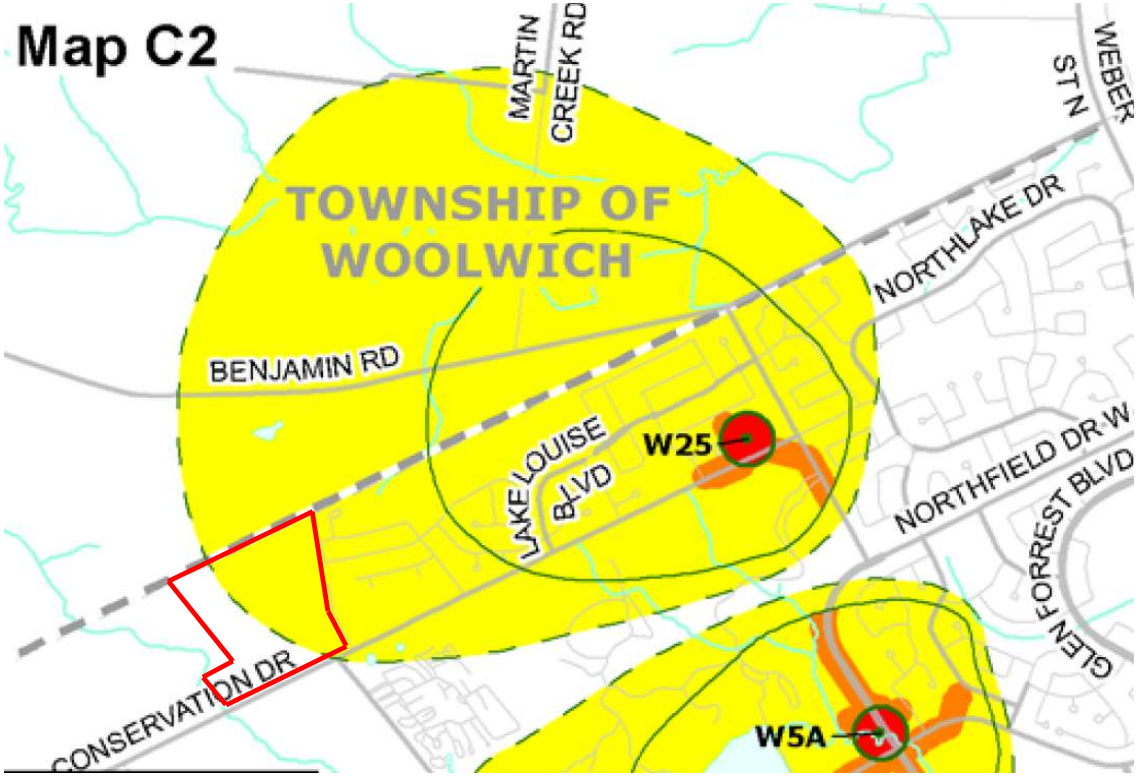
Map Created: 12/12/2021
Map Center: 43.47208 N, -80.51012 W

Note: WHPA-Q1 and WHPA-Q2 represented by same boundary as shown.

Stantec

Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**E-1**
Title:	**WHPA-Q1 and WHPA-Q2**

10.8 Schedule D: Region of Waterloo Groundwater Systems: Map C



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

	Significant Drinking Water Threat Policy Categories	Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal			
2.	Sewage Systems			
3, 4.	Agricultural Source Material			
6, 7.	Non-Agricultural Source Material*			
8, 9.	Commercial Fertilizer*			
10, 11.	Pesticide			
12, 13.	Road Salt*			
14.	Storage of Snow			
15.	Fuel			
16.	DNAPLs			
17.	Organic Solvents			
18.	Aircraft De-icing			
21.	Livestock Area			
22.	Oil Pipelines			

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within Non-GUDI Wellhead Protection Zones on this map. For details refer to the Drinking Water Threats Tables from the Ministry of the Environment and Climate Change, and the text of this Source Protection Plan.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of this plan for further details.

Well
Main Road
Minor River
Lake / Main River
Lower Tier Boundary

Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C
Site Location

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Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**E-2**
Title:	**Source Protection Plan - Significant Drinking Water Threat Policy Applicability**

APPENDIX F:
Wellhead Protection Sensitivity Area Categories

Schedule B: Source Water Protection Land Use Categories

Category 'A'

- Waste treatment and disposal facilities, including lagoons, landfills, communal/municipal sewage treatment facilities and including large sewage vaults at sewage pumping stations, but not including facilities regulated under the Nutrient Management Act.
- Salvage yards, including automobile wrecking yards or premises
- Bulk storage of hazardous chemicals and hazardous substances (as listed in O.Reg. 347 under the Environmental Protection Act), including bulk storage of oil, gasoline or petroleum products, and including transportation terminals for these substances/chemicals (including truck/trailer/container parking, washing or cleaning depots)

Category 'B'

- Bulk storage of road salt and snow disposal sites
- Primary metal manufacturing, including iron and steel mills and ferro-alloy manufacturing; steel product manufacturing from purchased steel; alumina and aluminum production and processing; non-ferrous metal production and processing; and foundries
- Manufacturing of fabricated metal products, including manufacturing of unfinished metal products and metal finishing operations
- Manufacturing and assembly of transportation equipment, including motor vehicles and parts, aerospace products and parts, rail cars, ships and boats
- Manufacturing of machinery, including agricultural, commercial, industrial, and other machinery
- Chemical manufacturing including chemicals; resins; fertilizers, pesticides and other agricultural chemicals; pharmaceutical and medicines; paint, coating and adhesives; inks and other chemicals but excluding soap and cleaning compound manufacturing. Including manufacturing, packaging, repackaging, and bottling. Excludes uses involving bulk storage of hazardous materials which are included under Category 'A'
- Manufacturing of petroleum and coal products, including manufacturing of asphalt materials. Excludes uses involving bulk storage of hazardous materials which are included under Category 'A'
- Manufacturing of electronic components such as semiconductors, printed circuit boards, and cathode ray tubes
- Manufacturing of electrical equipment, appliances and components
- Commercial or industrial dry cleaning of textiles and textile products, excluding depots not performing on-site dry cleaning
- Manufacturing of leather and allied products including footwear
- Wood and wood product preservation and treatment
- Gasoline stations and other retail establishments with gasoline sales
- Wholesale/distributing of cleaning products, pesticides, herbicides, fungicides and chemicals

Category 'C'

- Manufacturing of rubber products
- Manufacturing of soap, cleaning compounds and toilet preparations
- Textile and fabric finishing and fabric coating
- Manufacturing of plastic products
- Manufacturing of wood products including wood furniture, and excluding wood preservation
- Manufacturing of glass and glass products
- Manufacturing of paper and paper products including newsprint and boxes
- Printing and related support activities, excluding business support services such as photocopy services
- Repair and Maintenance of automobiles and automotive machinery, electronic equipment, industrial and commercial machinery, and personal and household goods repair
- Golf courses
- Airports, train and public transit terminals, except terminals with no fuel storage or transfer of shipped goods or materials
- Medical, health and other laboratories (other than clinics generally associated with commercial plazas)
- Miscellaneous manufacturing not included elsewhere, including jewellery, silverware, medical equipment and signs
- Recycling, recovery, or remanufacturing of materials including the collection, processing, manufacturing, or reuse of post-consumer or post-industrial materials, not including recycling or disposal of hazardous materials, and not including salvage yards or facilities with outdoor operations which are Category 'A' uses

Category 'D'

- Underground parking garages
- *Geothermal wells*
- *Mineral aggregate operations* including *wayside pits and quarries*

Schedule C: Other information and materials that may be required to process an application

Digital Plans

- Subdivision/Condominium Plan(s)

Cultural

- *Archaeological Assessment*
- *Cultural Heritage Impact Assessment*

Environmental

- Aggregate/Mineral Resource Analysis
- Local Air Quality Study

- Salt Impact Assessment
- Salt Management Plans
- Cut & Fill Analysis
- *Environmental Impact Statement*
- Comprehensive *Environmental Impact Statement*
- Natural Habitat Inventory
- Environmental Management Plan
- Tree Conservation and Planting Plans
- *Provincial and Federal Requirements* for *Fish Habitat*
- Slope Stability Study and Report
- Floodline Delineation Study/Hydraulics Study
- Hydrologic and Hydrogeologic Studies
- Source Water Protection Studies
- Best Management Practices for development within the Regional Recharge Area
- Best Management Practices (for golf courses)
- Environmental Site Assessment and/or Record of Site Condition
- *Cumulative Impact* Assessment
- Site Plan, Spill Protection Measures and other Best Management Practices for *Mineral Aggregate Operations*
- Final Rehabilitation Plan (for *mineral aggregate operations*)

Construction, Servicing and Infrastructure

- Preliminary Grading Plan
- Preliminary Stormwater Management Report/Plan and/or update to an existing Stormwater Management Plan
- Soils/Geotechnical Study
- Construction Methods and Spills Protection Measures
- Servicing Options Report
- Development Phasing Plan
- Water and Wastewater Servicing Plans and associated studies
- Hydrogeologic Studies for Privately Serviced Developments
- Impact on Existing Infrastructure Study

Land Use Compatibility

- Air Quality Assessment
- Dust Impact Analysis
- Land Use Compatibility Study
- Landfill Impact Study
- Agricultural Impact Assessment
- *Minimum Distance Separation*
- Noise Study
- Odour Impact Assessment
- Vibration Study
- Written Provincial approval (pursuant to the Environmental Protection Act for development within former waste management facilities)

- *Provincial and Federal Requirements* for *Alternative and/or Renewable Energy Systems* and *Fish Habitat*
- Approval from the Grand River Conservation Authority

Planning

- Affordable Housing Report/Rental Conversion Assessment
- Detailed Property Assessment of Affordable Rental Housing
- Farm Viability Study
- Planning Report
- Land Use Study for Retail/Commercial Land Uses in Support of the Planned Community Structure or Retail/Commercial Impact Analysis
- Retail Commercial Market Impact Study
- Urban Design Report/Brief

Transportation

- Transportation Impact Study
- Transportation System Impact Study
- Parking Analysis
- *Pedestrian* Route and Sidewalk Analysis
- Roundabout Feasibility Analysis
- Traffic Calming Options Report
- Transit Assessment
- Transportation Demand Management Options Report
- Provincial Requirements and Permits under the Public Transportation Act and Highway Improvements Act
- Environmental Assessment and Other Appropriate Studies for development adjacent to Proposed Regional and Provincial Corridors

APPENDIX G:
Borehole Logs

Monitoring Well: MW1-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	19-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	350.07 m AMSL
Number:	160340875	**Top of casing elevation:**	350.96 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	531967
Contractor:	Pro Core Drilling	**Northing:**	4814976

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.89 m
0	0		Ground Surface	350.07								
			TOPSOIL some sand and organics, dark brown	0.00 349.84			1	SS	0-0-2-2 (2)	10" 42%		Concrete
			SILTY SAND some organics, light brown	0.23 349.31								
			CLAYEY SILT trace sand sand content increasing with depth	0.76			2	SS	0-1-2-4 (3)	24" 100%		52 mm Schedule 40 PVC casing
5			clay content decreasing with depth	348.54	ATB1	Upper Maryhill Till and Equivalents						Holeplug
	2		SANDY SILT fine grained sand, some clay, grey	1.52			3	SS	0-1-2-2 (3)	15" 63%		
			becoming light greyish brown at 2.3 m BGS				4	SS	0-0-0-0 (0)	23" 96%		Top of sand (2.4 m BGS)
10			becoming wet at 2.8 m BGS	347.02								
			SILTY SAND fine grained, light brown, wet	3.05	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	5	SS	0-0-0-0 (0)	21" 88%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15				345.29								Bottom of screen (4.6 m BGS)
			SAND medium grained, light brown/grey, wet	4.78 344.89			6	SS	2-2-3-5 (5)	21" 88%		
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW2-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	17-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.56 m AMSL
Number:	160340875	**Top of casing elevation:**	356.52 m AMSL
Field investigator:	A.MacKay	**Easting:**	532498
Contractor:	Pro Core Drilling	**Northing:**	4815271

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.96 m
0	0		Ground Surface	355.56								
			TOPSOIL organics and fine sand, very dark brown, very moist	0.00 355.25								Concrete
			SAND fine grained, trace gravel, dark brown, loose, moist	0.30			1	SS	0-1-1-4 (2)	16.5" 69%		
			becoming brown, very moist, very loose at 0.9 m BGS				2	SS	0-1-0-1 (1)	10.5" 44%		52 mm Schedule 40 PVC casing
5			fine to medium grained sand beginning at 1.5 m BGS				3	SS	0-0-0-0 (0)	13" 54%		Holeplug
	2		becoming grey-brown at 2.3 m BGS		AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	0-0-1-7 (1)	n/a		Top of sand (2.4 m BGS)
10			becoming wet at 3.1 m BGS				5	SS	4-5-8-8 (13)	n/a		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15							6	SS	3-9-9-12 (18)	n/a		Bottom of screen (4.6 m BGS)
				350.38								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/LV

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Sheet 1 of 1

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW3-10

Project: North Waterloo Subwatershed Study
Client:
Location: North Waterloo, ON; 03
Number: 160340875

Field investigator: A.MacKay
Contractor: Pro Core Drilling
Drilling method: Track Mount, CME55, Hollow Stem Auger
Date started/completed: 12-Mar-2010 / 17-Mar-2010

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery
			Ground Surface	366.84						
0	0		TOPSOIL	0.00						
			fine sand, dark brown, loose, wet	366.53						
			SAND	0.30						
			fine grained, brown, loose, wet				1	SS	1-10-11-3 (21)	15" 63%
							2	SS	1-2-3-3 (5)	13" 54%
5	2		light brown from 1.5 to 2.9 m BGS				3	SS	2-5-5-5 (10)	12" 50%
							4	SS	1-1 (1)	13" 54%
10			fine to medium grained sand beginning at 2.9 m BGS				5	PQ	n/a	31" 124%
			some coarse grained sand beginning at 3.6 m BGS	362.98						
	4		SILT	3.86						
15			some fine grained sand, brown, firm to stiff, wet				6	PQ	n/a	58" 100%
				361.25						
			SAND	5.59						
20	6		fine grained, brown, loose				7	PQ	n/a	58" 97%
			fine to medium grained, some coarse grained, brown, loose, wet				8	PQ	n/a	50" 83%
25	8									
30							9	PQ	n/a	57" 97%
	10		layer of fine sand, trace silt, stiff, wet at 10 m to 10.3 m BGS				10	PQ	n/a	56" 93%
35										
					AFB1	Upper Moraine Stratified Sediments and Equivalents	11	PQ	n/a	55" 90%
40	12									
							12	PQ	n/a	49" 82%
45										
	14		fine to medium grained, trace silt, brown, loose, wet				13	PQ	n/a	45" 75%
50										
							14	PQ	n/a	41" 68%
55	16									
			layer of fine sand and silt, stiff at 17.4 to 17.7 m BGS				15	PQ	n/a	51" 85%
60			some silt beginning at 17.7 m BGS							
	18			348.09						
			SILT AND SAND	18.75			16	PQ	n/a	48.5" 81%
65			fine grained sand, brown, loose, wet							
	20									
70			layer of fine sand with silt, stiff, brownish grey at 20.3 to 21.8 m BGS				17	PQ	n/a	52" 87%
	22		some clay, grey beginning at 21.8 m BGS				18	PQ	n/a	41" 68%
75				343.52						
			SILTY CLAY	23.32						
80	24		grey, stiff, wet				19	PQ	n/a	46" 77%
							20	PQ	n/a	56" 93%
85	26			340.47						
			SILT	26.37	ATB2	Middle Maryhill Till and Equivalents	21	PQ	n/a	57" 95%
90	28		some fine sand, trace to some clay, greyish brown, soft, wet							

WELL DETAILS

GS Elev: 366.84 m AMSL	GS Elev: 366.81 m AMSL
TOC Elev: 367.60 m AMSL	TOC Elev: 367.62 m AMSL
Easting: 532774	Easting: 532776
Northing: 4815406	Northing: 4815407
Stick-up: 0.76 m	Stick-up: 0.81 m

Cement
Holeplug
52 mm Schedule 80 PVC casing
Bentonite Grout

Cement
52 mm Schedule 40 PVC casing
Holeplug
Top of sand (11.6 m BGS)
Top of screen (12.2 m BGS)
No.2 Silica Sand
No.10 Slot PVC screen 50 mm diameter
Bottom of screen (13.7 m BGS)

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
PQ - wireline continuous core sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

PQ - continuous core sampling
SS - split spoon sampling

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL - CLUST 11X17 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW3-10

Project: North Waterloo Subwatershed Study
Client:
Location: North Waterloo, ON; 03
Number: 160340875

Field investigator: A.MacKay
Contractor: Pro Core Drilling
Drilling method: Track Mount, CME55, Hollow Stem Auger
Date started/completed: 12-Mar-2010 / 17-Mar-2010

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery
95			SILT some fine sand, trace to some clay, greyish brown, soft, wet				22	PQ	n/a	44" 75%
	30						23	PQ	n/a	59" 97%
100				336.15						
			SILTY CLAY TILL trace coarse sand and fine gravel, greyish brown, very stiff, wet	30.68			24	PQ	n/a	58.5" 98%
105	32									
							25	PQ	n/a	52" 88%
110										
	34		trace coarse grained gravel beginning at 34.0 m BGS							
					ATB3	Lower Maryhill Till and Equivalents	26	PQ	n/a	61" 100%
115										
			some coarse sand, fine to coarse gravel, dark brown beginning at 35.5 m BGS				27	PQ	n/a	61" 102%
	36									
120										
			cobble, 0.13 m diameter, at 36.7 m BGS				28	PQ	n/a	55" 92%
	38									
125										
							29	PQ	n/a	60" 100%
				327.21						
130			SAND AND SILT some gravel, firm to stiff, wet	39.62 327.04						
	40		SILTY SAND TILL some sand and gravel, grey, very hard, moist	39.80	ATC1	Upper/ Main Catfish Creek Till	30	PQ	n/a	60" 100%
135										
				325.23						
			End of Borehole	41.61						
	42									
140										
	44									
145										
150	46									
155										
	48									
160										
	50									
165										
170	52									
175										
	54									
180										
	56									
185										

WELL DETAILS

GS Elev: 366.84 m AMSL
TOC Elev: 367.60 m AMSL
Easting: 532774
Northing: 4815406
Stick-up: 0.76 m

GS Elev: 366.81 m AMSL
TOC Elev: 367.62 m AMSL
Easting: 532776
Northing: 4815407
Stick-up: 0.81 m

Bentonite Grout
Holelplug
Top of sand (37.6 m BGS)
Top of screen (38.6 m BGS)
No.2 Silica Sand
No.10 Slot PVC screen 50 mm diameter
Bottom of screen (41.6 m BGS)

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
PQ - wireline continuous core sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

PQ - continuous core sampling
SS - split spoon sampling

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL - CLUST 11X17 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW4-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	347.87 m AMSL
Number:	160340875	**Top of casing elevation:**	348.64 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532399
Contractor:	Pro Core Drilling	**Northing:**	4815010

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.77 m
0	0		Ground Surface	347.87								
			TOPSOIL dark brown, moist	0.00 347.26			1	SS	0-0-3-3 (3)	8" 33%		Concrete Holeplug
			SANDY SILT fine grained sand, light brown, moist	0.61 346.60			2	SS	1-2-3-3 (5)	22" 92%		Top of sand (0.9 m BGS)
5	2		SILTY SAND fine grained, light brown, loose, wet silt content increasing with depth	1.27 345.43	ATB1	Upper Maryhill Port Stanley Till and Equivalents	3	SS	6-4-4-3 (8)	18" 75%		52 mm Schedule 40 PVC casing Top of screen (1.5 m BGS) No.2 Silica Sand
			CLAYEY SILT trace sand	2.44 344.21			4	SS	0-2-3-4 (5)	24" 100%		No.10 Slot PVC screen 50 mm diameter
10	4						5	SS	2-5-6-9 (11)	0" 0%		Bottom of screen (3.0 m BGS)
			End of Borehole	3.66								
15												
20	6											
25	8											

Screen Interval: 1.52 - 3.05 m BGS
Sand Pack Interval: 0.91 - 3.05 m BGS
Well Seal Interval: 0.15 - 0.91 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

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Sheet 1 of 1

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW5-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	19-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	351.08 m AMSL
Number:	160340875	**Top of casing elevation:**	351.91 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532368
Contractor:	Pro Core Drilling	**Northing:**	4814834

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.8. m
			Ground Surface	351.08								
0	0		TOPSOIL dark brown, moist	0.00 350.93			1	SS	0-2-4-8 (6)	18" 75%		Concrete
			CLAYEY SILT trace organics, light reddish brown, firm to stiff	0.15								Holeplug
					ATB1	Upper Maryhill Port Stanley Till and Equivalents	2	SS	2-3-4-6 (7)	11" 46%		52 mm Schedule 40 PVC casing
5			some gravel light brown beginning at 1.5 m BGS seams of medium grained sand beginning at 1.7 m BGS				3	SS	2-4-12-7 (16)	24" 100%		
	2		layer of coarse gravel at 2.1 m BGS trace sand and gravel at 2.3 m BGS									Top of sand (2.1 m BGS)
				348.33			4	SS	9-11-10-11 (21)	9" 38%		Top of screen (2.7 m BGS)
10			SILTY SAND fine to medium grained sand, light brown, wet	2.74			5	SS	10-14-12-8 (26)	14" 58%		No.2 Silica Sand
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents						No.10 Slot PVC screen 50 mm diameter
15				346.51								Bottom of screen (4.3 m BGS)
			End of Borehole	4.57								Natural cave
20	6											
25	8											

Screen Interval: 2.74 - 4.27 m BGS
Sand Pack Interval: 2.13 - 4.27 m BGS
Well Seal Interval: 0.30 - 2.13 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW6-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.58 m AMSL
Number:	160340875	**Top of casing elevation:**	356.48 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532737
Contractor:	Pro Core Drilling	**Northing:**	4814972

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.90 m
0	0		Ground Surface	355.58								
			SAND fine to medium grained,dark brown, loose, moist	0.00			1	SS	3-4-5-5 (9)	13" 54%		Concrete
			becoming reddish brown at 0.8 m BGS				2	SS	2-3-3-3 (6)	14" 58%		52 mm Schedule 40 PVC casing
5			trace gravel beginning at 1.5 m BGS				3	SS	1-1-1-2 (2)	14" 58%		Holeplug
	2			353.29								
			SAND medium grained, trace gravel, light brown, loose, moist	2.29	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	3-5-5-5 (10)	16" 67%		Top of sand (2.4 m BGS)
10							5	SS	3-3-2-4 (5)	13" 54%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4		some gravel, wet at 3.6 m BGS									No.10 Slot PVC screen 50 mm diameter
15			some coarse grained sand, trace gravel at 4.6 m BGS				6	SS	4-15-20-25 (35)	20" 83%		Bottom of screen (4.6 m BGS)
				350.40								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.15 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW7-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	358.74 m AMSL
Number:	160340875	**Top of casing elevation:**	359.67 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	533031
Contractor:	Pro Core Drilling	**Northing:**	4815108

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.93 m
0	0		Ground Surface	358.74								
			TOPSOIL dark brown	0.00 358.48								Concrete
			CLAYEY SILT trace gravel, light brown, firm to stiff, moist	0.25			1	SS	1-1-2-3 (3)	19" 79%		
							2	SS	2-3-5-5 (8)	13" 54%		52 mm Schedule 40 PVC casing
				357.52								
5	2		SAND fine to medium grained, trace silt, trace gravel, light reddish brown, loose, moist	1.22			3	SS	6-1-4-5 (5)	11" 46%		
				356.30	ATB1	Upper Maryhill Port Stanley Till and Equivalents						Holeplug
			SILT trace fine to coarse sand, trace gravel, stiff, light brown, moist	2.44			4	SS	1-5-7-12 (12)	15" 63%		
10	4		becoming clayey at 3.1 m BGS				5	SS	2-5-6-10 (11)	24" 100%		
				354.17								
15			SAND fine to medium grained, light brown, compact, moist	4.57			6	SS	4-14-20-24 (34)	18" 75%		Top of sand (5.2 m BGS)
			becoming wet at 5.2 to 6.1 m BGS									Top of screen (5.8 m BGS)
20	6				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	7	SS	8-20-22->50 (>42)	24" 100%		No.2 Silica Sand
												No.10 Slot PVC screen 50 mm diameter
25	8						8	SS	9-20-32-39 (52)	24" 100%		Bottom of screen (7.3 m BGS)
				350.51								Natural Cave
			End of Borehole	8.23								

Screen Interval: 5.79 - 7.32 m BGS
Sand Pack Interval: 5.18 - 7.32 m BGS
Well Seal Interval: 0.30 - 5.18 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW1-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	353.32 m AMSL
Number:	160900921	**Top of casing elevation:**	354.10 m AMSL
Field investigator:	D. Smith	**Easting:**	532466
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815187

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				354.10					
-2									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	353.32					
			TOPSOIL soft, dark brown (10 YR 3/3), fine grained sand, some silt/clay, trace medium grained sand, trace fine gravel, moist	0.00 352.94	1	SS	24" 100%	1-3-2-3 (5)	
2			FINE SAND soft, dark yellowish brown (10YR 4/6), some silt/clay, trace medium grained sand, trace fine gravel, moist colour change to light yellowish brown (10YR 6/4) at 0.56 m BGS reddish orange mottled discolourations at 0.81 m BGS becoming wet at 0.84 m BGS	0.38 352.23	2	SS	14" 58%	2-2-3-4 (5)	Bentonite Pellets 0 to 1.2 m Water Level 0.93 m BGS 10-May-19
4	1		MEDIUM SAND loose, greyish brown (10YR 5/2), trace silt/clay, some fine grained sand, trace coarse grained sand, wet compact at 1.52 m BGS	1.09	3	SS	21" 88%	3-6-6-6 (12)	
6	2		fine grained sand and silt/clay seam from 1.98 to 2.03 m BGS		4	SS	24" 100%	1-6-8-10 (14)	210 mm diameter borehole
8			trace fine gravel, subrounded, beginning at 2.59 m BGS						
10	3				5	SS	21" 88%	4-7-8-8 (15)	No. 2 Silica Sand 1.2 to 4.6 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.5 to 4.6 m
12	4								
14									
16	5		grading coarser, increase in coarse grained sand at 5.03 m BGS	348.14	6	SS	24" 100%	3-5-6-9 (11)	
			End of Borehole	5.18					

Screen Interval: 1.52 - 4.57 m BGS
Sand Pack Interval: 1.52 - 4.57 m BGS
Well Seal Interval: 0.00 - 1.22 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW2-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.20 m AMSL
Number:	160900921	**Top of casing elevation:**	358.92 m AMSL
Field investigator:	D. Smith	**Easting:**	532882
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815140

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				358.92					
			Ground Surface	358.20					Above Ground Casing 0.69 m stick-up
0	0		TOPSOIL	0.00					
			soft, dark brown (10YR 3/3), clayey silt, trace fine grained sand, moist	358.05	1	SS	24" 100%	2-1-2-2 (3)	
			CLAYEY SILT soft, dark brown (10YR 3/3), some sand, moist yellowish brown mottling at 0.48 m BGS	0.15					
				357.36					
			coarse grained sand and fine gravel present from 0.84 to 0.86 m BGS	0.86	2	SS	16" 67%	1-1-1-2 (2)	
			SILTY CLAY very soft, yellowish brown (10YR 5/4), trace fine grained sand, poorly graded, moist						
5									
			stiff, increase in silt, change to clayey silt at 1.68 m BGS		3	SS	24" 100%	1-4-5-8 (9)	
	2								Bentonite Pellets 0 to 4.3 m
			very stiff, trace fine gravel and coarse grained sand beginning at 2.29 m BGS						
			silty sand seam, wet, from 2.59 to 2.64 m BGS increase in clay, change to silty clay at 2.64 m BGS		4	SS	24" 100%	4-9-16-16 (25)	Water Level 2.77 m BGS 10-May-19
10				355.00					210 mm diameter borehole
			SANDY SILT compact, yellowish brown (10YR 5/4), some clay, fine grained sand, trace fine gravel, moist	3.20	5	SS	24" 100%	7-12-16-20 (28)	
	4								
15				353.55					
			FINE SAND compact, brown (10YR 5/3), some silt/clay, trace medium grained sand, moist becomes wet at 4.83 m BGS clay seam from 5.03 to 5.06 m BGS becomes moist at 5.05 m BGS	4.65	6	SS	21" 88%	4-12-14-14 (26)	
	6								No. 2 Silica Sand 4.3 to 7.6 m
20			wet from 6.10 to 6.25 m BGS increase in silt to silty sand, becomes stiff at 6.25 m BGS		7	SS	24" 100%	5-5-8-9 (13)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 4.6 to 7.6 m
			becomes wet at 6.66 m BGS						
25									
			decrease in silt to fine sand with some silt, trace fine gravel present, change to firm at 7.62 m BGS		8	SS	21" 88%	3-5-3-7 (8)	
	8		silty clay seam from 8.00 to 8.08 m BGS	349.97					
			End of Borehole	8.23					

Screen Interval: 4.57 - 7.62 m BGS
Sand Pack Interval: 4.57 - 7.62 m BGS
Well Seal Interval: 0.00 - 4.27 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW3-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	354.77 m AMSL
Number:	160900921	**Top of casing elevation:**	355.59 m AMSL
Field investigator:	D. Smith	**Easting:**	532771
Contractor:	Aardvark Drilling Inc.	**Northing:**	4814915

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				355.59					
			Ground Surface	354.77					Above Ground Casing 0.82 m stick-up
0	0		TOPSOIL loose, dark brown (10YR 3/3), fine grained sand topsoil, trace organics, trace silt/clay, moist	0.00 354.57					
			FINE SAND loose, dark yellowish brown (10YR 4/6), trace silt/clay, trace medium grained sand, moist	0.20 354.01	1	SS	21" 88%	2-2-4-2 (6)	
	1		MEDIUM SAND compact, brown (10YR 5/3), some fine and coarse grained sand, trace fine and coarse gravel, subrounded, moist	0.76	2	SS	12" 50%	3-8-8-5 (16)	Bentonite Pellets 0 to 2.7 m
5			loose, poorly graded medium grained sand with some fine grained sand, change to pale brown (10YR 6/3) at 1.52 m BGS		3	SS	18" 75%	2-4-4-5 (8)	
	2			352.48					210 mm diameter borehole
			FINE SAND loose, light brownish grey (10 YR 6/2), trace silt/clay, trace medium grained sand, moist	2.29	4	SS	16" 67%	1-3-7-7 (10)	Water Level 2.65 m BGS 10-May-19
10	3			351.72					
			MEDIUM SAND compact, light brownish grey (10YR 6/2), some fine grained sand, trace coarse grained sand and fine gravel, subrounded, wet grading finer beginning at 3.45 m BGS	3.05	5	SS	22" 92%	4-6-9-8 (15)	
	4								No. 2 Silica Sand 2.7 to 6.0 m
15			soft fine grained sand seam with trace silt/clay from 4.57 to 4.93 m BGS		6	SS	24" 100%	4-8-11-11 (19)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 3.0 to 6.0 m
	5		becomes loose at 4.93 m BGS						
	6								
20			becomes compact at 6.10 m BGS trace fine gravel and coarse grained sand beginning at 6.27 m BGS		7	SS	24" 100%	3-9-11-19 (20)	
			End of Borehole	348.06 6.71					

Screen Interval: 3.05 - 6.10 m BGS
Sand Pack Interval: 3.05 - 6.10 m BGS
Well Seal Interval: 0.00 - 2.74 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW4-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.72 m AMSL
Number:	160900921	**Top of casing elevation:**	359.49 m AMSL
Field investigator:	D. Smith	**Easting:**	532912
Contractor:	Aardvark Drilling Inc.	**Northing:**	4814898

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery / N Value	Diagram	Description
				359.49					
			Ground Surface	358.72					Above Ground Casing 0.77 m stick-up
0	0		TOPSOIL	0.00					
			loose, very dark brown (10YR 2/2), fine grained sand, some silt/clay, trace organics, moist	358.52	1	SS	24" 100% 1-1-2-2 (3)		
			FINE SAND	0.20					
			loose, very dark brown (10YR 2/2), some silt/clay, moist	358.16					
			colour change to dark yellowish brown (10YR 4/4) at 0.36 m BGS	0.56					
			FINE TO MEDIUM SAND						
			compact, pale brown (10YR 6/3), trace silt/clay, moist		2	SS	14" 58% 2-3-8-8 (11)		
			trace fine gravel and coarse grained sand, subrounded, beginning at 0.94 m BGS						
5			fine grained sand seam with some silt/clay from 1.60 to 1.80 m BGS		3	SS	18" 75% 4-5-11-16 (16)		
	2								
			black laminations begin, becomes poorly graded fine and medium grained sand beginning at 2.29 m BGS		4	SS	20" 83% 6-16-13-15 (29)		
10									Bentonite Pellets 0 to 5.8 m
				355.32	5	SS	19" 79% 5-11-16-18 (27)		
			MEDIUM SAND	3.40					
	4		compact, light grey (10YR 7/2), some fine grained sand, trace coarse grained sand, moist						
15			dense beginning at 4.6 m BGS		6	SS	20" 83% 12-18-18-20 (36)		210 mm diameter borehole
	6			352.62					
20			dense, light brownish grey (10YR 6/2), trace silt/clay, poorly graded, black laminations, moist	6.10	7	SS	19" 79% 10-16-22-26 (38)		Water Level 6.73 m BGS 10-May-19
25			increase in medium grained sand at 7.6 m BGS		8	SS	24" 100% 4-16-15 (31)		No. 2 Silica Sand 5.8 to 9.1 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 6.1 to 9.1 m
	8								
30				349.57					
			End of Borehole	9.14					

Screen Interval: 6.10 - 9.14 m BGS
Sand Pack Interval: 6.10 - 9.14 m BGS
Well Seal Interval: 0.00 - 5.79 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW5-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.45 m AMSL
Number:	160900921	**Top of casing elevation:**	358.23 m AMSL
Field investigator:	D. Smith	**Easting:**	532740
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815095

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery / N Value	Diagram	Description
				358.23					
									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	357.45					
			TOPSOIL	0.00					
			loose, silty sand topsoil, fine grained sand, trace clay, trace organics, moist, poor recovery - depth estimated	357.30	1	SS	3" 13% 1-3-1-2 (4)		
				0.15					
			FINE TO MEDIUM SAND loose, light brownish grey (10YR 6/2), trace coarse grained sand, trace fine gravel, moist	356.51					
			FINE SAND compact, pale brown (10YR 6/3), some silt/clay, moist, laminations of silt/clay with purplish brown discolourations	0.94	2	SS	16" 67% 4-7-5-4 (12)		
5			becomes wet, trace medium grained sand beginning at 1.73 m BGS	355.59	3	SS	18" 75% 3-2-4-6 (6)		
	2		SILT dense to very dense, pale brown (10YR 6/3), trace clay and fine grained sand, blocky, moist	1.85					Bentonite Pellets 0 to 4.3 m
			some fine grained sand at 2.29 m BGS		4	SS	24" 100% 8-14-20-17 (34)		
10			trace coarse grained sand and trace fine gravel beginning at 3.25 m BGS		5	SS	24" 100% 12-18-22-26 (40)		210 mm diameter borehole
	4								
15			some clay, greyish brown (10YR 5/2), well graded at 4.57 m BGS		6	SS	24" 100% 8-21-20-27 (41)		Water Level 4.53 m BGS 10-May-19
20	6				7	SS	24" 100% 17-25-32-30 (57)		No. 2 Silica Sand 4.3 to 7.6 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 4.6 to 7.6 m
25			trace sand, increase in clay to silty clay at 7.62 m BGS		8	SS	24" 100% 15-20-28-30 (48)		
	8			349.22					
			End of Borehole	8.23					

Screen Interval: 4.57 - 7.62 m BGS
Sand Pack Interval: 4.57 - 7.62 m BGS
Well Seal Interval: 0.00 - 4.27 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW6-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.24 m AMSL
Number:	160900921	**Top of casing elevation:**	358.02 m AMSL
Field investigator:	D. Smith	**Easting:**	532640
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815323

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				358.02					
-2									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	357.24					
			TOPSOIL loose, dark yellowish brown (10YR 4/4), silty sand topsoil, fine grained sand, trace clay, moist	0.00 357.04					Water Level 0.02 m BGS 10-May-19
			SILTY SAND loose, yellowish brown (10YR 5/4), trace clay, fine grained sand, moist	0.20 356.78	1	SS	22" 92%	1-2-2-1 (4)	
2			CLAYEY SILT firm to stiff, dark yellowish brown (10YR 4/4), some fine grained sand, moist	0.46					Bentonite Pellets 0 to 1.2 m
	1		colour change to brown (10YR 5/3), decrease in fine grained sand to trace, trace medium and coarse grained sand beginning at 0.84 m BGS trace fine and coarse gravel, subrounded, beginning at 1.02 m BGS		2	SS	17" 71%	2-3-5-6 (8)	
4									
6	2		fine grained sand seam, wet, from 1.96 to 1.98 m BGS	355.16	3	SS	24" 100%	2-4-5-7 (9)	
			black gravel beginning at 2.01 m BGS	2.08					210 mm diameter borehole
			SILTY SAND compact, brown (10 YR 5/4), fine grained sand, trace clay, wet						
8					4	SS	20" 83%	3-7-10-7 (17)	No. 2 Silica Sand 1.2 to 4.4 m
10	3		hard clay seam with purplish brown discolourations from 3.20 to 3.28 m BGS		5	SS	21" 88%	3-3-5-3 (8)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.4 to 4.4 m
12	4			352.67					
14			SANDY SILT dense, pale brown (10YR 6/3), fine grained sand, trace clay, blocky, moist	4.57	6	SS	23" 96%	6-19-19-19 (38)	
16	5		hard clay seam with purplish brown discolourations from 5.13 to 5.18 m BGS	352.06					
			End of Borehole	5.18					

Screen Interval: 1.40 - 4.40 m BGS
Sand Pack Interval: 1.40 - 4.40 m BGS
Well Seal Interval: 0.00 - 1.22 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW101-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	25-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.88 m AMSL
Number:	160900921	**Top of casing elevation:**	359.87 m AMSL
Field investigator:	D. Smith	**Easting:**	532701
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815051

SUBSURFACE PROFILE				SAMPLE DETAILS					INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Lab Analyses	Diagram / Description
				359.62						Above Ground Casing 0.99 m stick-up
			Ground Surface	358.88						
0	0		TOPSOIL (SAND)	0.00						Cement Seal 0 to 0.3 m
			Fine grained, trace organics, yellowish brown (10YR 5/4), dry	358.73	1	SS	18" 75%	2-4-9-7 (13)		
			SAND	0.15						
			Fine to medium grained, some coarse grained sand to coarse gravel, subangular, trace silt/clay, grayish brown (10YR 5/2), loose to compact, moist		2	SS	17" 71%	3-7-10-8 (17)		
			Trace fine and coarse gravel starting at 0.76 m							
			10 cm seam of fine grained sand, trace silt/clay at 1.01 m							
5					3	SS	19" 79%	2-4-5-9 (9)		
	2									210 mm diameter borehole
			Fine to medium grained sand, trace coarse grained sand to fine gravel starting at 2.29 m		4	SS	20" 83%	3-8-8-9 (16)		
10										Bentonite Chips 0.3 to 5.5 m BGS
					5	SS	20" 83%	3-7-12-16 (19)		
			2 cm seam of crushed rock at 3.38 m							
			Increase in moisture, small black laminations starting at 3.43 m	355.07						
	4		SAND	3.81						
			Fine grained, trace medium grained sand and silt, light grayish brown (10YR 6/2), moist, compact, poorly graded	354.92	6	SS	19" 79%	5-11-12-14 (23)		
			SAND	3.96						
15			Fine to medium grained, trace coarse grained sand, gravel, and silt/clay, grayish brown (10YR 5/2), moist, compact		7	SS	21" 88%	5-8-13-16 (21)		
					8	SS	19" 79%	6-11-14-15 (25)		
20	6									No. 2 Silica Sand 5.5 to 8.8 m
					9	SS	21" 88%	6-12-14-16 (26)		Water Level 6.6 m BGS 26-May-21
			Some coarse grained sand starting at 6.55 m	352.02						
			SAND	6.86						
			Fine grained, trace medium grained sand to fine gravel, trace silt/clay, grayish brown (10YR 5/2), wet, compact, poorly graded		10	SS	23" 96%	10-13-16-17 (29)		
25										
	8				11	SS	24" 100%	1-9-8-12 (17)		
			Some medium grained sand starting at 8.05 m							No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 5.7 to 8.8 m
				350.08	12	SS	24" 146%	1-5-15/4.4" (15/4.4")		
			End of Borehole	8.80						
30										

Screen Interval: 6.10 - 8.80 m BGS
Sand Pack Interval: 5.79 - 8.80 m BGS
Well Seal Interval: 0.30 - 5.79 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP1-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.94 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532705
Contractor:	TDC Excavating Ltd.	**Northing:**	4815091

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	357.94			
			TOPSOIL Sand	0.00 357.69			
			SAND Fine to coarse grained, trace silt, white/gray, moist, compact	0.25			
2	1						
4							
6	2						
8							
10	3						Backfilled with Natural Cave 0 to 5.7 m
12			30 cm thick isolated, discontinuous pockets of silty sand starting at 3.5 m BGS				
12	4				1	GS	
14							
16	5				2	GS	
18							
			Water table at 5.7 m BGS	352.24			
	6		End of Test Pit	5.70			

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. /

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP2-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	356.77 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532663
Contractor:	TDC Excavating Ltd.	**Northing:**	4815057

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	356.77			
			TOPSOIL Sand	0.00 356.54			
			SAND Fine to coarse grained, trace gravel, trace silt, white/gray, moist	0.23			
2	1						
4							
6	2						Backfilled with Natural Cave 0 to 4 m
8					1	GS	
10	3						
12				352.77			
	4		Sample collected from below test pit base	4.00	2	GS	
14			End of Test Pit				

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP3-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.98 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532702
Contractor:	TDC Excavating Ltd.	**Northing:**	4815036

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	357.98			
			TOPSOIL Sand, brown	0.00 357.78			
			SAND Medium to coarse grained, some silt, trace gravel, gray/white, moist, compact	0.20			
2			10 cm seam of gravelly sand, fine to coarse gravel, medium to coarse grained sand, subrounded, gray/white, moist from 0.7 to 0.8 m				
	1						
4							
6							
	2						
8							Backfilled with Natural Cave 0 to 5.2 m
10							
	3						
12					1	GS	
	4						
14							
16				352.77			
	5		Sample collected from below test pit base	5.21	2	GS	
18			End of Test Pit				
	6						

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP4-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	355.83 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532630
Contractor:	TDC Excavating Ltd.	**Northing:**	4815043

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	355.83			
			SAND Fine to coarse grained, white/gray, moist	0.00			
2							
	1				1	GS	
4							
6							
	2						Backfilled with Natural Cave 0 to 4 m
8							
10	3						
12							
	4			351.83			
			Sample collected from below test pit base	4.00			
14					2	GS	
			End of Test Pit				

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

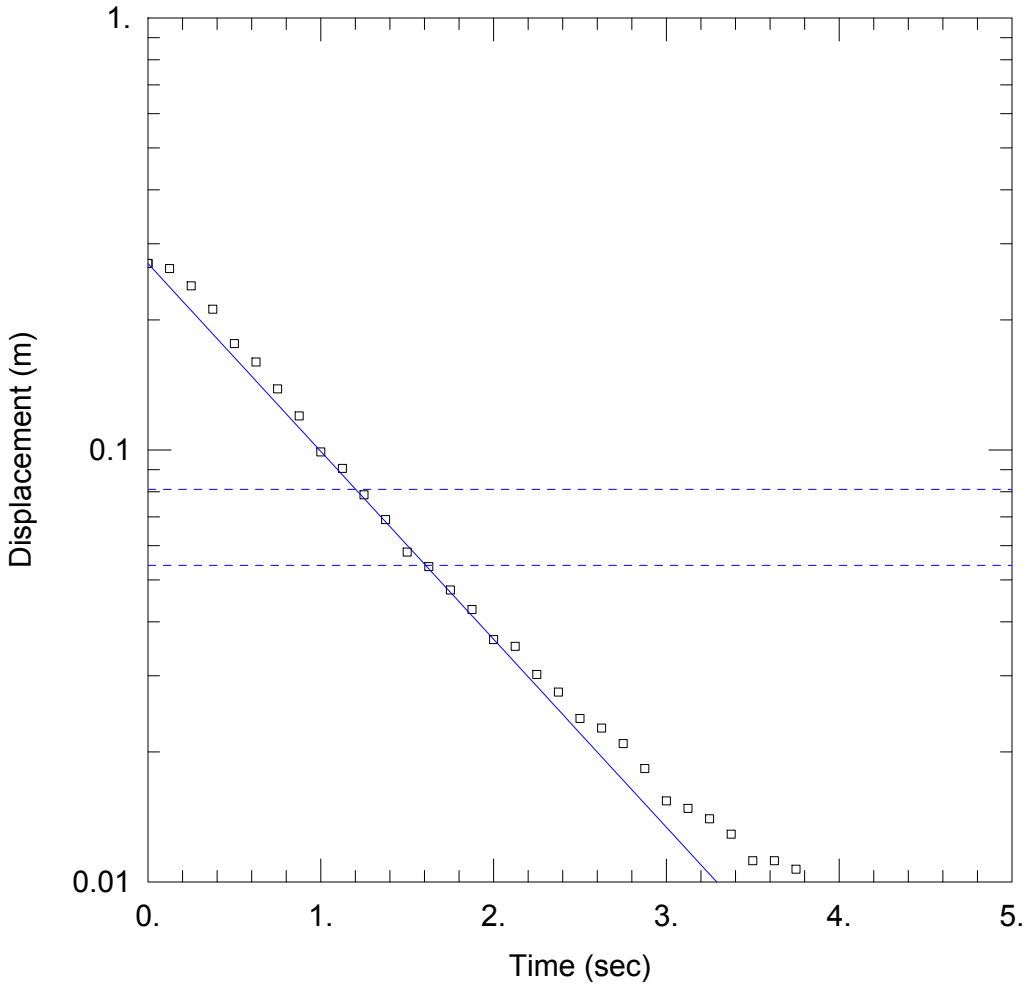
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

APPENDIX H:
Hydraulic Conductivity Testing Solutions



MW1-19

Data Set: \...\MW1-19_DS_JK.aqt
Date: 06/05/19 Time: 11:54:27

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW1-19
Test Date: May 10, 2019

AQUIFER DATA

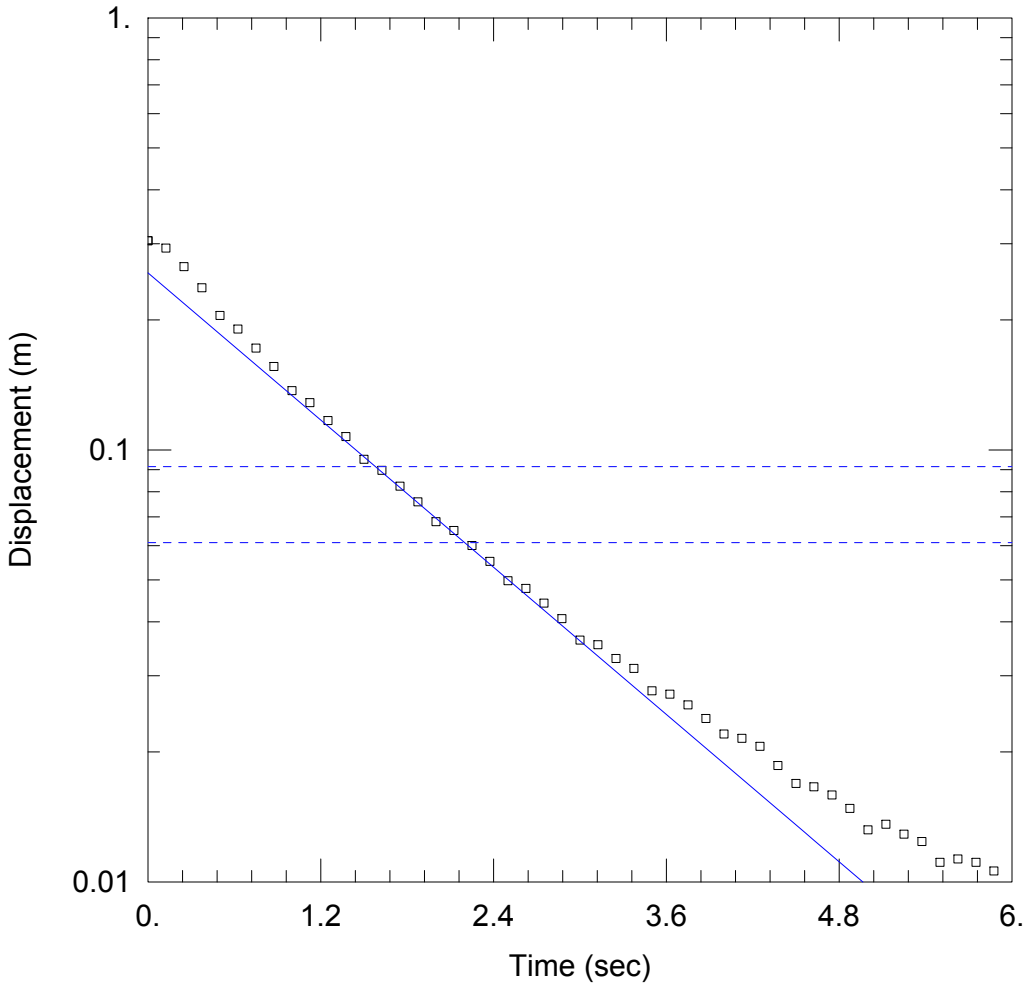
Saturated Thickness: 4.15 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW1-19)

Initial Displacement: 0.2702 m
Total Well Penetration Depth: 3.48 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.485 m
Screen Length: 3.05 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.00028 m/sec
y0 = 0.27 m



MW3-19

Data Set: \...\MW3-19_DS_JK.aqt
Date: 06/05/19 Time: 13:26:11

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW3-19
Test Date: May 10, 2019

AQUIFER DATA

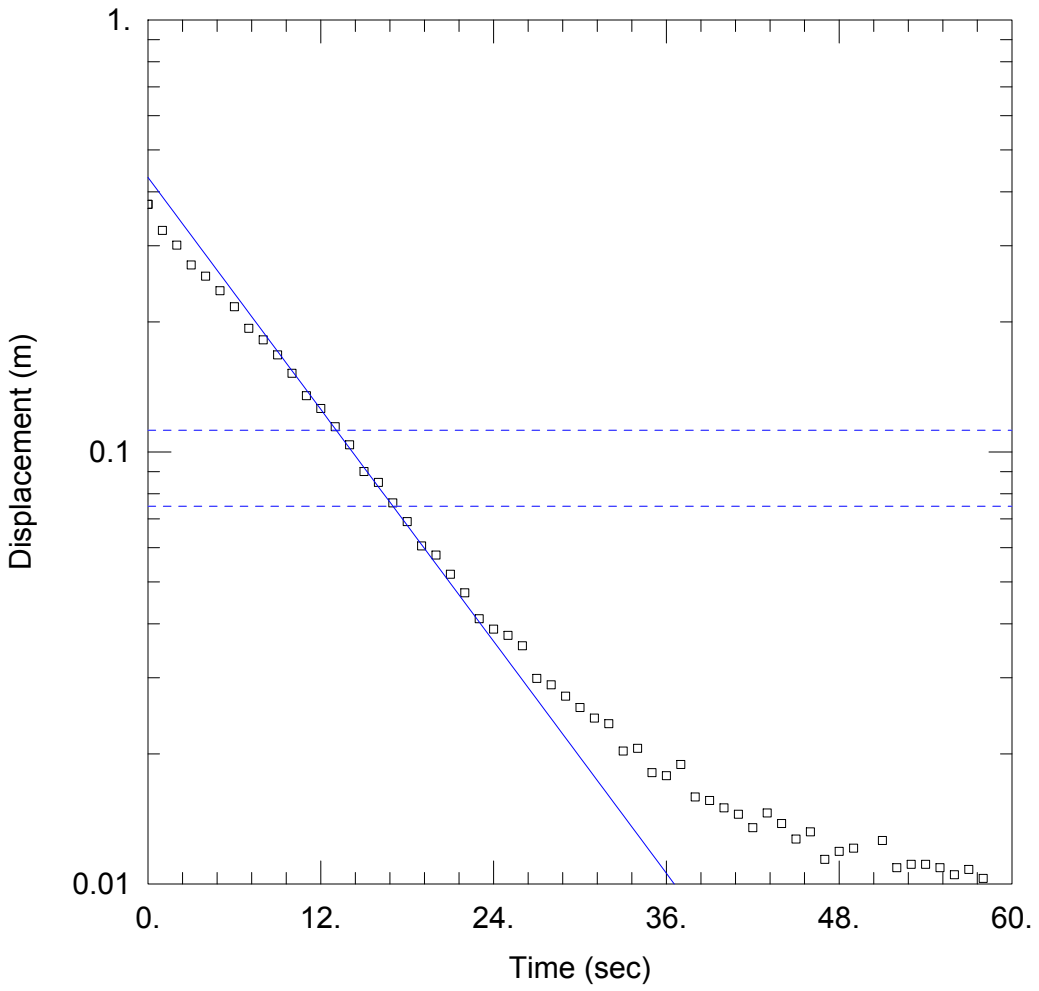
Saturated Thickness: 3.955 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW3-19)

Initial Displacement: 0.3049 m
Total Well Penetration Depth: 3.245 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.245 m
Screen Length: 3.05 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.00018 m/sec
y0 = 0.2569 m



MW4-19

Data Set: \...\MW4-19_DS_JK.aqt
Date: 06/05/19 Time: 13:31:58

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW4-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 2.37 m Anisotropy Ratio (Kz/Kr): 0.4

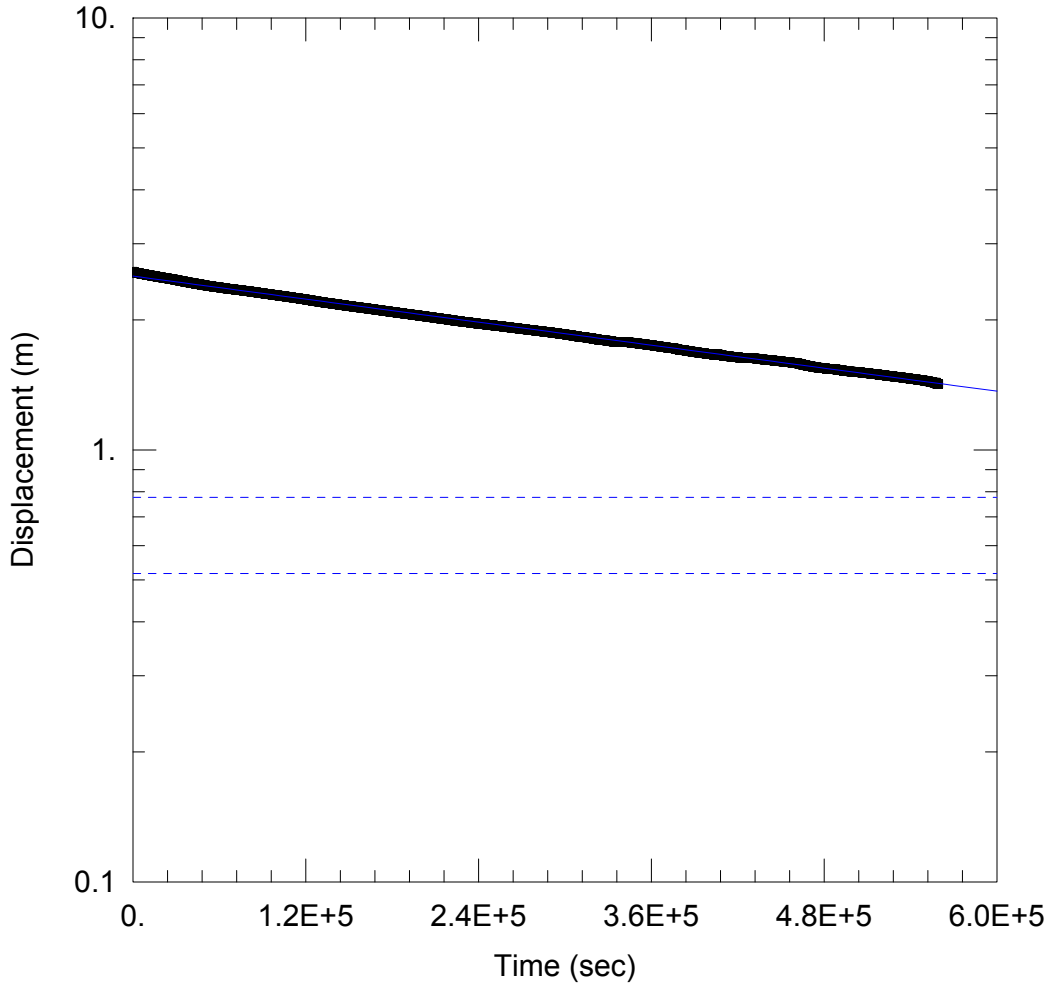
WELL DATA (MW4-19)

Initial Displacement: 0.3742 m
Total Well Penetration Depth: 2.37 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.37 m
Screen Length: 2.37 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.00019 m/sec y0 = 0.4319 m



MW5-19

Data Set: \...\MW5-19_incomplete ktest_DS_JK.aqt
Date: 06/05/19 Time: 13:55:19

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW5-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 3.635 m Anisotropy Ratio (Kz/Kr): 0.25

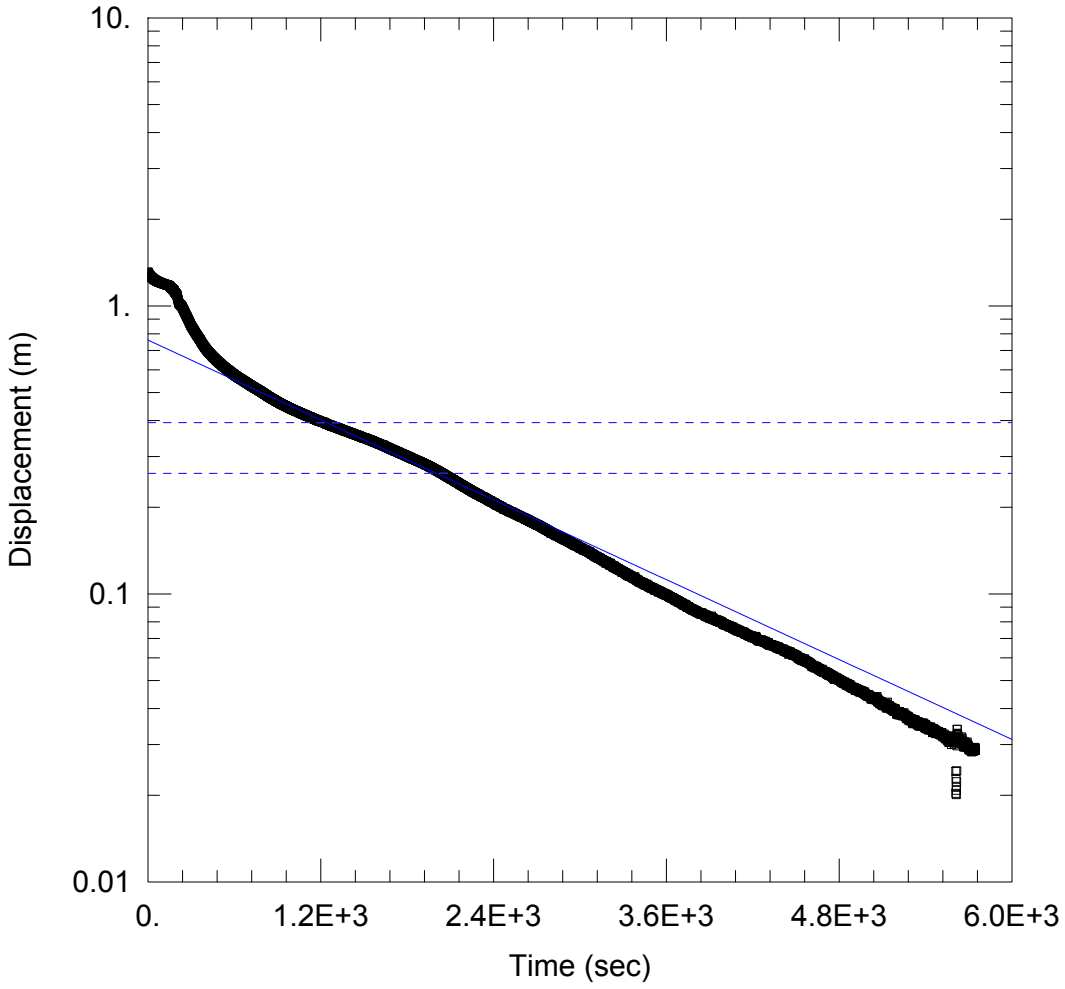
WELL DATA (MW5-19)

Initial Displacement: 2.588 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.05 m
Screen Length: 3.05 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.8E-9 m/sec y0 = 2.525 m



MW6-19

Data Set: \...\MW6-19_DS_JK.aqt
Date: 06/05/19 Time: 14:07:31

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW6-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 2.57 m Anisotropy Ratio (Kz/Kr): 0.2

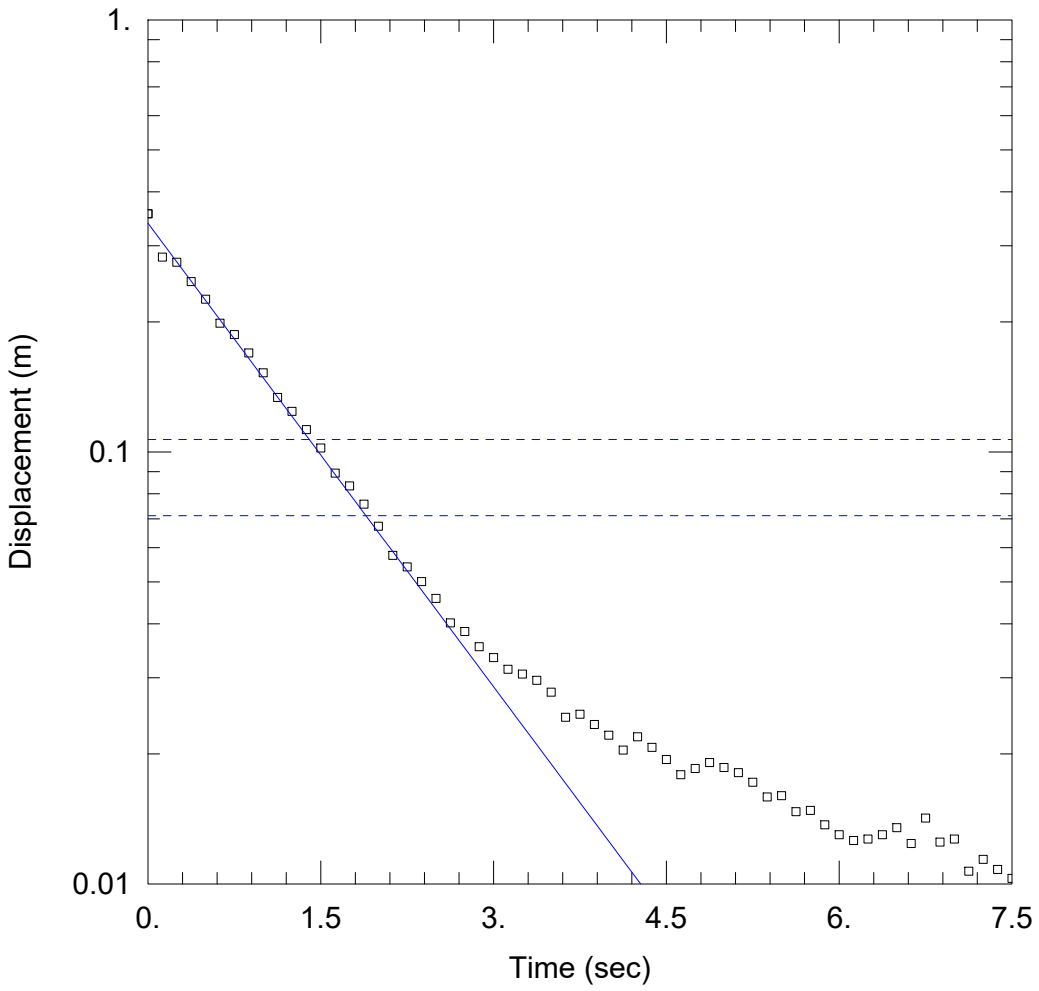
WELL DATA (MW6-19)

Initial Displacement: 1.311 m
Total Well Penetration Depth: 2.57 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.5 m
Screen Length: 2.57 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.6E-7 m/sec
y0 = 0.7609 m



MW101-21 TEST 2

Data Set: \...\MW101-21_eighth second test_DS_JK.aqt
Date: 06/01/21 Time: 17:50:42

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo, Ontario
Test Well: MW101-21
Test Date: May 26, 2021

AQUIFER DATA

Saturated Thickness: 2.18 m Anisotropy Ratio (Kz/Kr): 0.5

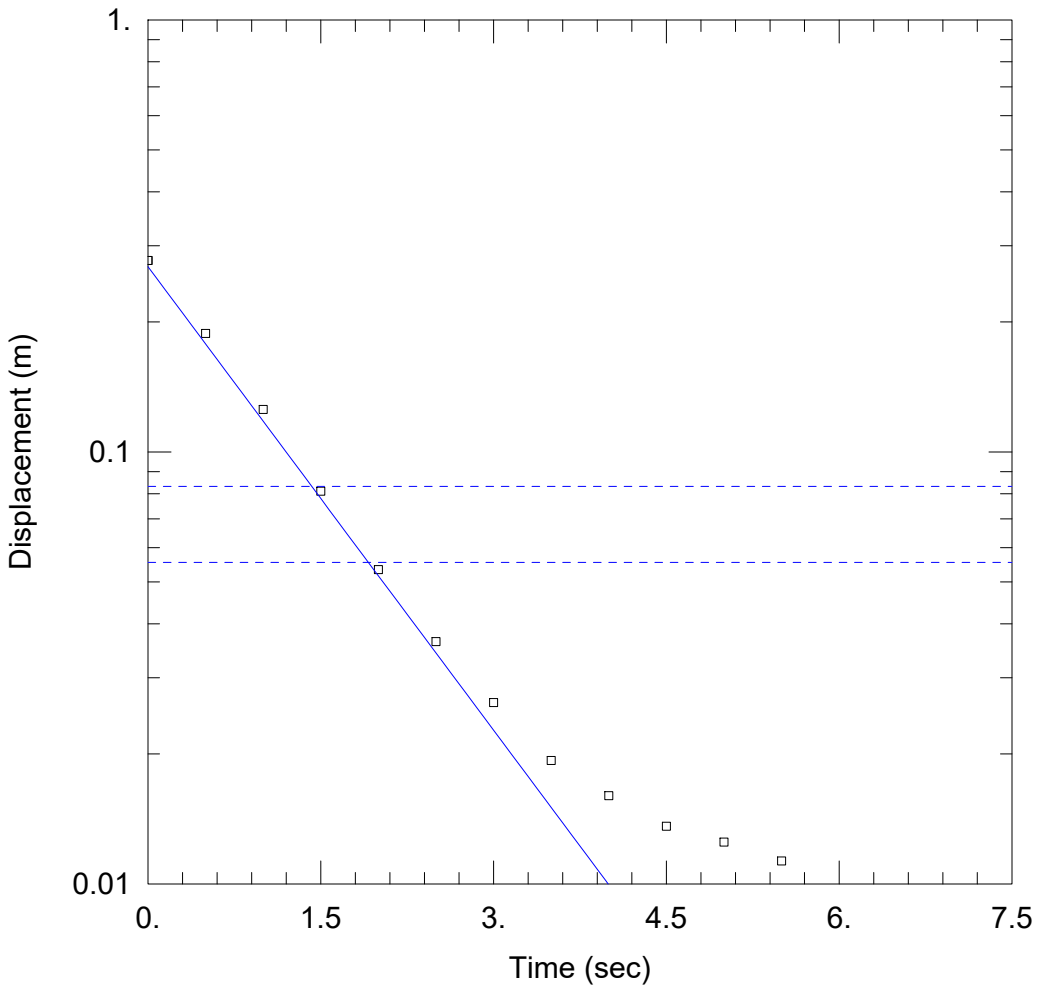
WELL DATA (MW101-21)

Initial Displacement: 0.356 m
Total Well Penetration Depth: 2.18 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 2.18 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.0016 m/sec y0 = 0.3383 m



MW101-21

Data Set: \...\MW101-21_half second test_DS_JK.aqt
Date: 06/01/21 Time: 17:52:15

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo, Ontario
Test Well: MW101-21
Test Date: May 26, 2021

AQUIFER DATA

Saturated Thickness: 2.18 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW101-21)

Initial Displacement: 0.2774 m
Total Well Penetration Depth: 2.18 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 2.18 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.0016 m/sec y0 = 0.2684 m

APPENDIX I:
Grain Size Analysis

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353 Bridge Street East, Kitchener, ON N2K 2Y5
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E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-696 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 1

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.1
% SAND (75 µm to 4.75 mm):	30.0
% Silt (2 µm to 75 µm):	42.9
% Clay (<2 µm):	27.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	60.2
37.5	100.0	0.026	54.9
26.5	100.0	0.017	51.4
19.0	100.0	0.010	46.2
13.2	100.0	0.007	42.7
9.5	100.0	0.005	37.5
4.75	99.9	0.003	30.5
2.00	99.6	0.001	24.4
0.850	99.6	ATTERBERG LIMITS, %	
0.425	98.0		
0.250	94.1	Plastic Limit	
0.106	77.0	Liquid Limit	
0.075	69.9	Plastic Index	

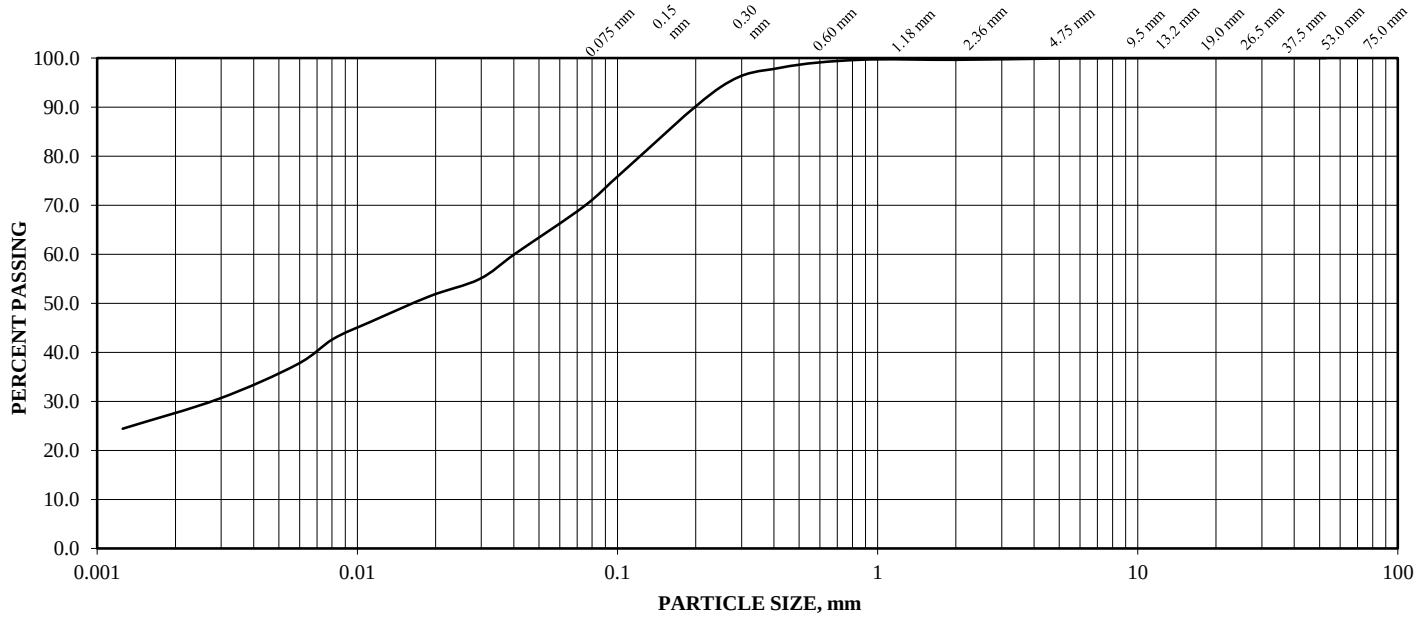
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

O. Rexha

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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-697 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 2

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	35 - 55 cm
SAMPLE NUMBER:	02
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	SILT, fine sand, clay
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.0
% SAND (75 µm to 4.75 mm):	25.8
% Silt (2 µm to 75 µm):	41.7
% Clay (<2 µm):	32.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	66.1
37.5	100.0	0.026	61.5
26.5	100.0	0.017	57.0
19.0	100.0	0.010	51.6
13.2	100.0	0.007	48.0
9.5	100.0	0.005	42.5
4.75	100.0	0.003	35.3
2.00	99.9	0.001	29.0
0.850	99.9	ATTERBERG LIMITS, %	
0.425	98.8		
0.250	95.3	Plastic Limit	
0.106	80.6	Liquid Limit	
0.075	74.2	Plastic Index	

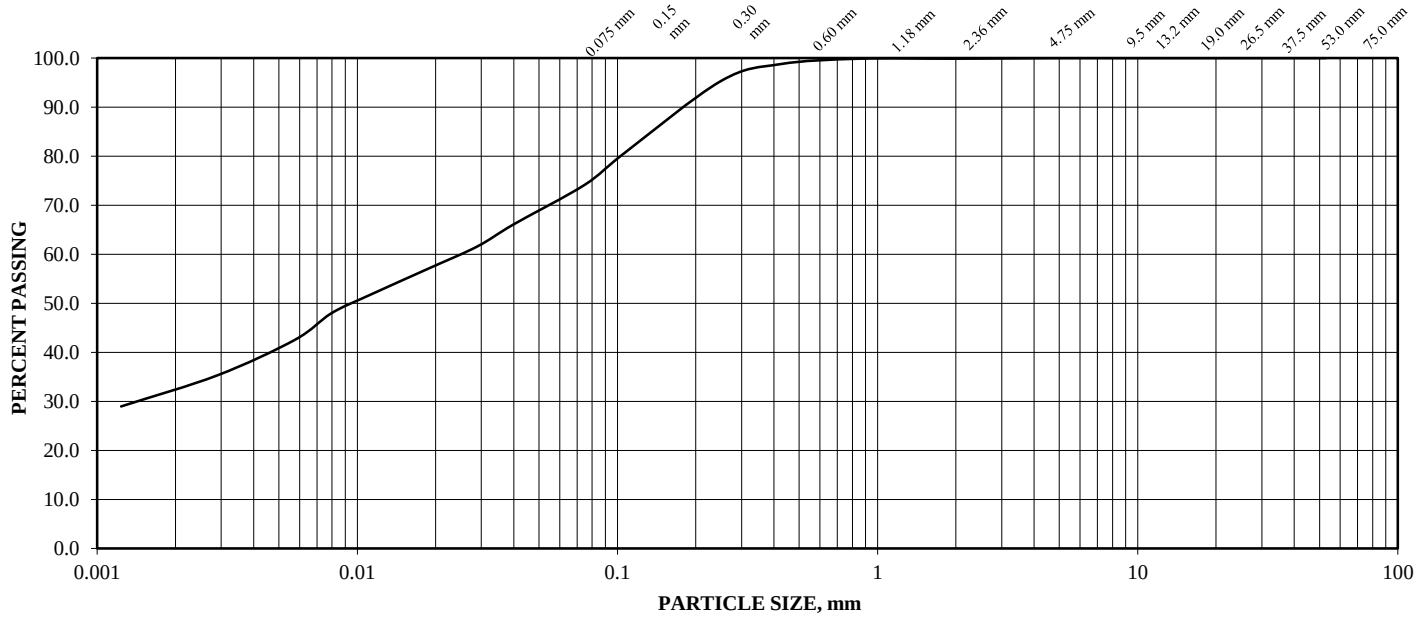
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-698 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 3

BOREHOLE / TEST PIT NUMBER:	GP 102-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	3.5
% SAND (75 µm to 4.75 mm):	81.1
% Silt (2 µm to 75 µm):	8.9
% Clay (<2 µm):	6.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	12.8
37.5	100.0	0.026	11.5
26.5	100.0	0.017	10.1
19.0	100.0	0.010	9.4
13.2	99.6	0.007	8.8
9.5	98.5	0.005	8.1
4.75	96.5	0.003	7.4
2.00	94.2	0.001	5.4
0.850	90.4	ATTERBERG LIMITS, %	
0.425	76.7		
0.250	53.2	Plastic Limit	
0.106	18.9	Liquid Limit	
0.075	15.4	Plastic Index	

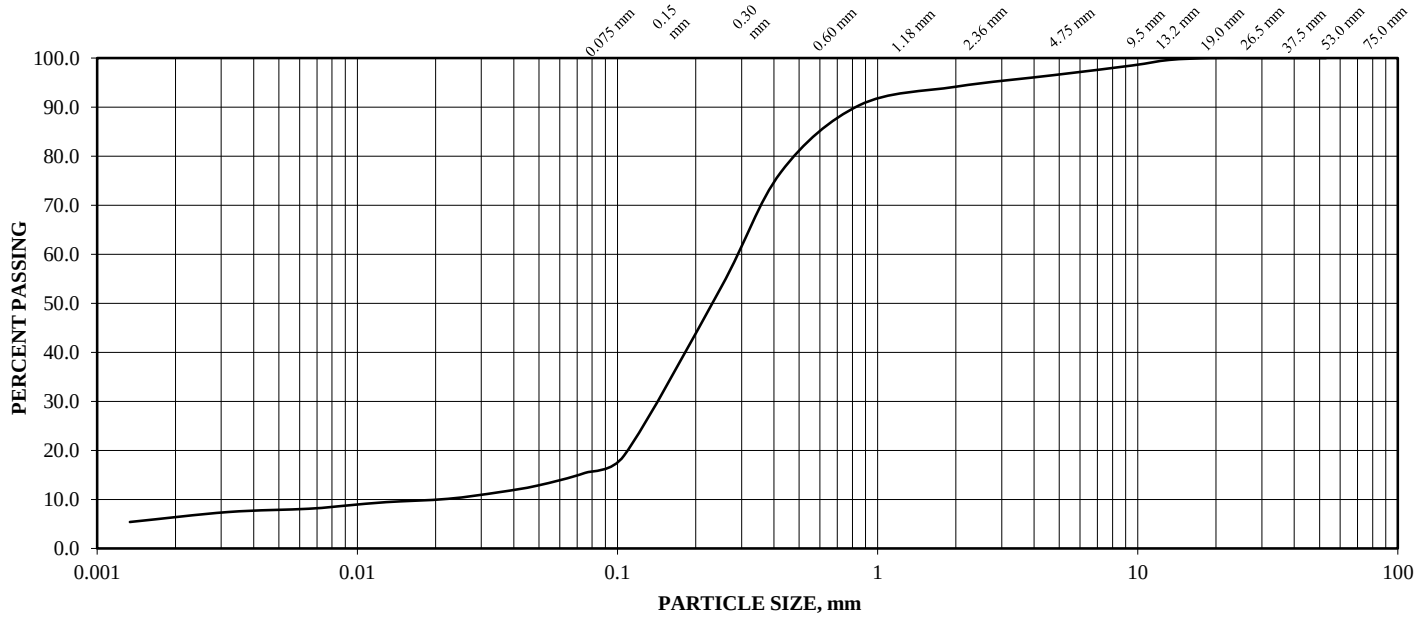
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-699 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 4

BOREHOLE / TEST PIT NUMBER:	GP 103-20
SAMPLING DEPTH:	0 - 15 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020
GRAIN SIZE PROPORTIONS, %	
% GRAVEL (> 4.75 mm):	0.2
% SAND (75 µm to 4.75 mm):	37.7
% Silt (2 µm to 75 µm):	45.1
% Clay (<2 µm):	17.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	51.3
37.5	100.0	0.026	46.1
26.5	100.0	0.017	41.0
19.0	100.0	0.010	32.5
13.2	100.0	0.007	28.2
9.5	100.0	0.005	24.8
4.75	99.8	0.003	19.6
2.00	99.7	0.001	14.5
0.850	99.4	ATTERBERG LIMITS, %	
0.425	92.1		
0.250	78.5	Plastic Limit	
0.106	64.8	Liquid Limit	
0.075	62.1	Plastic Index	

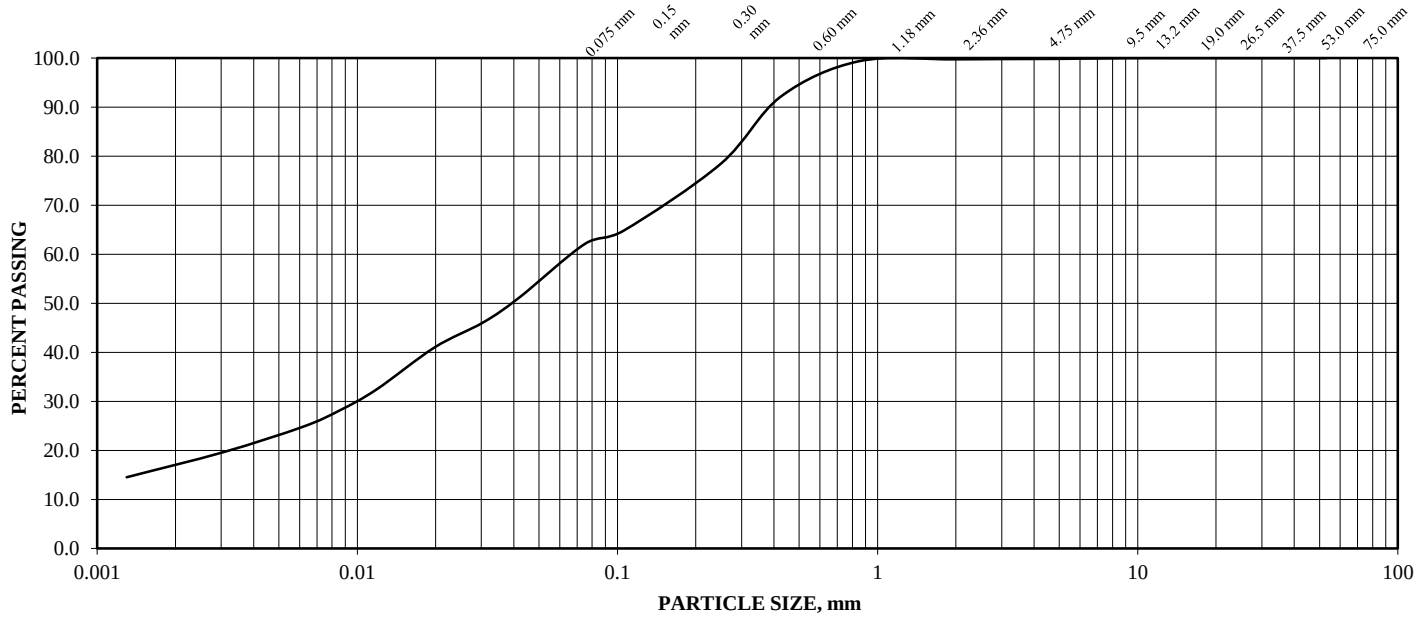
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

O. Rexha

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E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-700 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 5

BOREHOLE / TEST PIT NUMBER:	GP 104-20
SAMPLING DEPTH:	0 - 25 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	15.2
% SAND (75 µm to 4.75 mm):	71.2
% Silt (2 µm to 75 µm):	9.1
% Clay (<2 µm):	4.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	12.5
37.5	100.0	0.026	11.1
26.5	100.0	0.017	10.5
19.0	98.0	0.010	9.1
13.2	94.6	0.007	8.4
9.5	91.1	0.005	7.7
4.75	84.8	0.003	5.6
2.00	79.9	0.001	4.2
0.850	74.0	ATTERBERG LIMITS, %	
0.425	56.2		
0.250	35.0	Plastic Limit	
0.106	15.5	Liquid Limit	
0.075	13.6	Plastic Index	

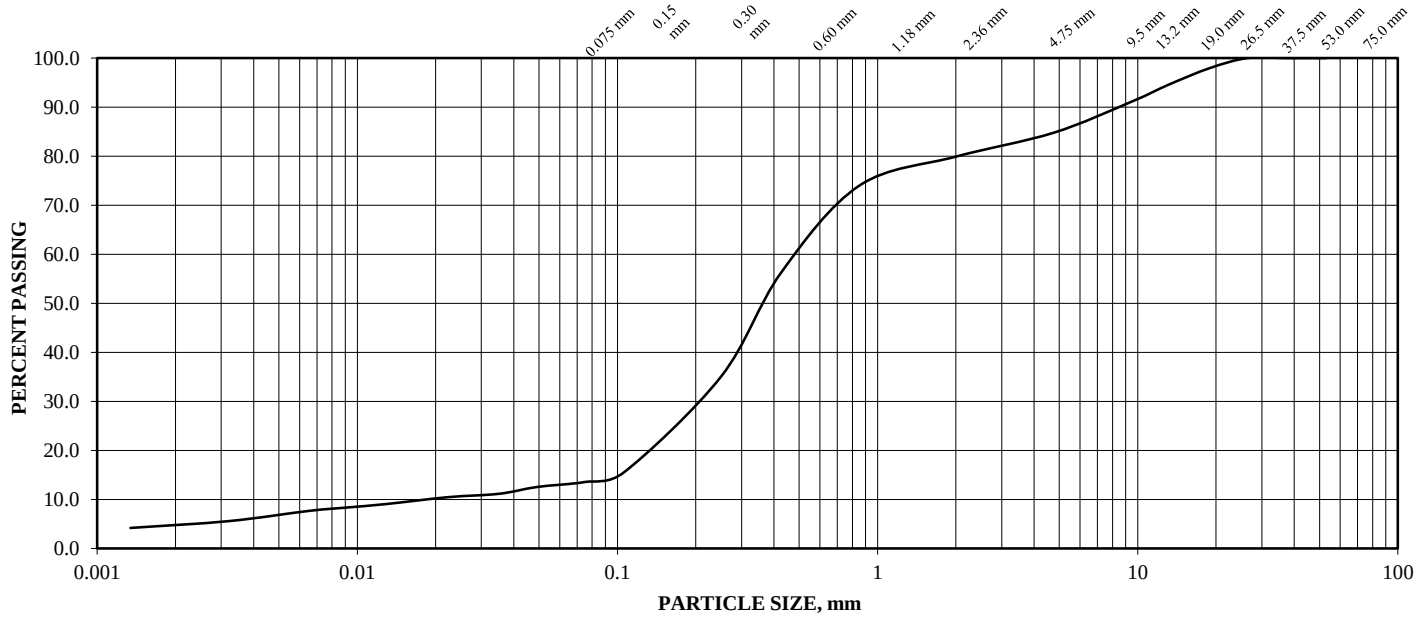
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

O. Rexha

TP1-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-797	**SAMPLE ID:**	TP1-21 Sample 01	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

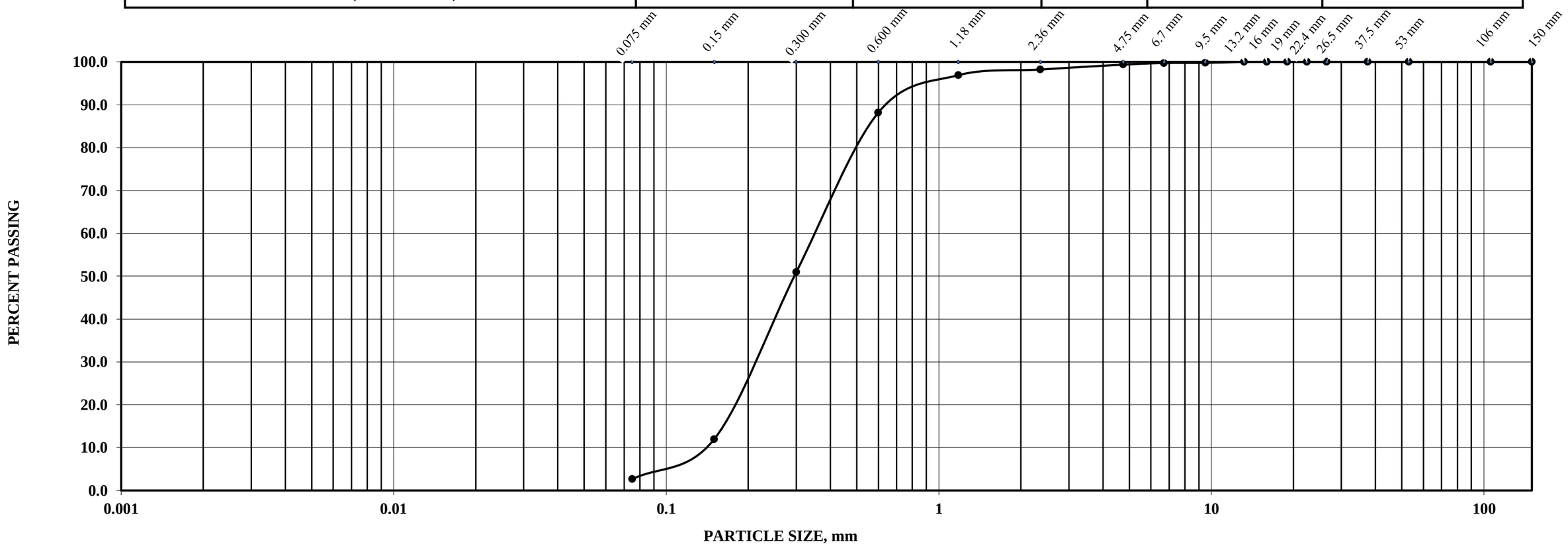
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.373	**D30**	0.219	**D10**	0.134	**Cc**	0.963	**Cu**	2.78

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.8
6.7	99.7
4.75	99.4
2.36	98.2
1.18	96.9
0.6	88.2
0.3	50.9
0.15	12.0
0.075	2.7

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.6
% SAND (75 µm to 4.75 mm):	96.7
% SILT (2 µm to 75 µm):	2.7
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, trace Silt

REMARKS

Figure: 2

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP1-GP3

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-798	**SAMPLE ID:**	TP1-21 Sample 02	**SAMPLE DEPTH:**	5.0 - 5.5m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

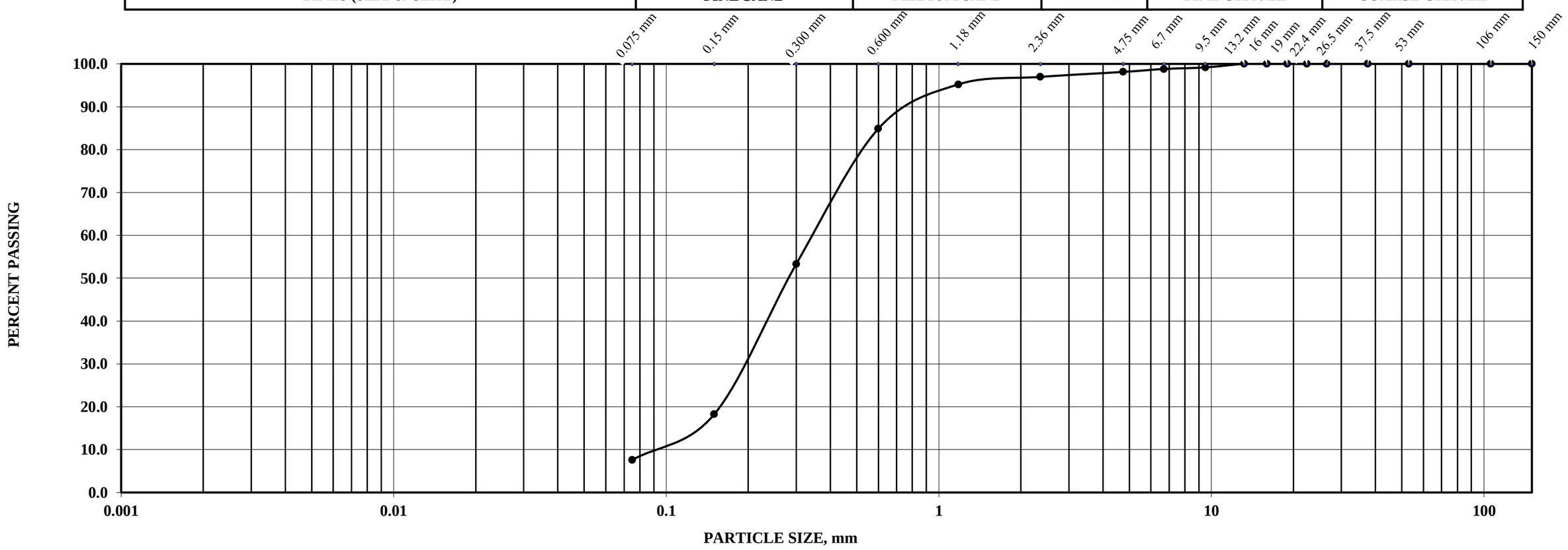
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.363	**D30**	0.200	**D10**	0.092	**Cc**	1.200	**Cu**	3.95

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.2
6.7	98.8
4.75	98.1
2.36	97.0
1.18	95.2
0.6	84.9
0.3	53.3
0.15	18.3
0.075	7.6

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	1.9
% SAND (75 µm to 4.75 mm):	90.5
% SILT (2 µm to 75 µm):	7.6
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, trace Silt

REMARKS

Figure: 3

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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Brantford

TP2-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-799	**SAMPLE ID:**	TP2-21 Sample 01	**SAMPLE DEPTH:**	2.6 - 2.9m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

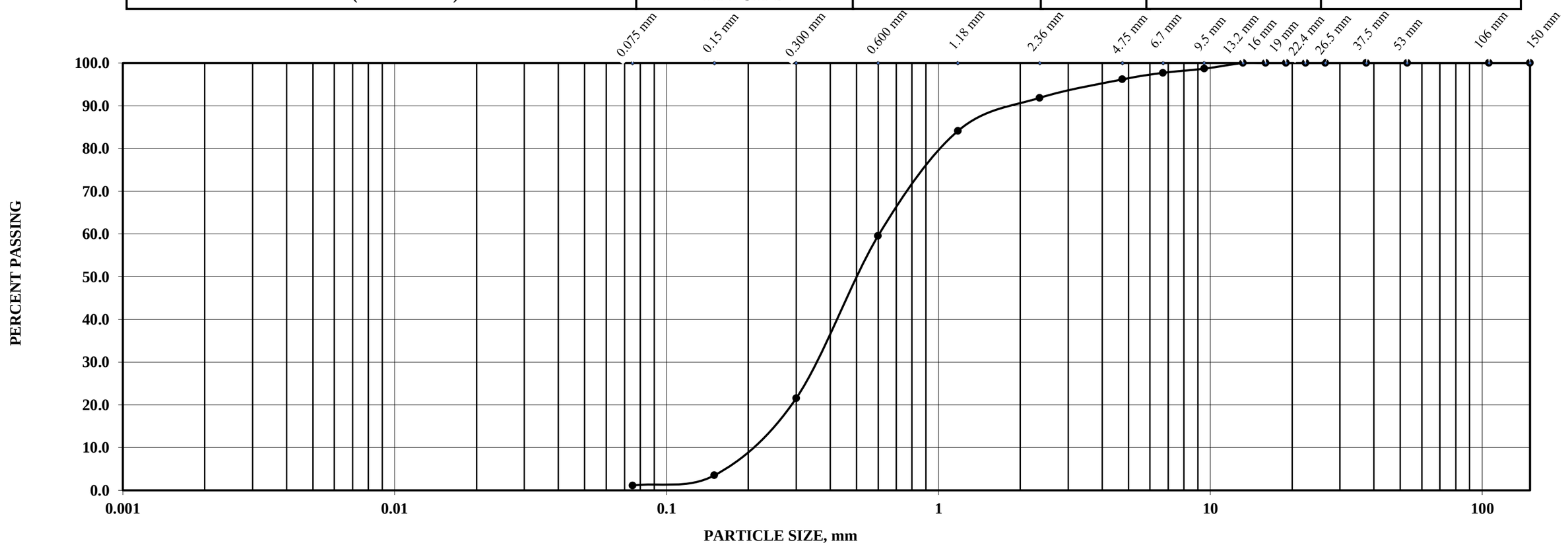
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.610	**D30**	0.367	**D10**	0.204	**Cc**	1.080	**Cu**	2.99

GRAIN SIZE ANALYSIS	
SIEVE SIZE mm	**% PASSING**
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	98.7
6.7	97.7
4.75	96.2
2.36	91.9
1.18	84.1
0.6	59.6
0.3	21.6
0.15	3.5
0.075	1.1

GRAIN SIZE PROPORTIONS, %		
% GRAVEL (> 4.75 mm):	3.8	
% SAND (75 µm to 4.75 mm):	95.1	
% SILT (2 µm to 75 µm):	1.1	
% CLAY (<2 µm):	-	
SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 4

TESTED BY: Kevin Frank
Laboratory Technician

REVIEWED BY David McBay, C.Tech.
Laboratory Supervisor

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TP2-GP3

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-800	**SAMPLE ID:**	TP2-21 Sample 02	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

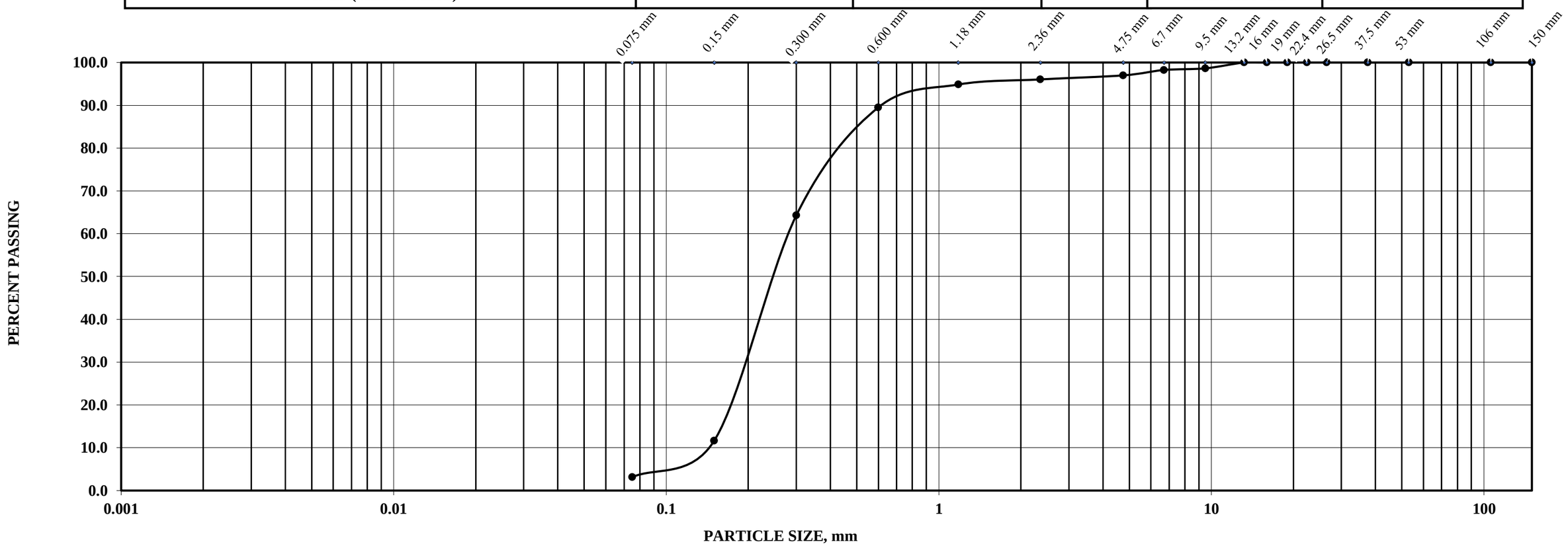
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.288	**D30**	0.202	**D10**	0.135	**Cc**	1.051	**Cu**	2.13

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	98.6
6.7	98.2
4.75	97.0
2.36	96.0
1.18	94.9
0.6	89.5
0.3	64.3
0.15	11.7
0.075	3.1

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	3.0
% SAND (75 µm to 4.75 mm):	93.9
% SILT (2 µm to 75 µm):	3.1
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 5

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP3-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-801	**SAMPLE ID:**	TP3-21 Sample 01	**SAMPLE DEPTH:**	3.7 - 4.0m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

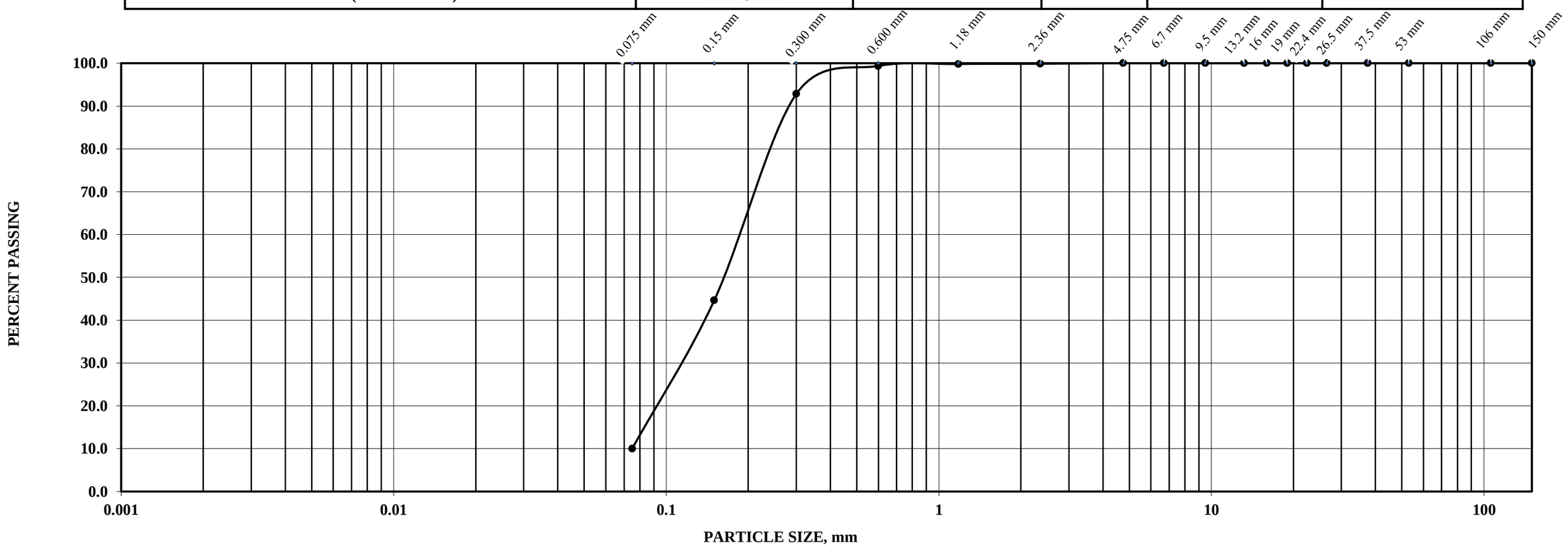
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.198	**D30**	0.118	**D10**	0.075	**Cc**	0.944	**Cu**	2.64

GRAIN SIZE ANALYSIS	
SIEVE SIZE mm	**% PASSING**
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	100.0
6.7	100.0
4.75	100.0
2.36	99.9
1.18	99.8
0.6	99.4
0.3	92.8
0.15	44.6
0.075	10.0

GRAIN SIZE PROPORTIONS, %		
% GRAVEL (> 4.75 mm):		
% SAND (75 µm to 4.75 mm):	90.0	
% SILT (2 µm to 75 µm):	10.0	
% CLAY (<2 µm):	-	
SOIL DESCRIPTION:	SP - SM	SAND, some Silt

REMARKS

Figure: 6

TESTED BY: Kevin Frank
Laboratory Technician

REVIEWED BY David McBay, C.Tech.
Laboratory Supervisor

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TP3-GP4

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-802	**SAMPLE ID:**	TP3-21 Sample 02	**SAMPLE DEPTH:**	5.2 - 5.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

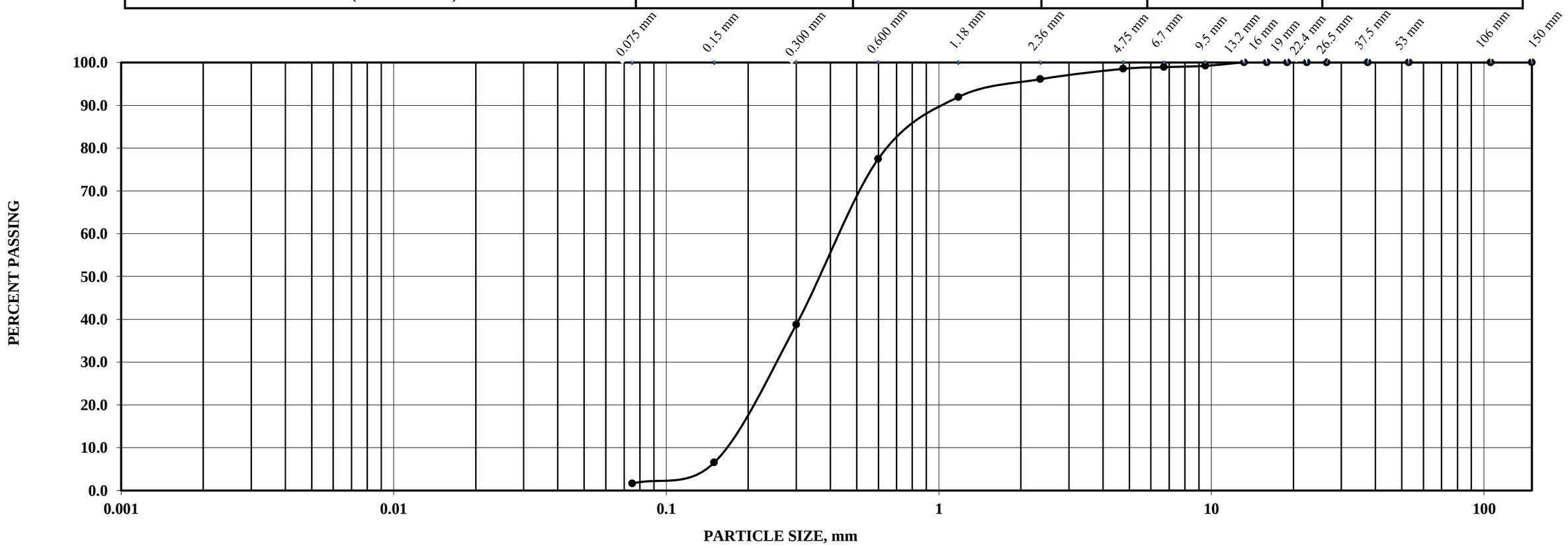
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.464	**D30**	0.232	**D10**	0.166	**Cc**	0.698	**Cu**	2.80

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.2
6.7	98.9
4.75	98.5
2.36	96.1
1.18	91.9
0.6	77.5
0.3	38.8
0.15	6.5
0.075	1.6

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	1.5
% SAND (75 µm to 4.75 mm):	96.9
% SILT (2 µm to 75 µm):	1.6
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 7

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP4-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-803	**SAMPLE ID:**	TP4-21 Sample 01	**SAMPLE DEPTH:**	2.6 - 2.9m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

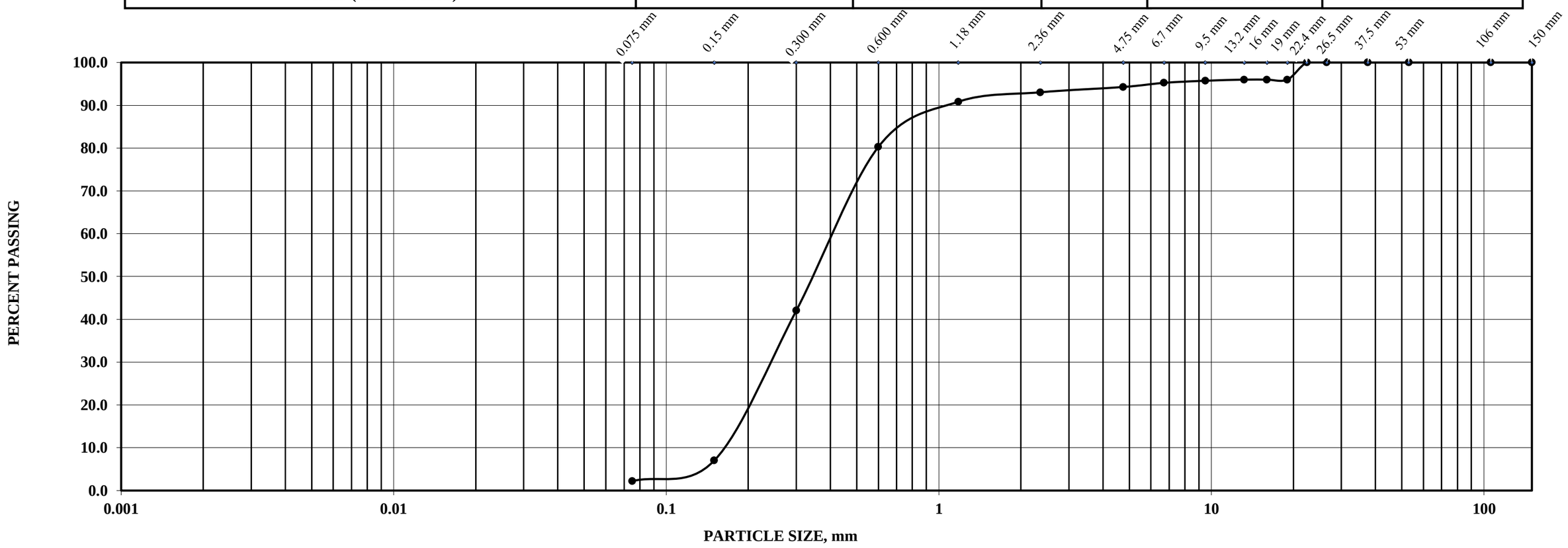
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.441	**D30**	0.248	**D10**	0.163	**Cc**	0.860	**Cu**	2.71

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	96.0
16	96.0
13.2	96.0
9.5	95.7
6.7	95.2
4.75	94.3
2.36	93.0
1.18	90.8
0.6	80.3
0.3	42.0
0.15	7.0
0.075	2.2

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	5.7
% SAND (75 µm to 4.75 mm):	92.1
% SILT (2 µm to 75 µm):	2.2
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 8

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP4-GP2

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-804	**SAMPLE ID:**	TP4-21 Sample 02	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

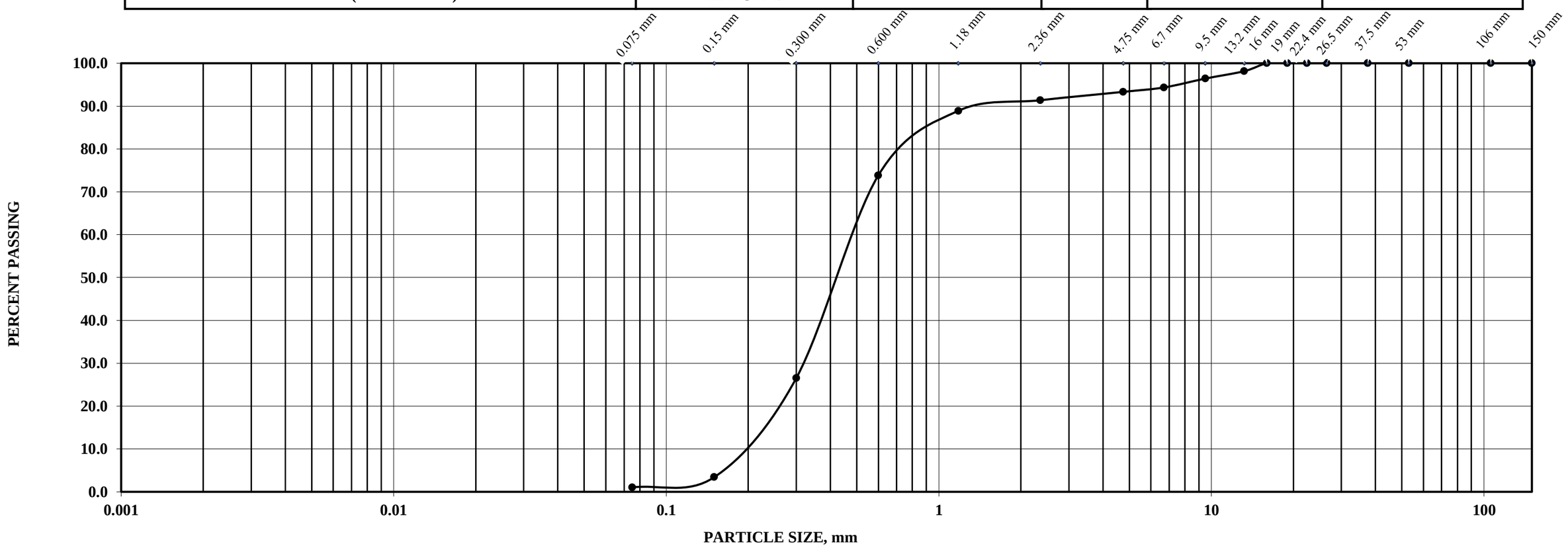
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.512	**D30**	0.322	**D10**	0.193	**Cc**	1.050	**Cu**	2.66

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	98.1
9.5	96.4
6.7	94.3
4.75	93.3
2.36	91.4
1.18	88.9
0.6	73.8
0.3	26.5
0.15	3.4
0.075	1.0

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	6.7
% SAND (75 µm to 4.75 mm):	92.3
% SILT (2 µm to 75 µm):	1.0
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 9

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

APPENDIX J:
Photographs



Photo 1: MW101-21 – May 28, 2021.



Photo 2: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 1 (TP1) – May 28, 2021. The location of this test pit is within the northeast corner of the proposed SWM infiltration basin.



Photo 3: Test Pit 1 (TP1) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 5.5 meters below existing grade comprise 90% to 97% sand.



Photo 4: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 1 (TP1) – May 28, 2021.



Photo 5: Excavation of Test Pit 2 (TP2) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.3 meters below existing grade comprise 94% to 95% sand.



Photo 6: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 2 (TP2) – May 28, 2021.

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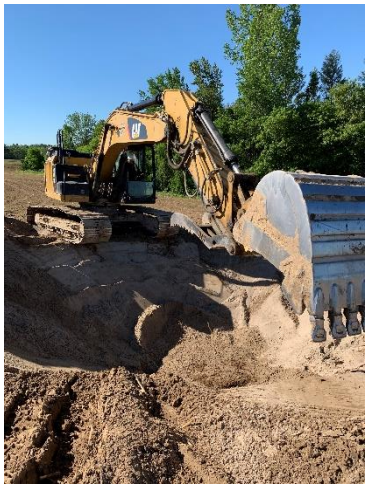


Photo 7: Excavation of Test Pit 3 (TP3) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 5.5 meters below existing grade comprise 90% to 97% sand.



Photo 8: Hand augering of hole in Test Pit 3 (TP3) for insertion of Guelph Permeameter – May 28, 2021



Photo 9: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 3 (TP3) – May 28, 2021



Photo 10: Test Pit 3 (TP3) infilled – May 28, 2021.



Photo 11: Various test pit excavations – May 28, 2021.

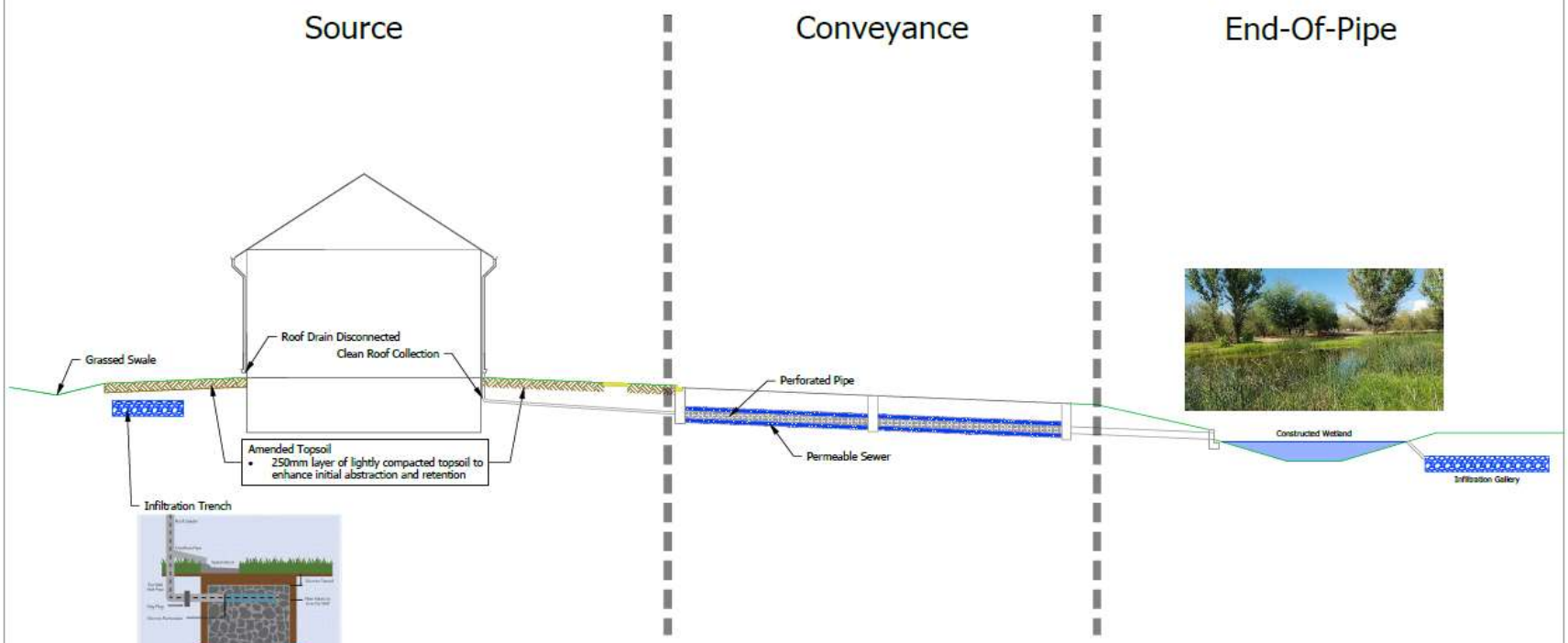


Photo 12: Test Pit 4 (TP4) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.4 meters below existing grade comprise 92% sand.

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APPENDIX K:
SWM Treatment Train Approach

Stormwater Management Treatment Train



Source: Meritech Engineering. 2021. Preliminary Stormwater Management Report. Revised October 2021.

Stantec

Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**K-1**
Title:	**Stormwater Management Treatment Train**

APPENDIX L:
Amended Soils Assessment Memo

Stantec

Memo

To:	Abraham J. Barrios, P.Eng Meritech Engineering	From:	Jennifer Young, P.Eng Stantec Consulting
File:	556, 5060, and 576 Conservation Drive, Waterloo, Ontario	Date:	November 19, 2020

Reference: Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario

Meritech Engineering (Meritech) on behalf of 2115881 Ontario Limited (Client), retained Stantec Consulting Limited (Stantec) to complete an assessment of the effectiveness of an increased depth of amended soils as an LID feature to meet infiltration water balance targets.

AMENDED SOILS ANAYSIS

The Treatment Train Tool (TTT, STEP V 1.2.1) was proposed to complete the analysis on the site soils. However, after setting up the model, Stantec came to the conclusion that the TTT was not able to perform the needed assessment and produce meaningful results. Consequently, the decision was made to move to a spreadsheet based analysis to determine the effect of soil depth on infiltration potential.

A water balance design spreadsheet was created to analyze the proposed lot level amended soils on typical townhome and single family residential lots.

SITE GEOLOGICAL AND HYDROGELOLGICAL CONDITIONS

The *Hydrogeological Assessment, 556, 560, and 576 Conservation Drive, Waterloo Ontario* (Stantec, November 2020) describes the site geology as located within the Waterloo Moraine with outwash sands and gravels separated by silt- and clay-tills. The groundwater table ranges from 0.1 m BGS to 7.2 m BGS.

Infiltration testing was conducted on the onsite topsoil using a double-ring infiltrometer to determine the infiltration rates of the existing topsoil for use as an LID feature. The measured infiltration rates for the soils onsite are summarized in Table 1.

Table 1: Infiltration Rate

Location	Infiltration Rate (mm/hr)
GP101	66
GP102	173
GP104	16

To be conservative, the lower range of infiltration for the topsoil was selected for design: 16 mm/hr. The possibility exists that the topsoil will have a greater capacity in some areas.

WATER BALANCE DESIGN SPREADSHEET

The water balance design spreadsheet used for the sizing and infiltration analyses tracks the volume of water in each part of the system (runoff, soil conditions, and groundwater) during each time-step for each of the

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

proposed LID/GI features on the site. This assessment considered two components: lawn areas for single family residential areas and lawn areas for townhome areas. The selected time-step for the design is five (5) minutes to be consistent with the available rainfall record. The water balance spreadsheet uses the rainfall, local soil characteristics as determined by the hydrogeological investigation, and drainage areas to each feature to calculate the volume of water for each of the following, for every time-step. Design parameters are summarized in Table 2.

Table 2: Design Spreadsheet Parameters

Amended Soils
• Rainwater directed onto pervious surfaces (includes roofs and lawn areas only);
• Beginning of time-step unsaturated runoff;
• Rain into soil;
• Beginning of time-step soil water volume;
• Water from soil to groundwater;
• Water that stays in soil;
• Beginning of time-step saturated runoff;
• Total runoff (saturated and unsaturated); and
• Evaporation

The set-up of the model included the following parameters:

- No initial abstractions or losses other than infiltration and evaporation were assumed during the analysis of the scenarios.
- The sum of the volume from each portion of the system represents a total volume of water in retention. For example, the total volume of unsaturated runoff (i.e., any volume of water that is unable to infiltrate into the soil) for each time step is summed to determine the total volume of unsaturated runoff.
- To accurately assess the operations of the soils, a continuous rainfall record was used. Although Waterloo Airport has long-term precipitation records, the Toronto and Region Conservation Authority (TRCA) collects long-term rainfall data across a wide area that is easily accessible, and in a readily usable format for this assessment. The Rathwood station was selected for its proximity to Waterloo, length of record (approximately three years), and similarity in annual rainfall amounts (903 mm/year).
- The soil depth was varied between 150 and 300 mm.
- The initial condition of the soil water content was set to the field capacity value at the last time step to balance the volumes within the calculation. Typical evaporation values were included to show the wetting and drying front experienced by the soils over the three year rainfall record.

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

- The soil porosity, field capacity, and wilting point are representative of non-engineered sandy-loam or loam soils and represent a natural soil capacity.
- The spreadsheet model assumed that rooftop surfaces were disconnected and flowed onto the lawn area. The inputs for the drainage areas to each infiltration component for the water balance is presented in Table 33. The green infrastructure water balance design spreadsheet is in Appendix D.

Table 3: Summary of Post-Development Design Water Balance Inputs

Parameter	Townhomes	Single Family	Unit
Impervious Area	710	510	Sq. m
Pervious Area	470	420	Sq. m
Total Area	1,180	930	Sq. m
Soil Depth	150	150	mm
Soil Exfiltration Rate	1	1	mm/hr
Soil Porosity	0.35[1]	0.35[1]	
Soil Field Capacity	0.15[1]	0.15[1]	
Soil Wilting Point	0.1[1]	0.1[1]	
Soil Infiltration Rate	16	16	mm/hr
[1]Typical values for sandy-loam, loam soils adapted from the BC Agricultural, Food, and Fisheries Ministry			

Results

Based on the spreadsheet analysis, directing the roof runoff to the lawns does not capture 90% of the typical yearly rainfall. The 90% capture target corresponds to the water balance requirements for the site; basically, if 90% of the annual rainfall can infiltrate and evapotranspirate, the site is achieving the predevelopment water balance. In this case, the limiting factor to the infiltration system (soils) is the topsoil infiltration rate of 16 mm/hr. This rate limits the infiltration of precipitation with higher intensities into the soil, resulting in unsaturated runoff. Due to the limitations of the infiltration rates, the depth of soil has no impact on the volume of water captured by the LID feature. To achieve the 90% capture target, the soil would have to be amended with sand to increase the infiltration rate to one that could accept higher intensity rainfall. This soil would look more like a bioretention soil mix having over 60% sand, which is very difficult to grow turf on without extensive watering.

Since the existing onsite soils do have moderately high infiltration rates, further analysis was done to compare the assumed infiltration rates (mm/yr) from the *Preliminary Stormwater Management Report 556 and 557 Conservation Drive, City of Waterloo* (Meritech, 2020) to those seen in the design water balance spreadsheet. As part of the treatment train approach for the site, the assumed annual infiltration rate for pervious areas in Table 5 of the Meritech report is 272 mm/year on average. This rate of 272 mm/year, along with the other proposed infiltration measures, meets the water balance requirements for the site.

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

To determine the annual infiltration rate in the spreadsheet, the total volume contributing to groundwater was divided by the total rainfall volume for the area to get a percent value. This value was then multiplied by the average yearly rainfall in mm/yr to determine a yearly groundwater contribution depth in mm/yr. This approach was also repeated for the evaporation for each area. Table 4 shows the infiltration and evaporation rates for the lawn areas onsite in the design water balance spreadsheet.

Table 4: Pre- and Post-Development Retention and Runoff Results (Total Site)

Area	Average Yearly Rainfall	Percent Average Rainfall Capture	Infiltration		Evaporation	
	mm/yr		%	mm/yr	%	mm/yr
Townhomes	903	78%	41%	374.0	37%	332.6
Single Family	903	81%	42%	378.0	39%	354.0

Comparing the yearly infiltration rates shows that the Meritech infiltration rate of 272 mm/year represents an appropriate assumption in the water balance assessment and validates the approach in the SWM report Based on this analysis, the topsoil onsite has an annual infiltration rate that supports the treatment train approach to meet the water balance for the site in post-development conditions.

The above conclusions are based on the assumption that the topsoil will be reapplied to the site in such a way that the native infiltration rates are maintained post development. This means that the soils will not be over compacted (maintain existing bulk density of soils) or otherwise impacted during construction. We recommend performing infiltration testing after installation to confirm infiltration rates.

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Attachment: Green Infrastructure Design Spreadsheet – Single Family
Green Infrastructure Design Spreadsheet – Townhome

Fill in RED text

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	0
2	Feb	28	0
3	Mar	31	0
4	Apr	30	38.82
5	May	31	59.39
6	Jun	30	82.51
7	Jul	31	95.89
8	Aug	31	89.54
9	Sep	30	67.67
10	Oct	31	44.54
11	Nov	30	29.93
12	Dec	31	0

03/02/2017 14:55	1322.024306	days
17/09/2020 15:30	3270.700	mm
	3.621984399	
	903.0132767	mm/yr average

Lawns		
Impervious Area To Lawn	510	sq.m
Lawn Area	420	sq.m
Total area:	930	sq.m
Subsoil exfil. rate:	1	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	16	mm/hr
Soil wilt point vol:	6.3	cu.m
Soil porosity vol:	22.1	cu.m
Soil field cap vol:	9.5	cu.m
Soil initial vol:	6.3	cu.m
I/P	1	

Summary	Lawns	Total	
Total evaporation	1135.8	1135.8	
Total exfiltration	1212.4	1212.4	
Total drainflow	0.0	0.0	
Total runoff	548.3	548.3	
Total Reused			
Sum	2896.5	2896.5	
Total rainfall	2896.5	2896.5	
% Treated	81%	81%	
% untreated	19%	19%	
% Captured	81%	81%	
EIA	19%	19%	
Infiltration	42%	377.98	mm/yr
Evapouration	39%	354.09	mm/yr

Lawns

All in cubic metres

Month		Precip (mm)	Kitchener ETO	Rain Water onto pervious	Unsaturated Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to GW	Water that does not exfiltrate	Water that Stays in Soil	beginning water that runsoff	Total Runoff	Evaporation
						0.00		0.00	0.00	0	0.00	0.00	0.00
2	07/02/2017 11:15	0.1	0	0.09	0.00	0.09	6.765	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:20	0	0	0.00	0.00	0.00	6.858	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 11:25	0.1	0	0.09	0.00	0.09	6.858	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:30	0.2	0	0.19	0.00	0.19	6.951	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 11:35	0.2	0	0.19	0.00	0.19	7.137	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 11:40	0.1	0	0.09	0.00	0.09	7.323	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:45	0	0	0.00	0.00	0.00	7.416	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 11:50	0.1	0	0.09	0.00	0.09	7.416	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:55	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:00	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:05	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:10	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:15	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:20	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:25	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:30	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:35	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:40	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:45	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:50	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:55	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:00	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:05	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:10	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:15	0.1	0	0.09	0.00	0.09	7.509	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:20	0	0	0.00	0.00	0.00	7.602	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:25	0.1	0	0.09	0.00	0.09	7.602	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:30	0.1	0	0.09	0.00	0.09	7.695	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:35	0.1	0	0.09	0.00	0.09	7.788	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:40	0.1	0	0.09	0.00	0.09	7.881	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:45	0.2	0	0.19	0.00	0.19	7.974	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 13:50	0.1	0	0.09	0.00	0.09	8.16	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:55	0.1	0	0.09	0.00	0.09	8.253	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:00	0.1	0	0.09	0.00	0.09	8.346	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:05	0.1	0	0.09	0.00	0.09	8.439	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:10	0.1	0	0.09	0.00	0.09	8.532	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:15	0.1	0	0.09	0.00	0.09	8.625	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:20	0.1	0	0.09	0.00	0.09	8.718	0.00	0.09	0.0930	0.00	0.00	0.00

Fill in RED text

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	0
2	Feb	28	0
3	Mar	31	0
4	Apr	30	38.82
5	May	31	59.39
6	Jun	30	82.51
7	Jul	31	95.89
8	Aug	31	89.54
9	Sep	30	67.67
10	Oct	31	44.54
11	Nov	30	29.93
12	Dec	31	0

03/02/2017 14:55	1322.024306	days
17/09/2020 15:30	3270.700	mm
	3.621984399	
	903.0132767	mm/yr average

			Precip (mm)	Kitchener ETO
Month				
2	07/02/2017 11:15	0.1	0	
2	07/02/2017 11:20	0	0	
2	07/02/2017 11:25	0.1	0	
2	07/02/2017 11:30	0.2	0	
2	07/02/2017 11:35	0.2	0	
2	07/02/2017 11:40	0.1	0	
2	07/02/2017 11:45	0	0	
2	07/02/2017 11:50	0.1	0	
2	07/02/2017 11:55	0	0	
2	07/02/2017 12:00	0	0	
2	07/02/2017 12:05	0	0	
2	07/02/2017 12:10	0	0	
2	07/02/2017 12:15	0	0	
2	07/02/2017 12:20	0	0	
2	07/02/2017 12:25	0	0	
2	07/02/2017 12:30	0	0	
2	07/02/2017 12:35	0	0	
2	07/02/2017 12:40	0	0	
2	07/02/2017 12:45	0	0	
2	07/02/2017 12:50	0	0	
2	07/02/2017 12:55	0	0	
2	07/02/2017 13:00	0	0	
2	07/02/2017 13:05	0	0	
2	07/02/2017 13:10	0	0	
2	07/02/2017 13:15	0.1	0	
2	07/02/2017 13:20	0	0	
2	07/02/2017 13:25	0.1	0	
2	07/02/2017 13:30	0.1	0	
2	07/02/2017 13:35	0.1	0	
2	07/02/2017 13:40	0.1	0	
2	07/02/2017 13:45	0.2	0	
2	07/02/2017 13:50	0.1	0	
2	07/02/2017 13:55	0.1	0	
2	07/02/2017 14:00	0.1	0	
2	07/02/2017 14:05	0.1	0	
2	07/02/2017 14:10	0.1	0	
2	07/02/2017 14:15	0.1	0	
2	07/02/2017 14:20	0.1	0	

Lawns		
Impervious Area To Lawn	710	sq.m
Lawn Area	470	sq.m
Total area:	1180	sq.m
Subsoil exfil. rate:	1	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	16	mm/hr
Soil wilt point vol:	7.1	cu.m
Soil porosity vol:	24.7	cu.m
Soil field cap vol:	10.6	cu.m
Soil initial vol:	7.1	cu.m
I/P	2	

Summary	Lawns	Total	
Total evaporation	1353.8	1353.8	
Total exfiltration	1522.2	1522.2	
Total drainflow	0.0	0.0	
Total runoff	799.1	799.1	
Total Reused			
Sum	3675.1	3675.1	
Total rainfall	3675.1	3675.1	
% Treated	78%	78%	
% untreated	22%	22%	
% Captured	78%	78%	
EIA	22%	22%	
Infiltration	41%	374.03	mm/yr
Evapouration	37%	332.63	mm/yr

Lawns

All in cubic metres

Rain Water onto pervious	Unsaturated Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to GW	Water that does not exfiltrate	Water that Stays in Soil	beginning water that runsoff	Total Runoff	Evaporation
		0		0	0	0	0	0	0
0.118	0	0.118	7.64	0	0.118	0.1180	0	0	0
0	0	0	7.758	0	0	0.0000	0	0	0
0.118	0	0.118	7.758	0	0.118	0.1180	0	0	0
0.236	0	0.236	7.876	0	0.236	0.2360	0	0	0
0.236	0	0.236	8.112	0	0.236	0.2360	0	0	0
0.118	0	0.118	8.348	0	0.118	0.1180	0	0	0
0	0	0	8.466	0	0	0.0000	0	0	0
0.118	0	0.118	8.466	0	0.118	0.1180	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0.118	0	0.118	8.584	0	0.118	0.1180	0	0	0
0	0	0	8.702	0	0	0.0000	0	0	0
0.118	0	0.118	8.702	0	0.118	0.1180	0	0	0
0.118	0	0.118	8.82	0	0.118	0.1180	0	0	0
0.118	0	0.118	8.938	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.056	0	0.118	0.1180	0	0	0
0.236	0	0.236	9.174	0	0.236	0.2360	0	0	0
0.118	0	0.118	9.41	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.528	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.646	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.764	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.882	0	0.118	0.1180	0	0	0
0.118	0	0.118	10	0	0.118	0.1180	0	0	0
0.118	0	0.118	10.118	0	0.118	0.1180	0	0	0