WEST WATERLOO, WESTHILL DISTRICT NORTH/SOUTH COLLECTOR ROAD

Technical Memorandums

Project Location:
Ira Needles Boulevard & Erb Street
City of Waterloo

Prepared for:
Westhill Land Owners

Prepared by:
MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, ON N2B 3X9

December 4, 2018

MTE File No.: 34280-101



TECHNICAL MEMORANDUMS

The following MTE Technical Memorandums dated December 4, 2018 are included in this document under the following Tabs.

TAB 1 - Erb Street Pond Chronology

TAB 2 - Hydrogeological Assessment

TAB 3 - Surface Water Monitoring

TAB 4 - Technical Design Overview

TAB 5 - Municipal Services and Utilities

TAB 6 – Stormwater Management Alternatives Considered

TAB 1

TECHNICAL MEMORANDUM

MTE FILE NO.:	C 34280-101
DATE:	December 4, 2018
Prepared By:	Charles Carré, E.I.T.

Re: Erb Street Pond Chronology
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained to complete the existing conditions characterization for the proposed road connection from The Boardwalk extension to the proposed connection between Erb Street West and Ira Needles Boulevard, in the City of Waterloo.

This technical memorandum presents the chronology of historical events that led to the creation of the Erb Street SWM Pond and surrounding wetland features. It is intended to provide additional background information for the historical and existing stormwater management (SWM) strategies for the study area, and is to be considered during the identification, assessment, and determination of an appropriate preferred route alternative for the north south collector road from Thorndale Drive to the proposed connection between Erb Street West. This technical memo provides background information for the assessment of the north south collector road alternatives.

This document draws upon the existing information found in several previous reports and studies completed by public agencies and private developers relating to projects undertaken within the study area. It also catalogues a series of historical aerial photos of the study area in order to establish a timeline as to when the Erb Street Pond began to form.

2.0 STUDY AREA

The proposed WW-WD, NS-CR is located west of Ira Needles Boulevard, in the southwestern portion of the City of Waterloo. The internal private road (The Boardwalk) begins at the south end of the big box commercial development, near the entrance to Walmart. The road continues northwest, through the development, to its current terminus at the north end of the Boardwalk commercial development, at the existing roundabout extension of the municipally owned Thorndale Drive.

The study area is located in the upper reach of the Subwatershed 314 – Laurel Creek Watershed and is owned by a variety of landowners, including; the Region of Waterloo, the City of Waterloo, the INCC Corporation, Hydro One, Home Hardware, and the Cressman family. The study area generally includes a small portion of the Region of Waterloo's Waterloo Landfill at 925 Erb Street West, a small portion of the

Hydro One corridor (south of Erb Street West), the residences at 87, 73, and 65 Ira Needles Boulevard, the Westhill Meadows Golf course at 41 Ira Needles Boulevard, and the Waterloo Commons commercial development at 653-659 Erb Street West. These properties will be herein referred to as the 'Subject Lands'.

3.0 HISTORICAL BACKGROUND

A series of historical aerial photographs of the study area were used to address concerns regarding the timeline of the formation of the Erb Street Pond. It is suspected that the major earthworks associated with the creation of the Region of Waterloo's landfill, located to the west of the pond, are primarily responsible for disturbing the natural stormwater management that occurred at that time.

The photos of the study area between 1930 and 1971 show no presence of any wetland or surface water feature near the location of what is now considered the Erb Street Pond; southwest of the intersection of Erb Street West and Ira Needles Boulevard. Sometime between the years 1971 and 1975, work began on constructing the Region's landfill site. It appears that the earthworks associated with this construction began to disturb existing drainage paths as well as increase the runoff generated on the previously farmed lands; which would have otherwise absorbed a majority of the annual precipitation. An aerial photo from 1975 demonstrates significant ponding near the Erb Street Pond location. It appears that the pond began to collect surface runoff from the Region's landfill site and the surrounding areas south of Erb Street where other work was being done.

Historically, the properties between 101 Ira Needles Boulevard and Erb Street, which encompass the study area, included multiple topographic low lying depressions with no natural surface runoff outfalls. Following rainfall events, surface water would collect in these depressions and would eventually infiltrate back into the ground. In order to prevent surface water from ponding on their properties, the land owners collectively installed a 250mm diameter underground clay tile drain through the properties to drain the excess surface and sub-surface water. The drain was installed in two sections; the first in the 1930s and the second in the 1950s. The completed drain was installed from just south of what is now Westhill Meadows Golf Course and extended north, well beyond Erb Street West. Before major development was undertaken in the area, the drain would outlet into a channel on the north side of Erb Street West and be conveyed north to Clair Creek. Based on the land owners' testimonies, the installation of the tile drain significantly improved the drainage situation on their properties.

In the spring of 1996, construction of the Westhill Meadows Golf Course began. The golf course property, 41 Ira Needles Boulevard, was significantly graded and reshaped during this time. Based on the adjacent land owners' testimonies, the contractor used heavy equipment to move large quantities of soil (approximately 14,000m^3 of soil was used to construct the golf course. Unfortunately, much of the grading work was done during rainy days, where the heavy equipment often sank deep into mud. Per their testimonies, the adjacent landowners tried to have the contractor alter the equipment operations for fear of having the underground tile drain become damaged or destroyed. However, their pleas were neglected. Soon after completion of the golf course, the homeowners to the south started noticing significant surface ponding on their properties. This ponded water would last for several weeks, rather than the usual days it took to drain a significant rainfall event in prior years.

As a result, the City of Waterloo required the owner of the golf course to install a drainage ditch across the course. The course's consultant suggested a 150mm diameter underground pipe that led to an onsite storage pond complete with a control valve. Unfortunately, this system was incorrectly installed at elevations

that could only collect surface water. The golf course drain could not properly drain the sub-surface water that was causing problems on the neighboring sites; which was previously being adequately drained by the underground clay tile drain. After a series of site visits and investigations into the problem, it was concluded that the previously installed drain must have been damaged or destroyed by the grading activities that took place to construct the golf course.

An investigation into the downstream wetland, what is now considered the Erb Street Pond, suggested that the overall size of the wetland had dramatically increased due to ongoing activities upstream. However, the wetland water level was measured to be approximately 3.0m lower than the surface ponding on the properties south of the golf course.

In May of 1997, the Region/City of Waterloo staff cleaned the area near the culvert installed under Erb Street West; the outlet for the Erb Street Pond. After debris was removed, water was observed to be draining through the culvert; from the south side of Erb Street West to the north side. A new field survey revealed that the surface water elevations on the properties south of Erb Street West had dropped, but not enough to actually dry out the newly formed wetlands. It was therefore concluded that the condition of the Erb Street West culvert would have a minimal impact on drainage of these adjacent properties.

Presently, the wetlands which formed on the properties south of the golf course still exist. The location and condition of the original clay tile drain running underneath the golf course is unknown at this time. However, it is evident by the presence of the wetlands that the tile is not functioning as it was originally designed.

Refer to the appended chronological aerial photography figures for more details.

4.0 SUPPORTING DOCUMENTATION

Laurel Creek Watershed Study (January 1993)

The report concentrates primarily on the Laurel Creek watershed catchment. Referenced in the study is a water quality assessment of Laurel Creek, which was completed in 1973 by the Ministry of the Environment (MOE) (now the Ministry of Environment, Conservation, and Parks). Also referenced are Clair Creek floodline maps, which were prepared in 1981. The study analyses the underlying soils within the watershed and suggests that water quality and quantity controls are imperative throughout the study area to encourage groundwater recharge (infiltration), reduce streamflow erosion, and protect the overall quality of the groundwater baseflow and the water courses.

Laurel Creek Subwatershed 314 Management Plan (October 1996)

This plan concluded that the Erb Street Pond was located in a Constraint Level One Area. An assessment established that the pond received runoff from the landfill area and future development lands south of Erb Street West. This pond provided significant storage (approximately 150,000m^3) before spilling onto Erb Street West. The pond and storm sewer outlet were designed to limit runoff into the Clair Creek tributary, to protect it from things like streamflow erosion. The designed 600mm diameter storm sewer outlet provided 48 hour detention of the 25mm storm. It was strongly suggested that this outlet should be maintained in its existing location and form, or at least be relocated somewhere to achieve the same levels of control. The Plan concluded that it was imperative that the Region of Waterloo, the City of Waterloo, landowners/developers, and the GRCA prepare a management plan for the Erb Street Pond/wetland and maintain it as a significant storage area for stormwater runoff from the areas south of Erb Street West.

Final SWM Report & Scoped Environmental Impact Study: Erb Street Pond (April 2004)

As part of the Ira Needles Boulevard (INB) development project, it was determined that the best SWM strategy for Zone 6 (INB R.O.W. from STA 24+575 to STA 24+960) of the development would be the construction of a SWM facility in conjunction with the existing wetland and pond (Erb Street Pond). The objective of this report was to:

- Secure approval from the Grand River Conservation Authority (GRCA) and the issuance of a Fill Permit;
- Secure approval from the City of Waterloo and serve as basis for future SWM requirements for the adjacent lands that currently drain to the Erb Street Pond; and
- Secure approval from the MOE and the issuance of a certificate of approval of municipal and private sewage works.

Once all the approvals were received, the forebay into the Erb Street Pond was constructed for all upstream lands in the ultimate developed conditions. Revisions were made to the outlet of the pond, which was to be sized to service the entire lands. The existing 600mm diameter CSP culvert was replaced with a 900mm diameter concrete sewer, complete with a 550mm diameter orifice plate.

The design strategy proposed some grading (which provided additional storage) and some additional landscaping around the forebay. It demonstrated that with some excavation of the wetland, grading the SWM facility would provide the quantity and quality controls necessary to service the entire upstream developed conditions. The future needs of the pond upgrades were discussed, but not implemented at this time.

Engineering Report for Proposed Commercial Development, Erb Street & Ira Needles Boulevard (For Rock Developments by Odan Detech, Revised July 10th, 2009)

This report proposed the Erb Street Pond as the principle stormwater management facility to provide quality and quantity control for the proposed development. This development is now known as Waterloo Commons.

Westhill District Plan – Final Stormwater Management Report (January 2011)

MTE was responsible for the design and construction of the regrading of the forebay, similar to the future pond upgrades discussed above in the 2004 EIS. This SWM report proposed that the design of the forebay, and associated pond works, would have to meet the MOE's "Normal" Level 2 water quality control criterion. The proposed SWM quantity control was to have the pond's outlet changed from the 900mm pipe with 550mm diameter orifice plate to a multiple staged outlet. A 220mm diameter round orifice and a 200x1725mm slot orifice was proposed to be installed in a discharge control manhole downstream of the pond. However, this new discharge control structure was never implemented and the outlet remained as is.

Due to ownership issues, no regrading of the wetland was proposed. This report was prepared as an alternative solution to provide the required SWM controls without entering Rock's land to complete the work.

The following is a list of key dates as they relate to the design and implementation of the works proposed in the Final Stormwater Management Report:

- June 23, 2010 – A meeting with the governing agencies. Discussions included buying the wetland from Rock and transferring ownership of the forebay from the Region to the City.
- August 26, 2010 – Original report dated and submitted to the City, the Region, and the GRCA.
- October 8, 2010 – MTE received City comments.
- MTE revised the original report on November 9, 2010 to address the City's comments.
- November 12, 2010 – MTE received Region comments.
- December 10, 2010 – MTE received GRCA comments.
- MTE revised the new report on January 25, 2011 to address the Region's and the GRCA's comments.
- MTE submitted response letters to the comments received by the City, the Region, and the GRCA.
- March 30, 2011 – New comments are received from the GRCA.
- April 7, 2011 – A design brief is created and submitted to the GRCA to address their new comments.
- Aug. 9, 2011 – An addendum is submitted to the City, the Region, and the GRCA to address all the revisions that have taken place since the original report submission.
- Oct. 13, 2011 – The GRCA provides MTE with an approval letter for the proposed works.

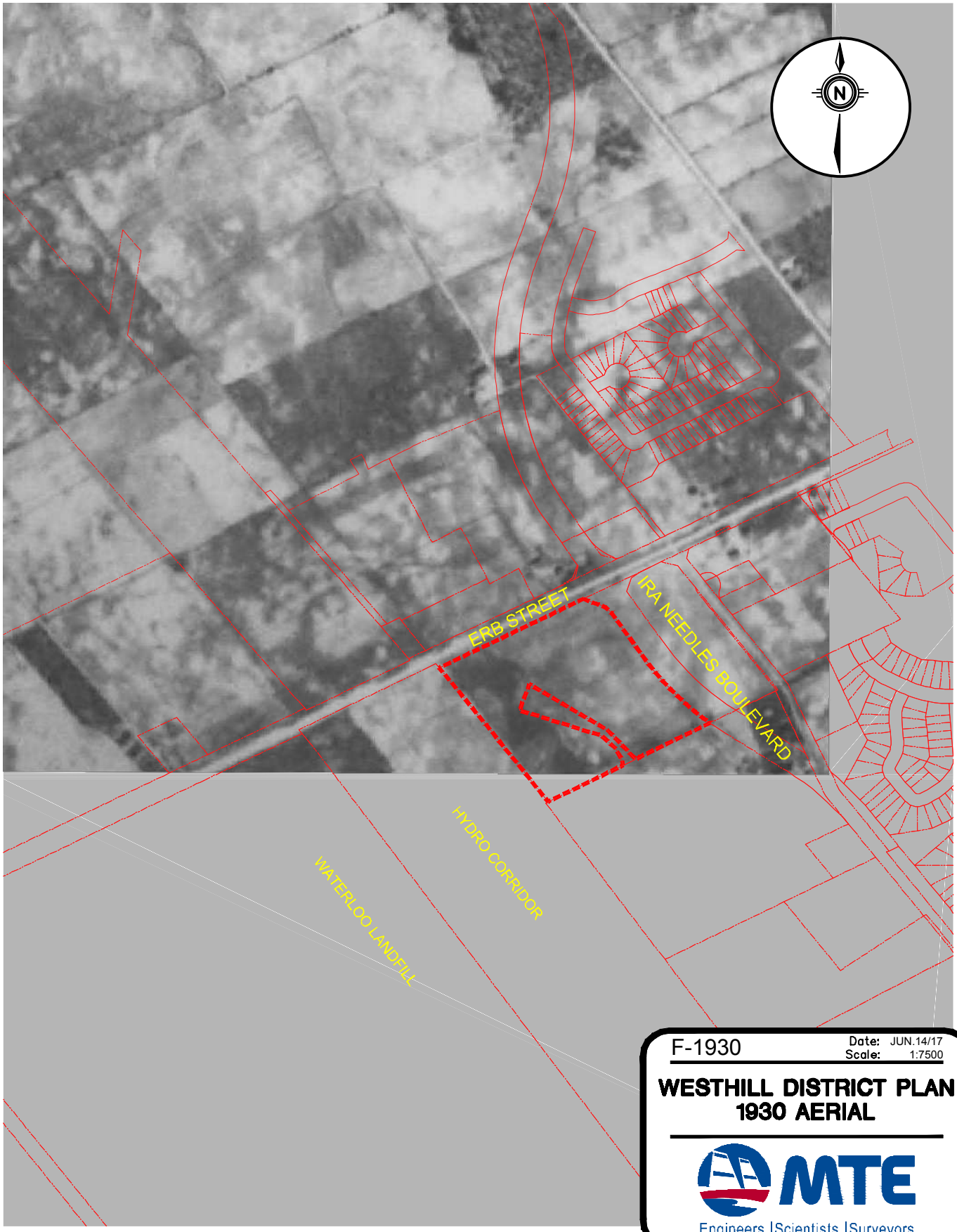
5.0 CONCLUSIONS

Based on the analysis of the chronology of historical events that led to the creation of the Erb Street Pond and surrounding wetland features, the following conclusions are provided:

1. Based on historical aerial photography, it appears that the formation of the Erb Street Pond began between the years 1971 and 1975, which coincides with start date of the construction work on the adjacent Region of Waterloo's landfill site.

2. Works related to the construction of the Westhill Meadows Golf Course in 1996 appears to have damaged or destroyed an existing tile drain, which was installed by adjacent landowners, throughout the study area. This drain was originally installed to eliminate ponding surface water on the adjacent sites. However, due to it being damaged, permanent wetland features began to appear throughout the properties south (upstream) of the Erb Street Pond.

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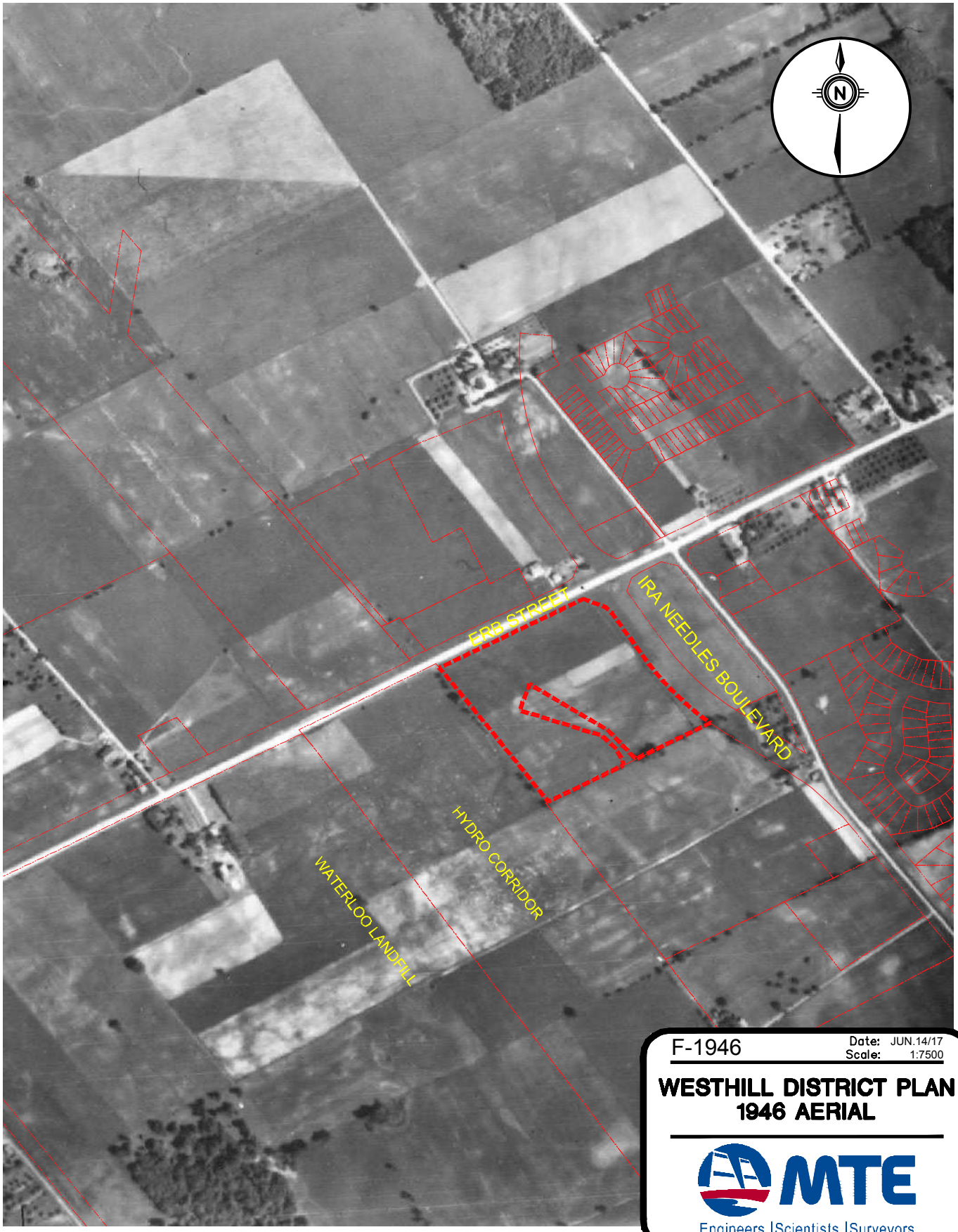
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1930 AERIAL

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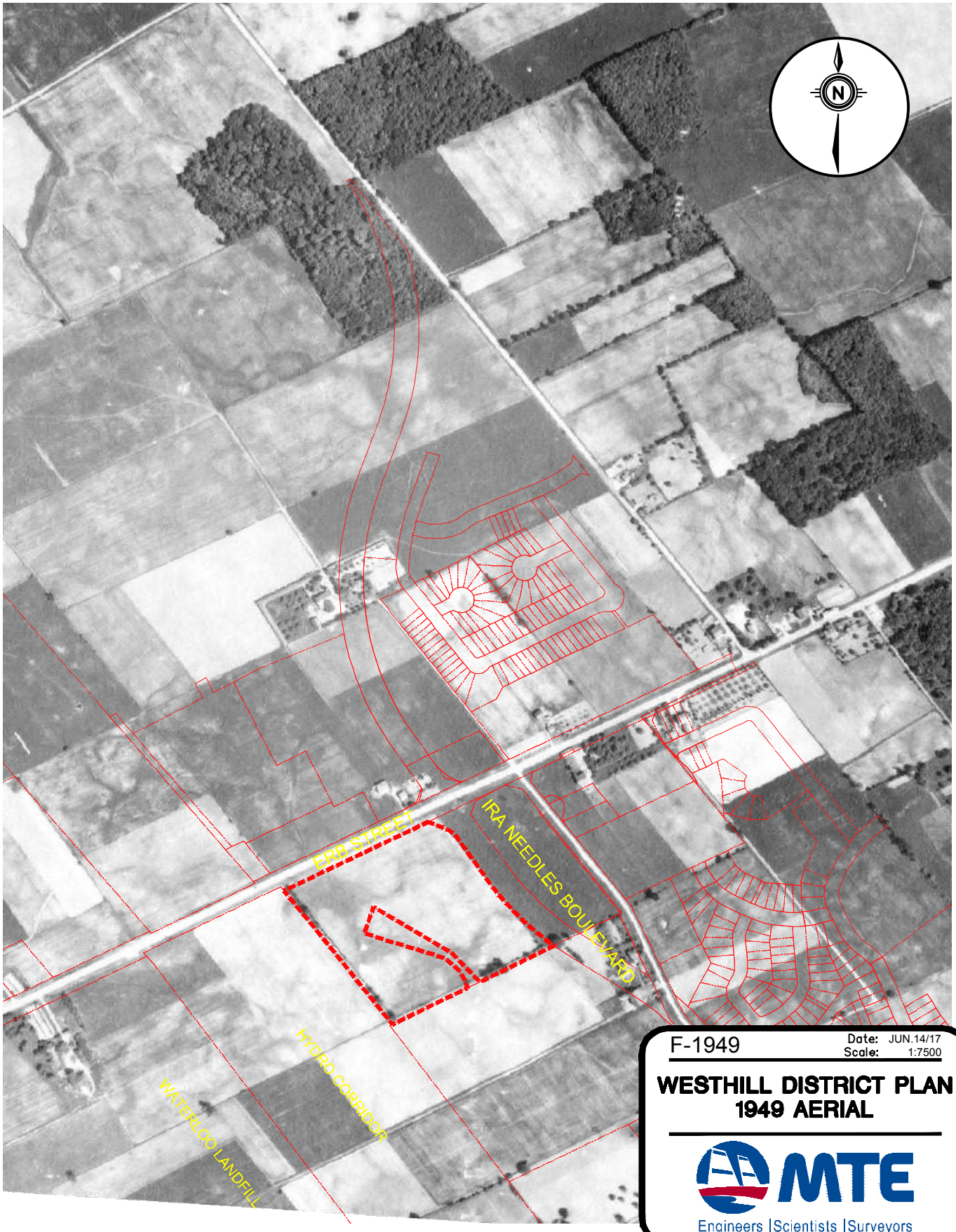
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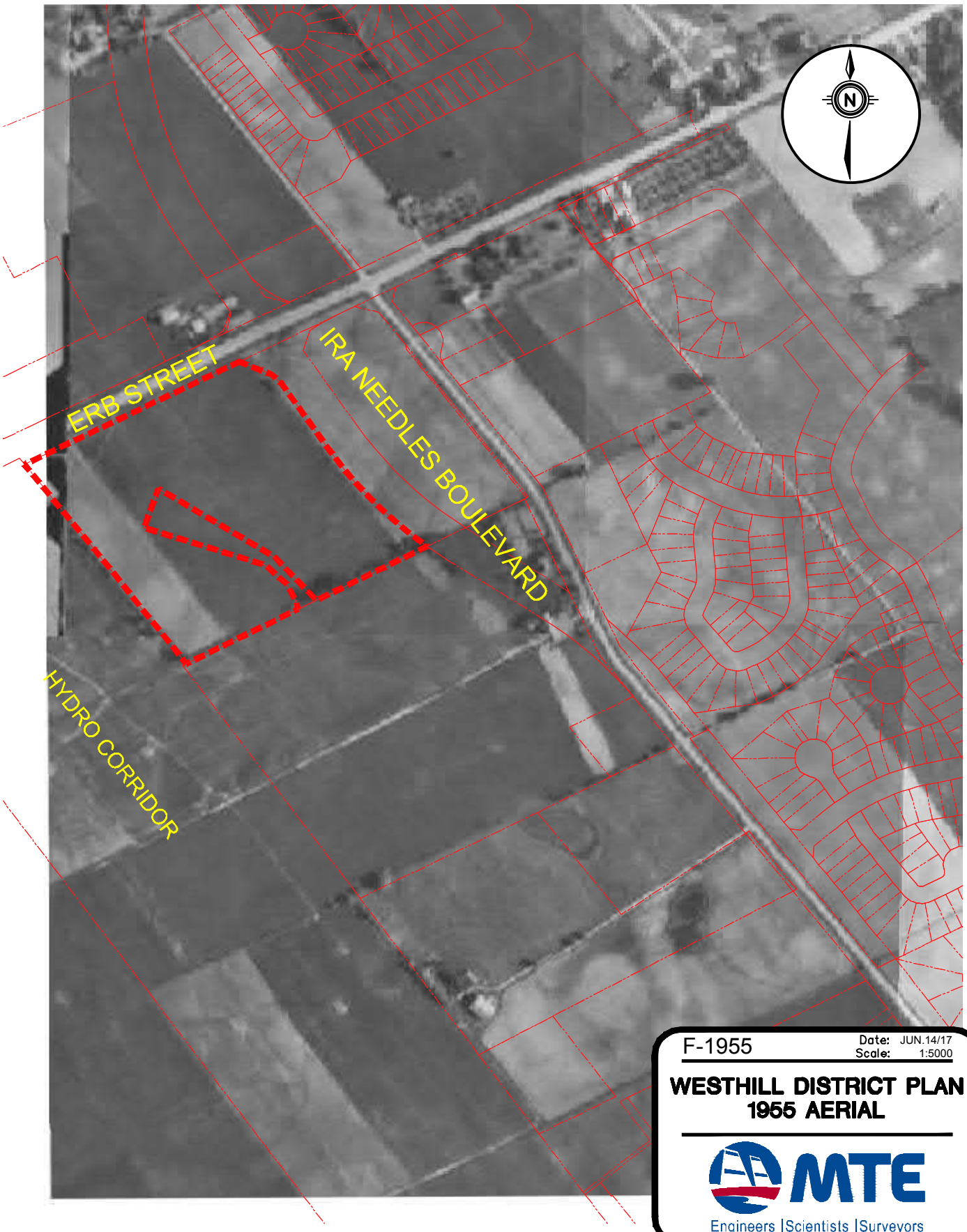
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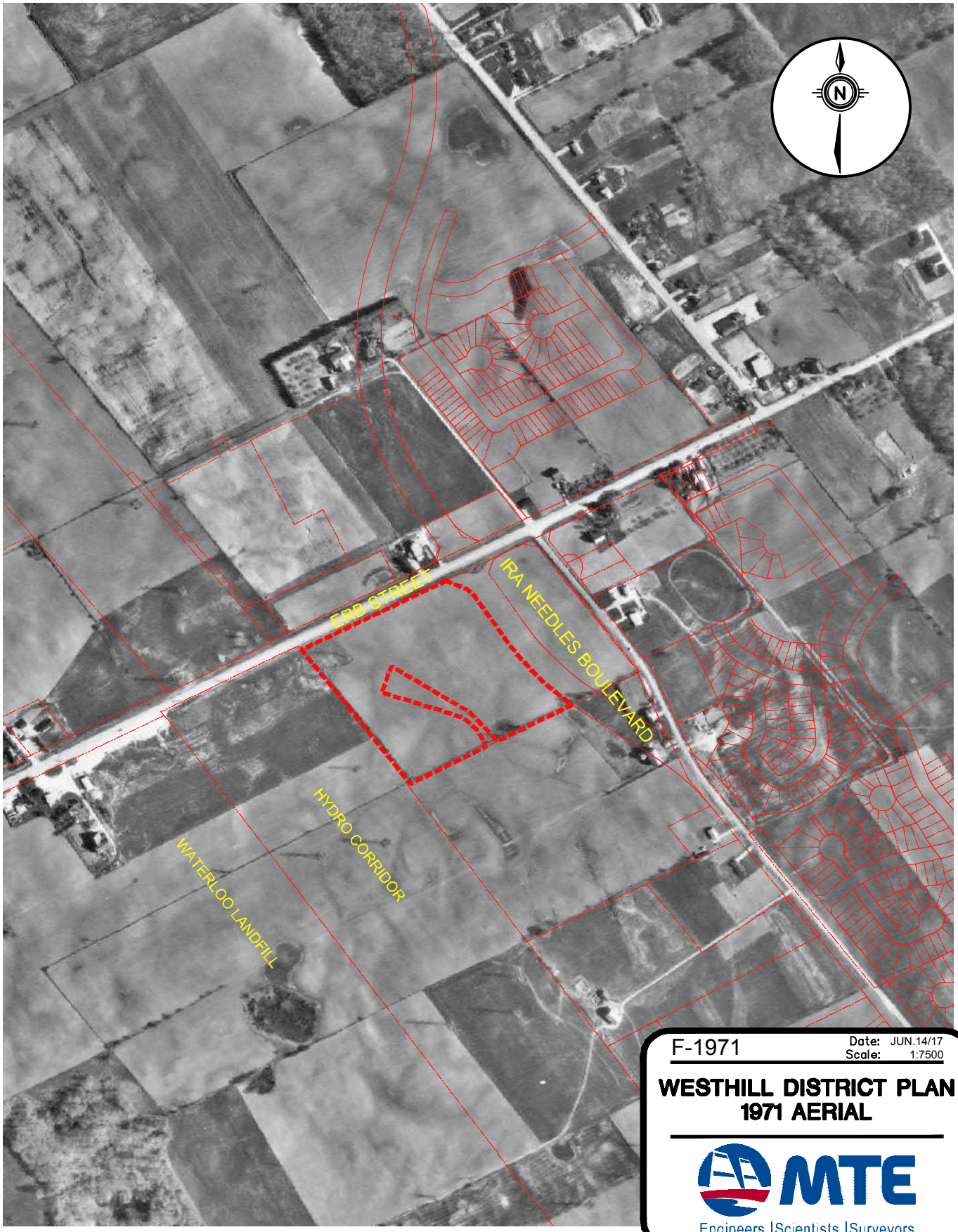
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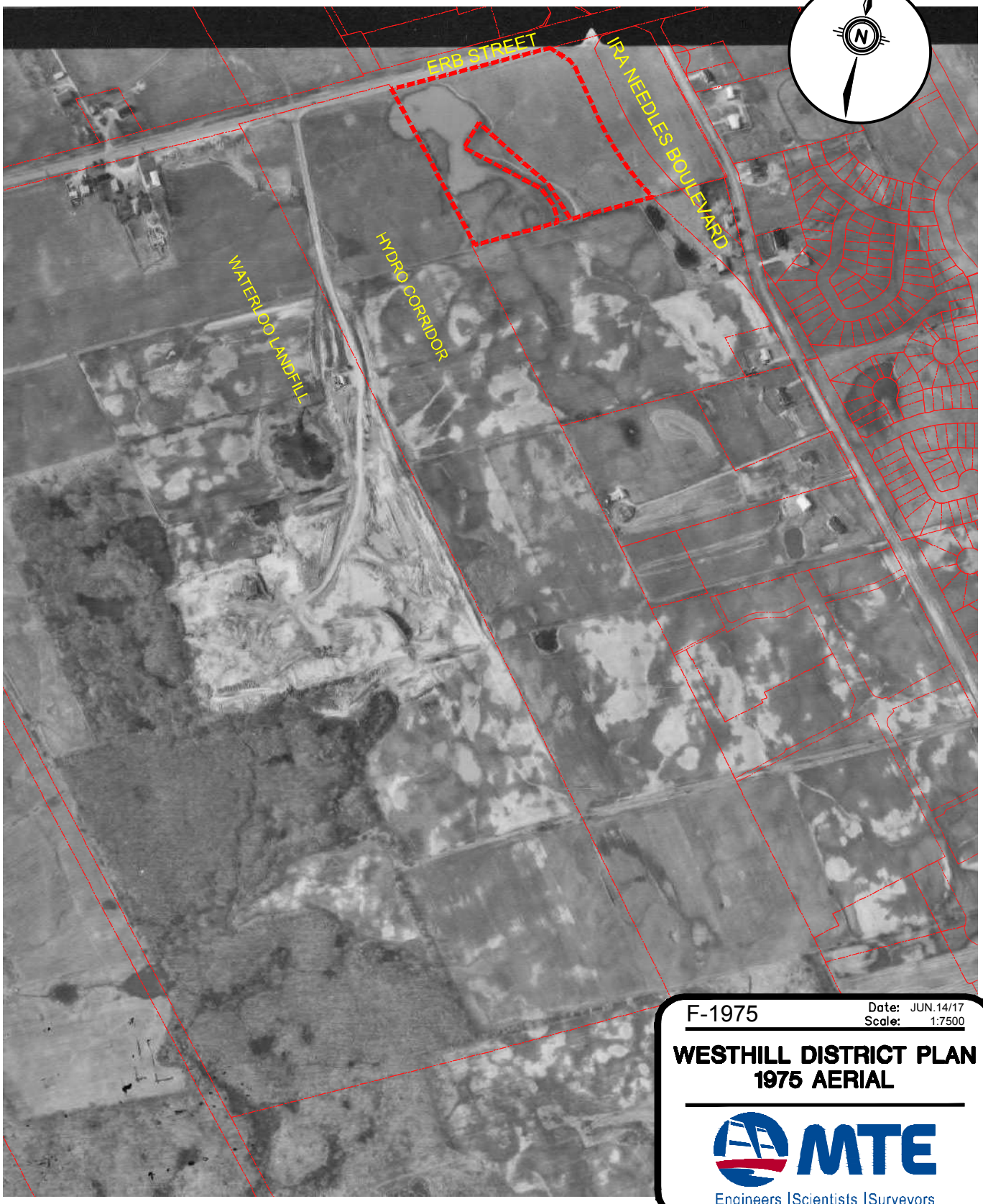
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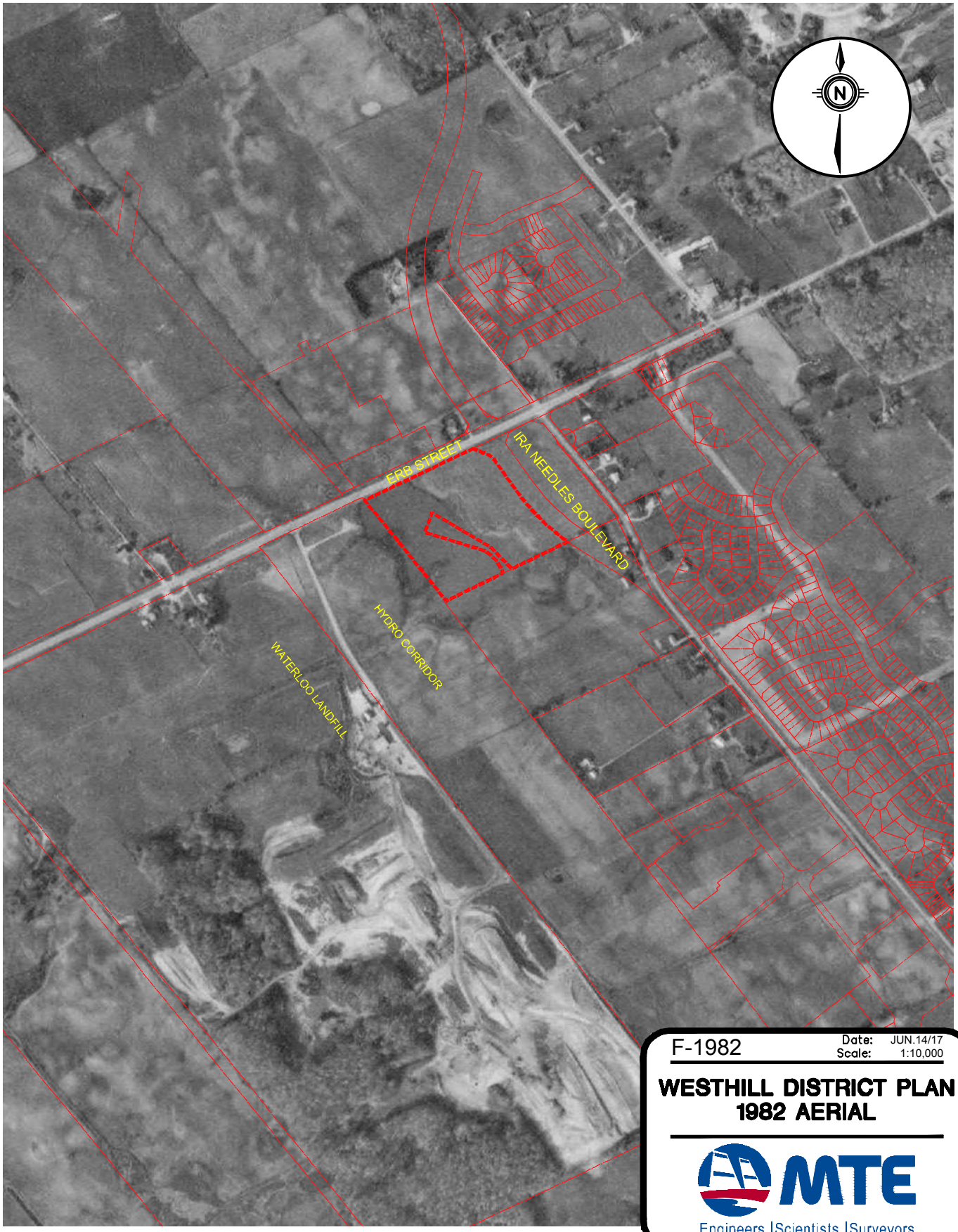
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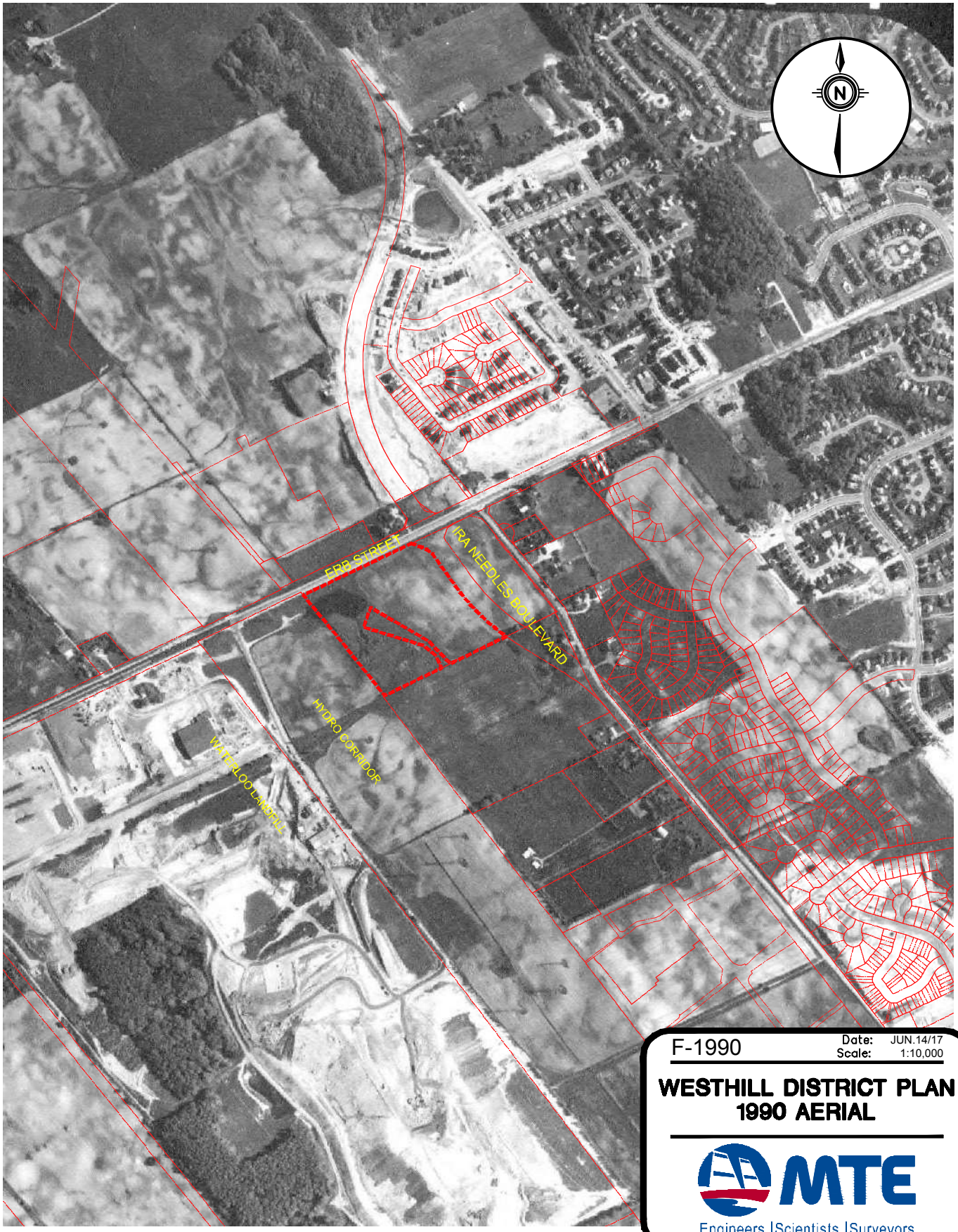
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1982 AERIAL

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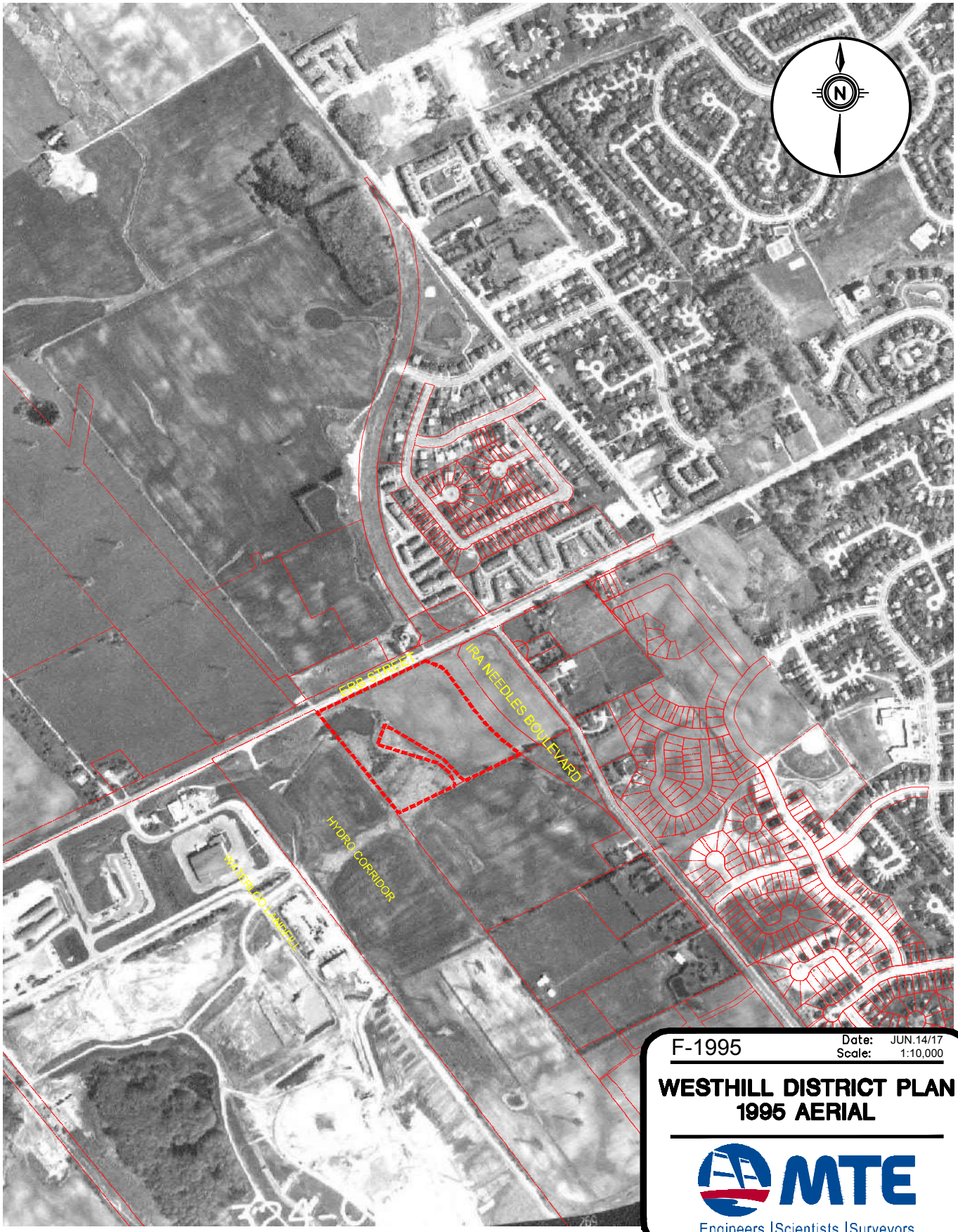
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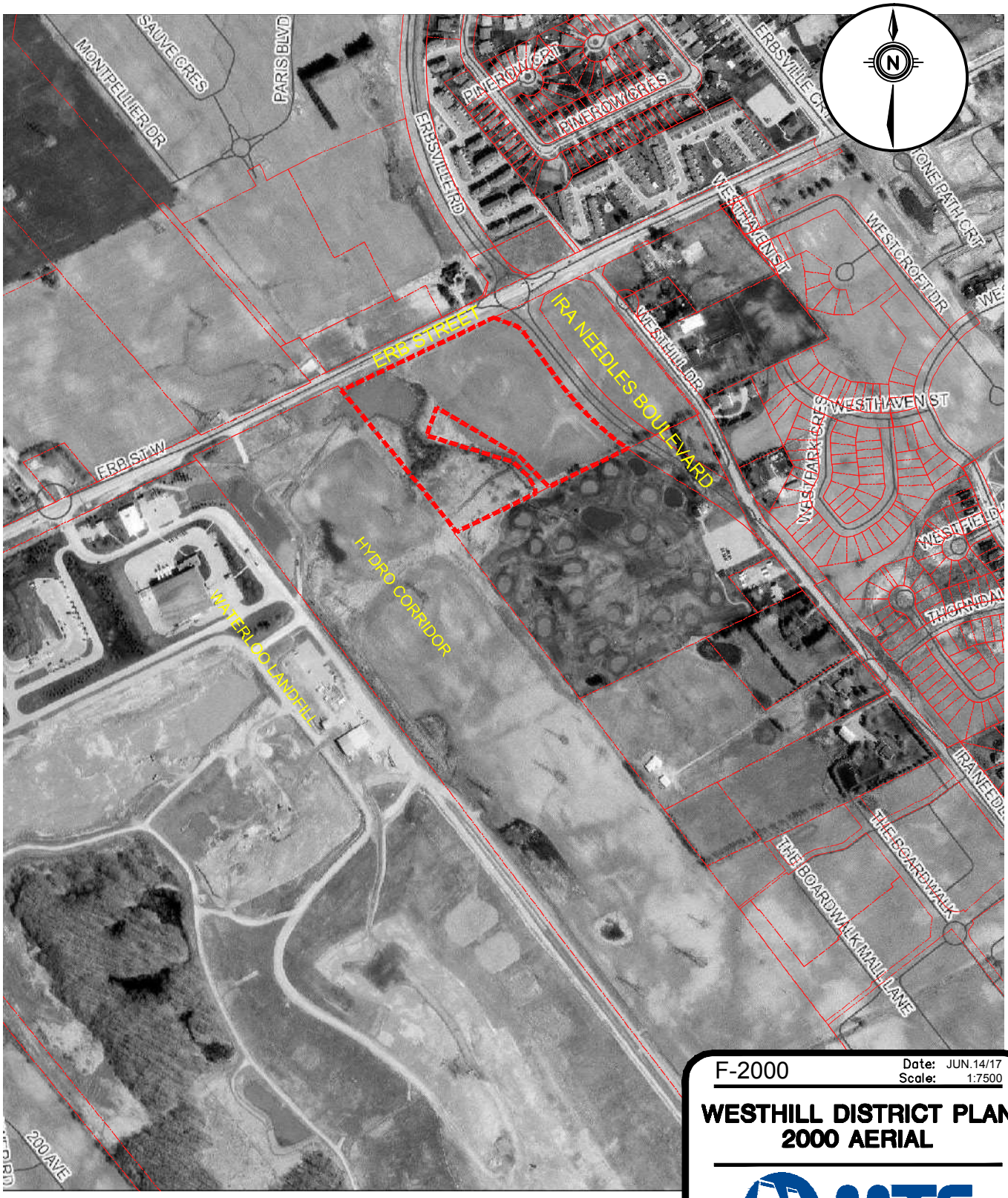
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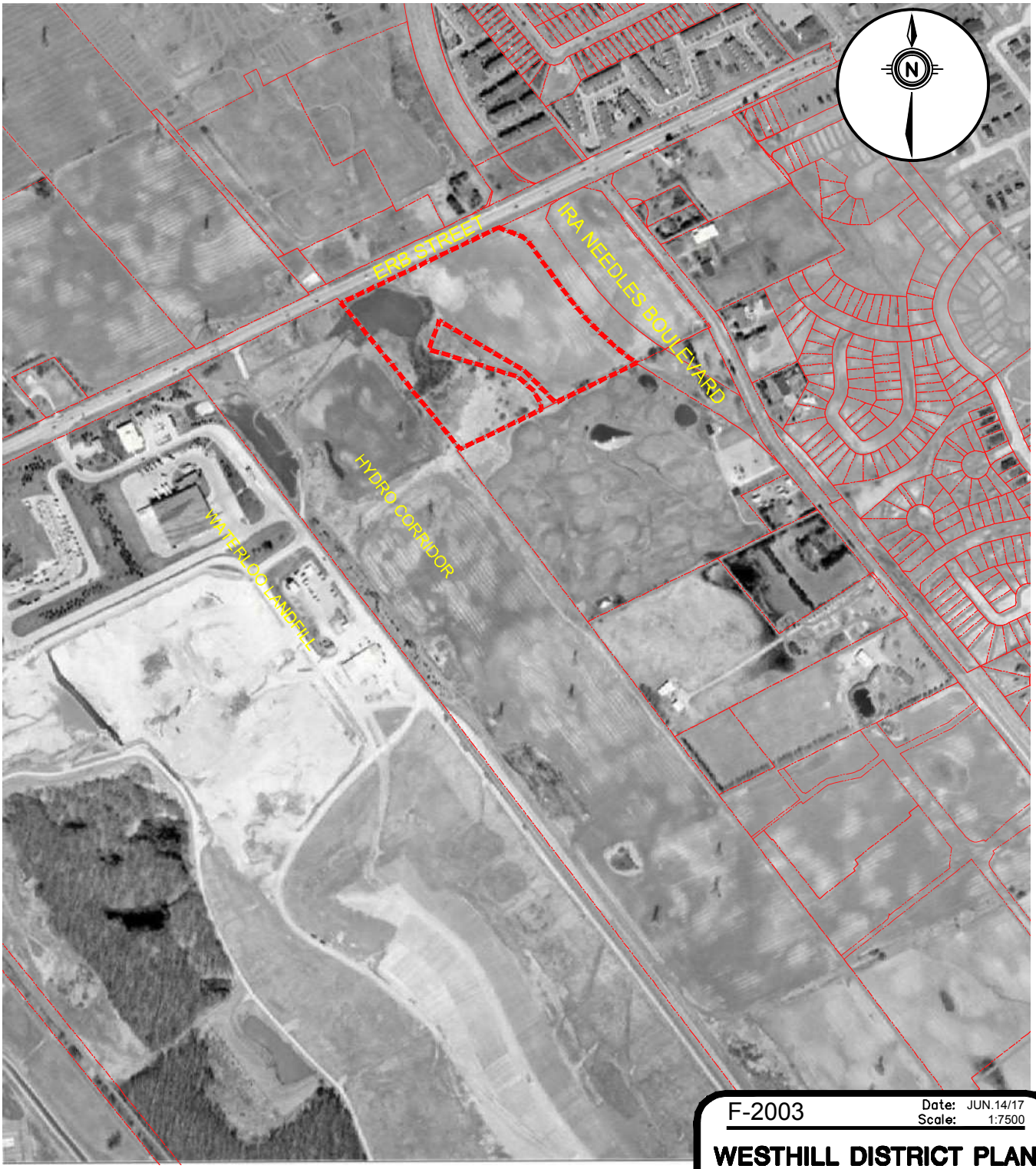
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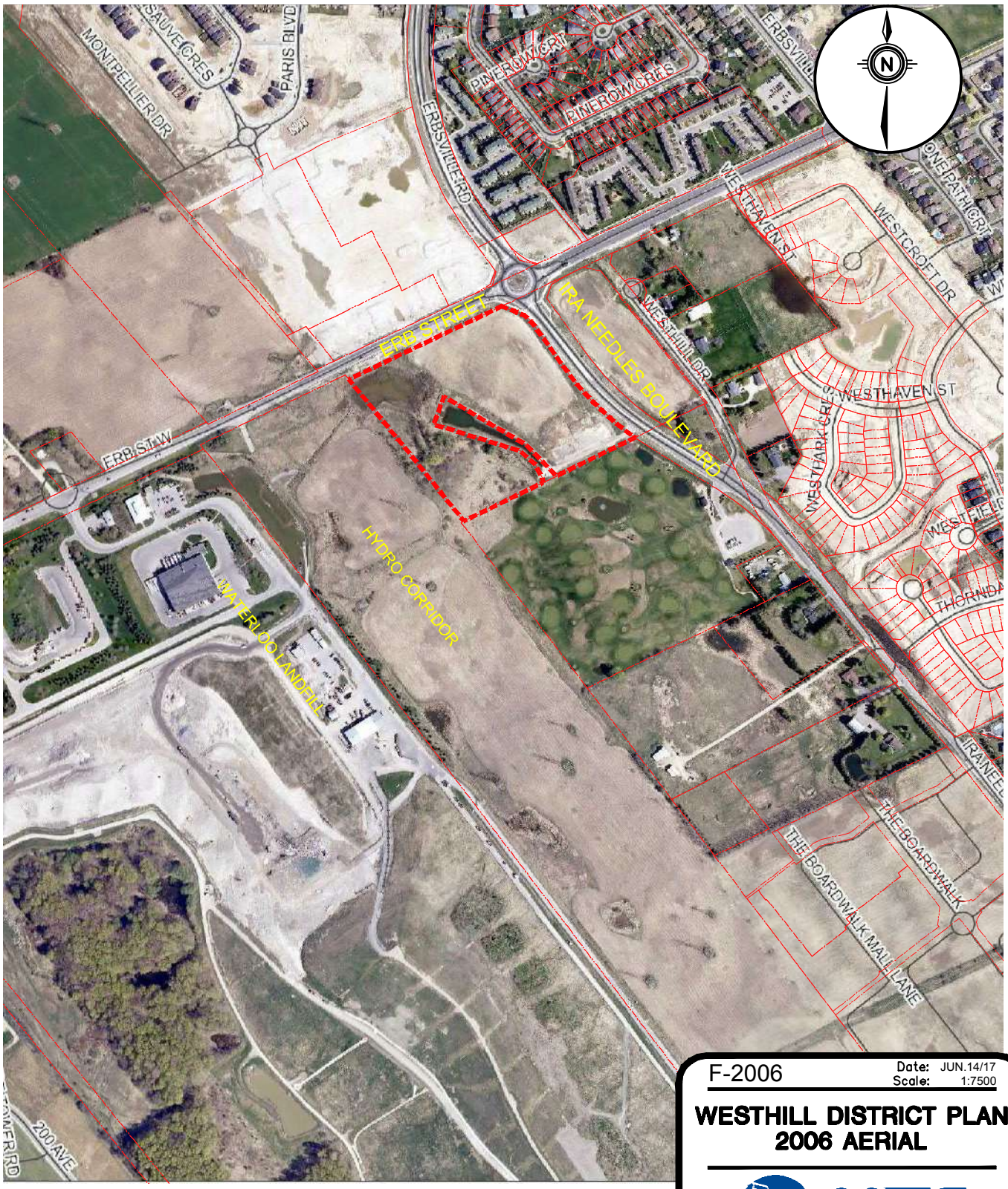
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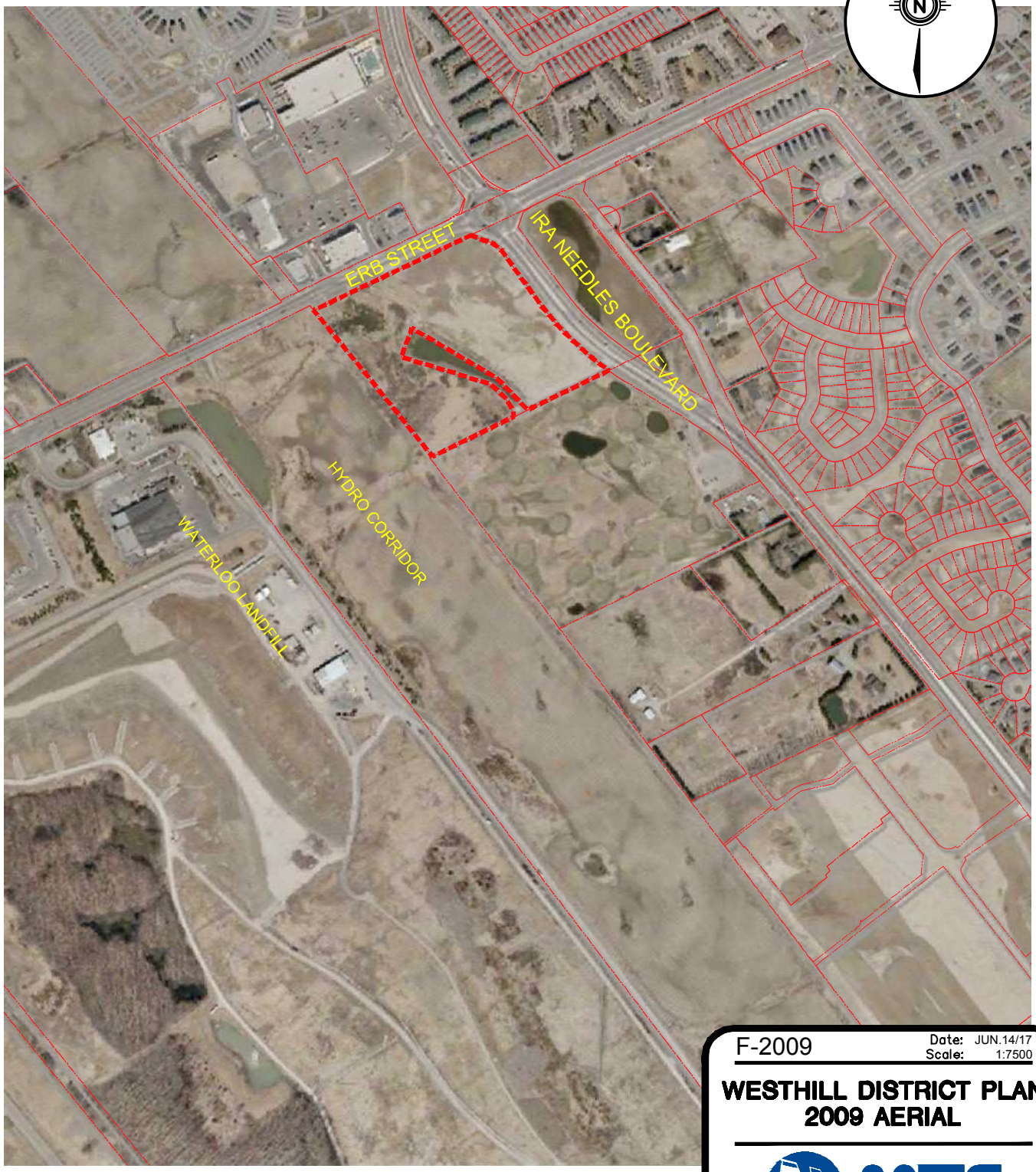
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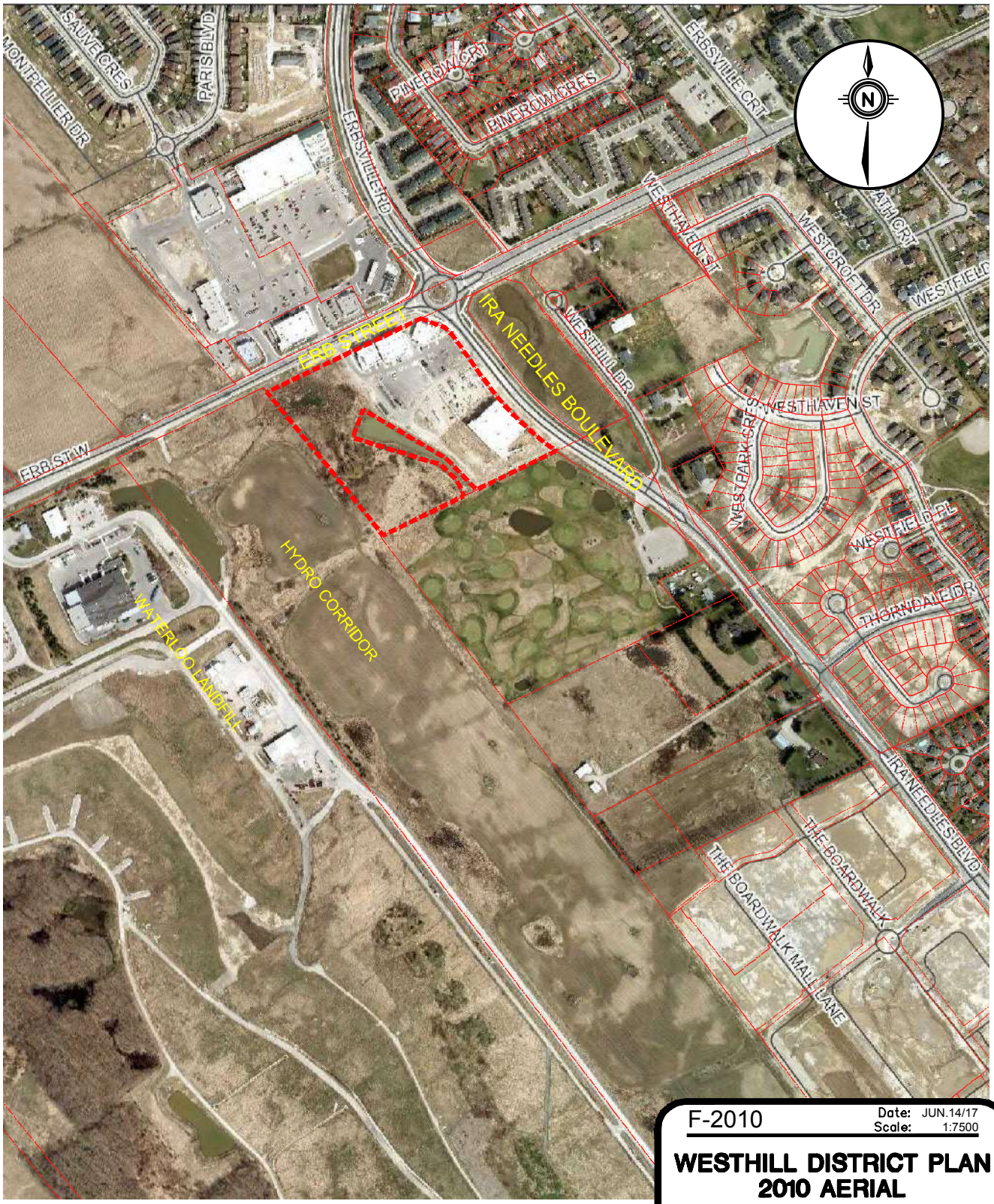
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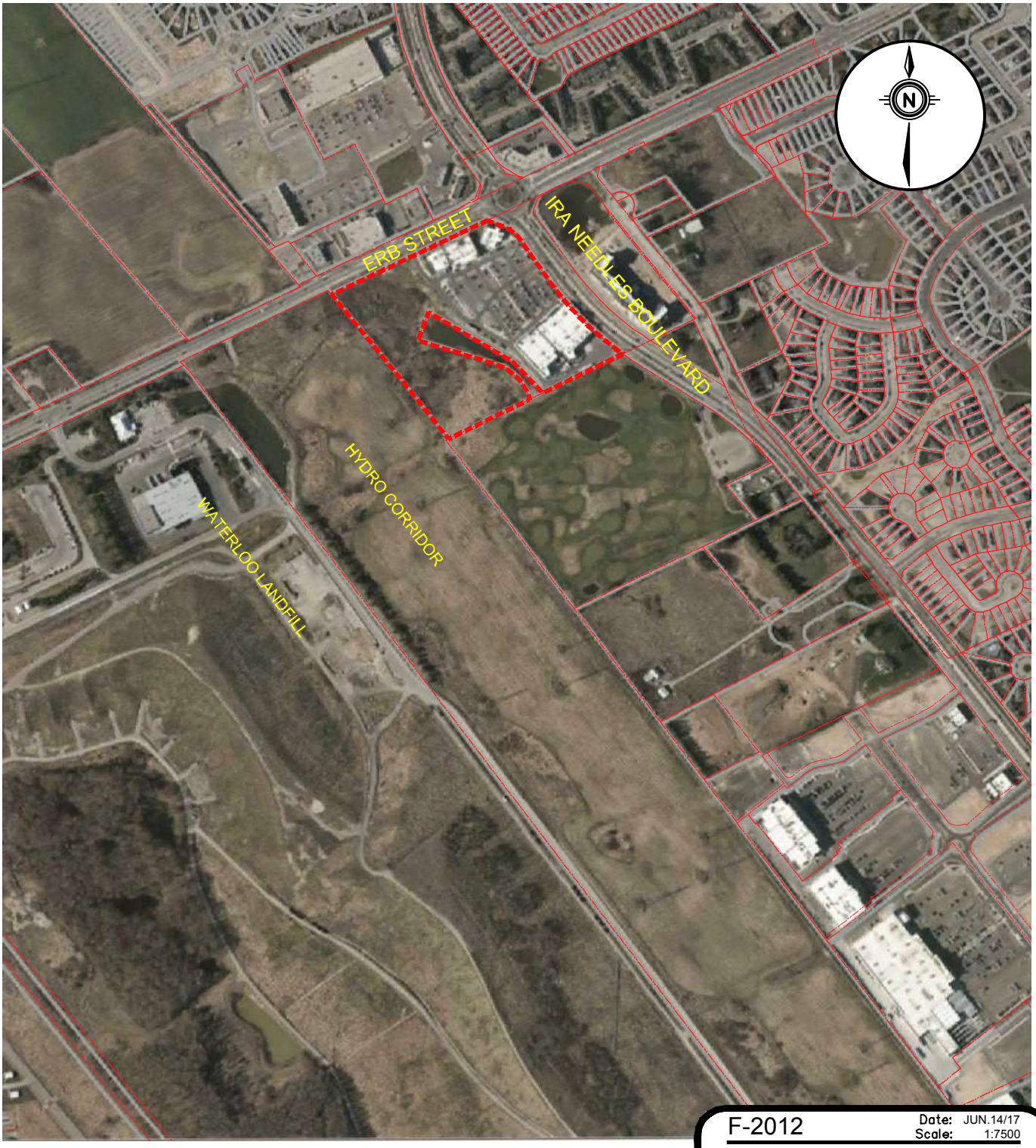
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F-2012

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WESTHILL DISTRICT PLAN
2012 AERIAL

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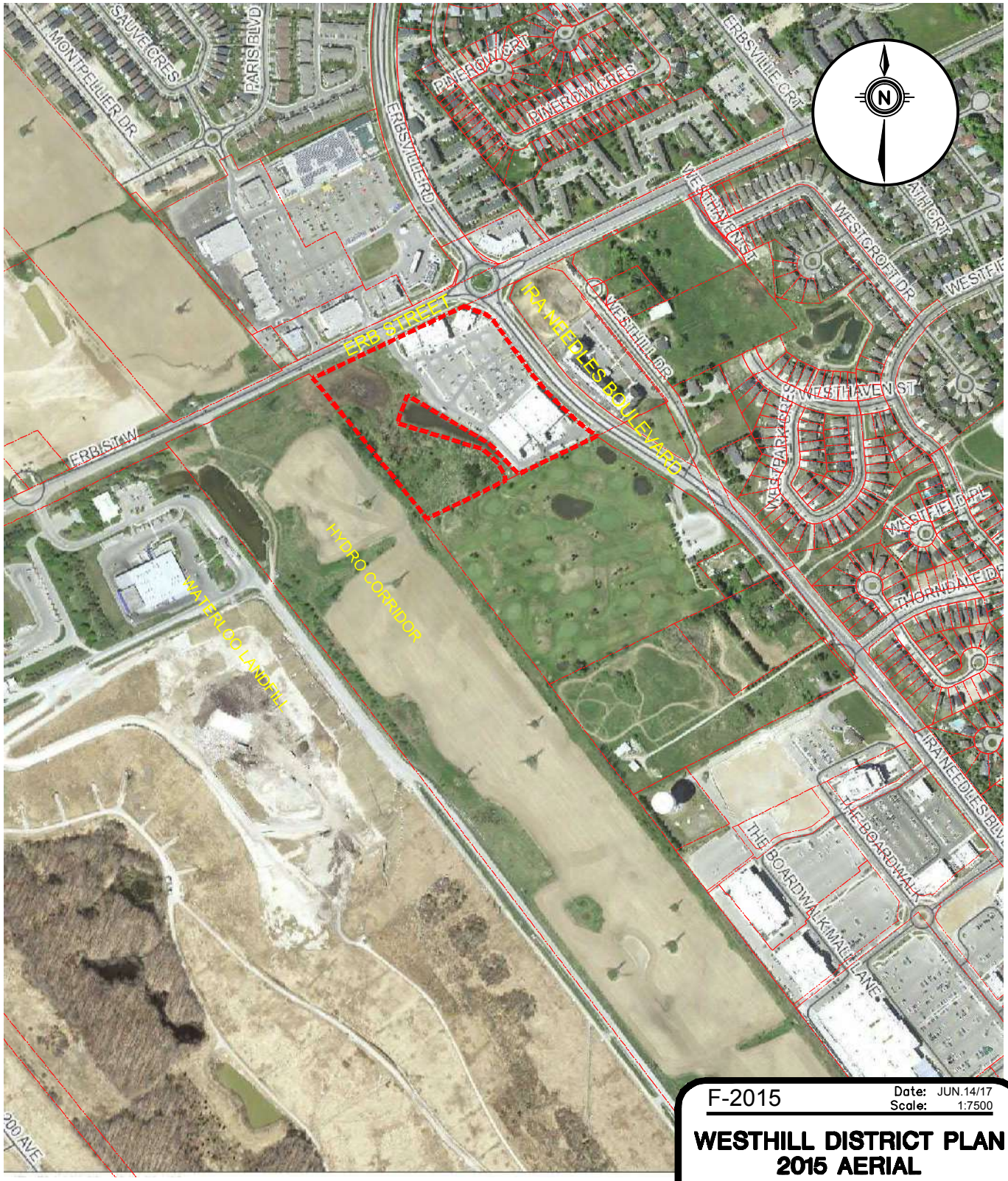
WESTHILL DISTRICT PLAN
2014 AERIAL

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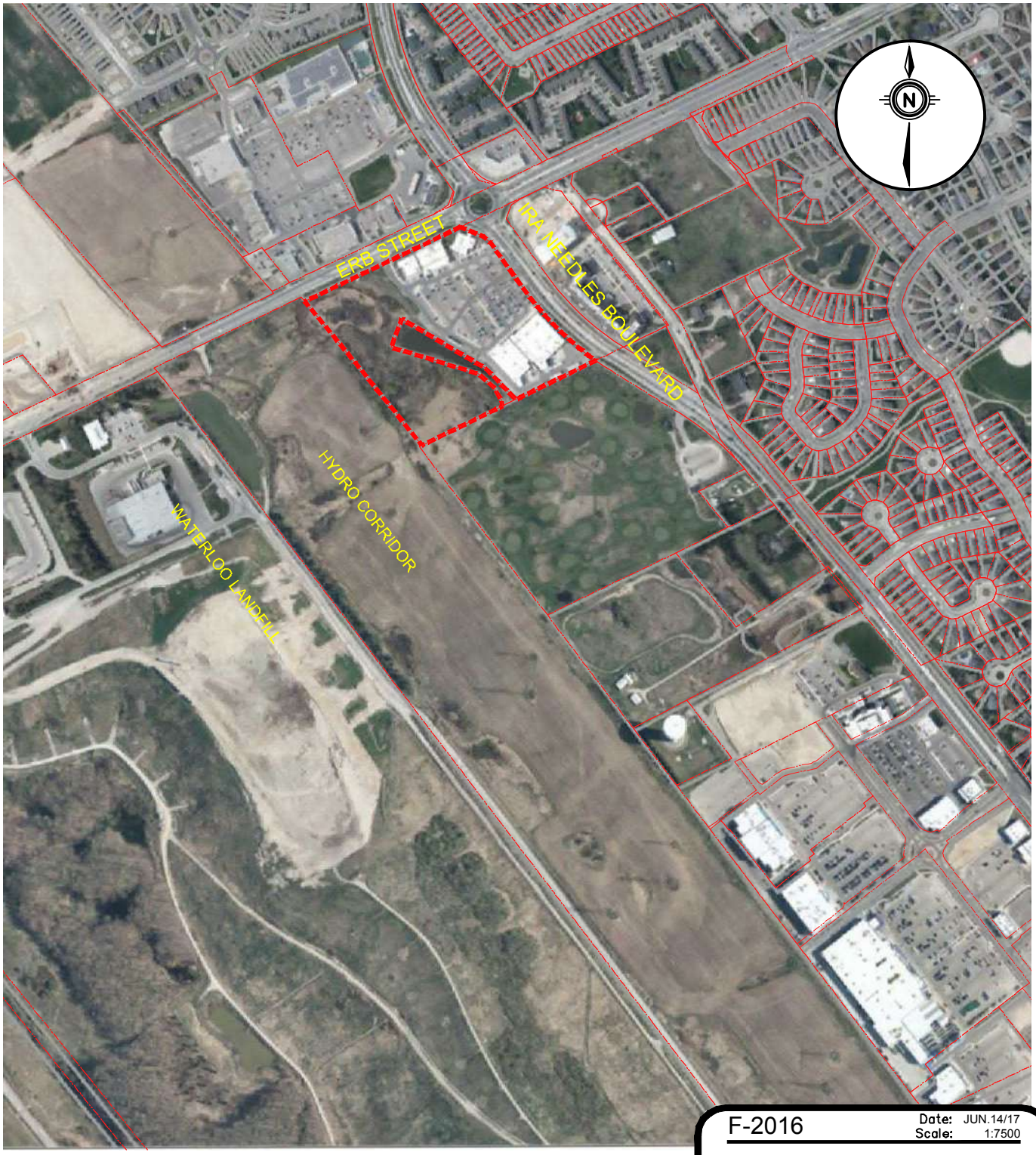
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2015 AERIAL

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WESTHILL DISTRICT PLAN
2016 AERIAL

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F-2017

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WESTHILL DISTRICT PLAN
2017 AERIAL

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TAB 2

TECHNICAL MEMORANDUM

MTE FILE NO.: C 34280-101
DATE: December 4, 2018
Prepared By: Farouk Abu-Hijleh, E.I.T.

Re: Hydrogeological Assessment
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained to complete the hydrogeological characterization and assessment of properties associated with the proposed road connection from The Boardwalk extension to the proposed connection between Erb Street West and Ira Needles Boulevard, in the City of Waterloo.

This technical memorandum aims to characterize and assess the geological and hydrogeological conditions within the study area for the Erb Street Connection. Information provided in this document is to be considered during the identification, assessment, and determination of an appropriate preferred route alternative for the north south collector road from Thorndale Drive to Erb Street. This study satisfies the requirements of the hydrogeological characterization for the assessment of alternatives for the north south collector road.

This memorandum should be read in conjunction with the following documents prepared and submitted by MTE for the Subject Lands:

- Erb Street Pond Chronology – WW-WD, NS-CR (MTE, 2018)
- Municipal Services and Utilities – WW-WD, NS-CR (MTE, 2018)
- Surface Water Monitoring – WW-WD, NS-CR (MTE, 2018)
- Technical Design Overview – WW-WD, NS-CR (MTE, 2018)
- Stormwater Management Strategy - WW-WD, NS-CR (MTE, 2018)

1.1 Study Area

The proposed WW-WD, NS-CR is located in southwest Waterloo, west of Ira Needles Boulevard, in the City of Waterloo. The proposed road extension is understood to include the following properties:

- 41, 65, 73, and 87 Ira Needles Boulevard;
- 651 and 663 Erb Street West (Waterloo Commons); and
- Part of Lots 39, 40, and 41 of the German Company Tract (Hydro One Corridor).

The above mentioned properties are herein referred to as the "Subject Lands" for the purposes of this memorandum. **Figure 1** illustrates the Subject Lands Key Map. The Study Area further includes a portion of the Region of Waterloo's Landfill located at 925 Erb Street West. **Figure 2a** and **Figure 2b** illustrate the boundaries of the Study Area and features considered for this hydrogeological assessment.

2.0 SCOPE AND METHODOLOGY

A scoped hydrogeological investigation was completed for the Study Area. The objective of the scoped hydrogeological investigation is to identify and evaluate the hydrogeological features located with the Study Area. More specifically, this investigation aims to:

- Assess the local and regional hydrogeological characteristics;
- Determine local surface water and groundwater elevations; and
- Assess local wetland and groundwater interactions across the Subject Lands.

In order to meet these objectives, the following scope of work was implemented:

1) Site Classification:
    - Review of available published reports relating to Subject Lands.
    - Brief description of Study Area features and existing conditions.
    - Ministry of the Environment, Conservation, and Parks (MECP) well records review.
    - Published Map review:
        - Ontario Base Maps;
        - Quaternary Geology Maps; and
        - Bedrock Geology Maps.
    - Review of interactive online mapping tools:
        - Grand River Conservation Authority (GRCA) Source Water Protection Plan;
        - GRCA Regulation Areas;
        - MECP Source Water Protection Atlas. and
        - Ministry of Natural Resources and Forestry (MNRF) Natural Heritage Areas Map.
2) Field Investigation:
    - Review of select off-Site wells within 500 m of the Site to identify:
        - Neighboring wells;
        - Well depths;
        - Well construction details; and
        - Local geological information.
    - Installation of two shallow groundwater monitoring wells within the Subject Lands.
    - Installation of one mini-piezometer within the Subject Lands.
    - Installation of five surface water piezometers within the Subject Lands.
    - Manual measurement of stabilized surface water and groundwater levels.
    - Grain size analysis of select soil samples.
    - Collection of surface water and groundwater samples to document pre-development water chemistry (to be analyzed for general water quality parameters).
    - Installation of electronic pressure transducers (data loggers) for continuous monitoring of groundwater and surface water levels.

3) Analysis and Reporting:
   - Geologic and hydrogeological summary.
   - Preparation of geological cross-sections through the Subject Lands.
   - Determination of shallow groundwater system properties:
     - Horizontal hydraulic gradient;
     - Average linear groundwater velocity; and
     - Shallow groundwater flow patterns.
   - Assessment of surface water and groundwater interactions associated with wetland features located on the Subject Lands.

3.0 BACKGROUND REVIEW

The following documents relating to the Subject Lands were available for review by MTE staff as part of the hydrogeological assessment:

- Westhill Meadows Golf Course, 41 Ira Needles Boulevard, Waterloo, ON Preliminary Geotechnical Investigation completed by CMT Engineering Inc. (CMT) October 9, 2008;
- Westhill Meadows Golf Course, 41 Ira Needles Boulevard, Waterloo, ON Phase II Environmental Site Assessment completed by MTE October 24, 2008;
- 73 and 86 Ira Needles Boulevard Waterloo, ON Groundwater- Wetland Interaction at Westhill District Plan Update Technical Memorandum completed by MTE January 26, 2011;
- Proposed Kitchener-Waterloo Zone 6 Elevated Tank and Related Services, Geotechnical Investigation completed by Genivar Consultants LP (Genivar) November 11, 2011;
- 87 and 101 Ira Needles Boulevard Waterloo, ON Phase II Environmental Site Assessment completed by MTE January 26, 2016;
- Proposed Thorndale Drive Extension, 87 Ira Needles Boulevard Waterloo, ON Geotechnical Investigation completed by CVD January 27, 2016;
- Proposed Medical Building, 101 Ira Needle Boulevard, Waterloo, ON Geotechnical Investigation completed by Chung and Vander Doelen (CVD) February 10, 2016; and
- Waterloo Commons, 651-663 Erb Street West Waterloo, ON Phase II Environmental Site Assessment completed by MTE April 21, 2017.

Information pertinent to the hydrogeological assessment is briefly summarized below:

Preliminary Geotechnical Investigation - CMT (October 9, 2008)

CMT conducted a preliminary geotechnical investigation of 41 Ira Needles Boulevard, Waterloo, ON. As part of the investigation, five boreholes were advanced (CMT-BH01-08 through to CMT-BH05-08) to depths ranging from 4.9 metres to 7.3 metres below ground surface (mBGS), where ground surface elevations ranged between 378.55 metres and 384.03 metres above mean sea level (mAMSL). One of the five boreholes (CMT-BH01-08) was installed as a monitoring well. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of topsoil atop a layer of loose silty sand fill material, underlain by a clayey silt till, followed by a layer of silty clay. CMT staffed noted the presence of a 0.7 m thick layer of peat, a 0.15 m thick seam of sand, and a 0.1 m thick seam of sand at CMT-BH01-08, CMT-BH02-08, and CMT-BH03-08, respectively. Groundwater was measured to be 0.54 mBGS (380.63 mAMSL) at CMT-BH01-08 on October 8, 2008. No significant groundwater was reported to be found in the remaining boreholes during drilling. CMT borehole logs are provided in **Appendix A**.

Phase II Environmental Site Assessment - MTE (October 24, 2008)

MTE completed a Phase II Environmental Site Assessment (ESA) for 41 Ira Needles Boulevard, Waterloo, ON. The purpose of the Phase II was to evaluate the environmental condition of the property as part of a Record of Site Condition (RSC) process at the time of the report. The Phase II was completed in conjunction with the geotechnical investigation completed by CMT in 2008 and therefore references the monitoring well and boreholes (CMT-BH01-08 through to CMT-BH05-08) discussed in the previous section.

Soil samples were collected from CMT-BH01-08, CMT-BH03-08, and CMT-04-08. Select samples were submitted under chain of custody to ALS Laboratories for analysis of pH, Phenoxy Acid Herbicides, Miscellaneous / Organochlorine Pesticides, Petroleum Hydrocarbons fractions F1-F4 and VOCs. The analytical results for submitted soil samples did not indicate the presence of environmental impacts on the property.

A surface water sample was collected from an on-site irrigation pond (SW1) and groundwater samples were collected from CMT-BH01-08 and an on-site irrigation well (labelled Deep Well). Samples were submitted under chain of custody to ALS Laboratories for analysis of Petroleum Hydrocarbons fractions (F1-F4) and Benzene, Toluene, Ethylbenzene and Xylene (BTEX), and Volatile Organic Compounds (VOCs). The analytical results for submitted surface water and groundwater samples did not indicate the presence of environmental impacts on the property.

Wetland Interaction at Westhill District Plan Update Technical Memorandum - MTE (January 26, 2011)

MTE completed a technical memorandum for the assessment of groundwater-wetland interaction for wetland features located in the southeast portion of the Study Area. The memorandum provides an overview of the background hydrogeological information and fieldwork to characterize the nature of the wetland-groundwater interactions of wetland features located at 73 and 83 Ira Needles Boulevard. As part of the field activities, four test trenches (MTE-TT1-11 through to MTE-TT4-11) were excavated to depths ranging from 3 m to 3.6 mBGS. Test trench locations are illustrated on **Figure 2b**.

Stratigraphy within the test trenches was generally described to consist of topsoil underlain by silt till which ranged from ground surface to the maximum investigated depth of 3.6 mBGS. MTE staff identified the presence of 1.22 m of clayey silt fill material overlaying the silt till at TT4-11. MTE Test Trench logs are provided in **Appendix B.**

In general, findings from the test trench excavations were reported to reveal dry sub-grade conditions at investigated locations. Based on this information, the isolated wetland features located at 73 and 87 Ira Needles Boulevard were interpreted to not exhibit a groundwater connection. These wetland features are described to likely be dominated by climate (e.g. precipitation and snow melt events) and retain water due to the fine grained nature of the underlying low permeable materials, and the inflow of surface and stormwater.

Geotechnical Investigation - Genivar (November 11, 2011)

Genivar completed a geotechnical investigation for the Kitchener-Waterloo Zone 6 elevated tank and related services located along Ira Needles Boulevard Waterloo ON. As part of the investigation, 10 boreholes were advanced (GEN-BH10-1 through to GEN-BH10-10) to depths ranging from 6.6 m to 15.7 mBGS. Four of the 10 boreholes (GEN-BH10-1, GEN-BH10-4, GEN-BH10-7, and GEN-BH10-10) were installed as monitoring wells. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of lacustrine silty clay and clay soils with some seams of silt, silty sand and gravelly sand, within 6 m to 8 mBGS. The two deeper boreholes (GEN-BH10-9 and GEN-BH10-10) extended to 15.7 mBGS and stratigraphy was described to consist of sand, silty sand, and non-plastic sandy silt soils overlain by a predominantly clayey soil upper zone. Genivar borehole logs are provided in **Appendix C.**

The groundwater table in the general site area was interpreted to be below the maximum drilling depth of 15.7 mBGS (370.1 mAMSL) as soils encountered during the drilling of GEN-BH10-9 and GEN-BH10-10 were described as ‘dry to moist’. Some free groundwater was observed within the upper layered soils and described to be indicative of perched water conditions with the coarser sand, silt and gravelly sand seams within the generally clayey soil zones. Groundwater levels measured in monitoring wells recorded to range from 1.1 m to 5.88 mBGS (378.3 mAMSL to 385.3 mAMSL).

Hydraulic conductivities of the silty clay and clayey silt materials were estimated to range between 10^{-9} and 10^{-10} m/sec.

Phase II Environmental Site Assessment - MTE (January 26, 2016)

MTE completed a Phase II ESA for 87 and 101 Ira Needles Boulevard, Waterloo, ON. The purpose of the Phase II was to evaluate the environmental condition of the property for due diligence purposes in advance of the proposed land conveyance. As part of the ESA, three boreholes were advanced (MTE-BH101-15 through to MTE-BH103-15) to depths ranging from 3.05 m to 6.10 mBGS. Additionally, the Phase II was completed in parallel with the geotechnical investigations completed by CVD in 2016 and therefore references the boreholes (CVD-BH104-15 through to CVD-BH109-15 and CVD-BH201-15 through to CVD-BH206-15) discussed in the below sections. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of topsoil and silty sand fill above a mixture of clayey silt with sand seams and peat. Wet to saturated conditions were encountered between 1.3 m and 6.1 m mBGS. Detailed soil identification was completed by CVD as part of the geotechnical investigations and provided under a separate cover. MTE borehole logs are provided in **Appendix D**.

Although monitoring wells were not permanently installed as part of the ESA, a temporary PVC riser pipe with a 3 metre long, 32 mm diameter, slotted PVC screen was set in place to allow for the collection of stabilized water levels in CVD-BH202-15. CVD-BH202-15 was measured to be dry upon completion on December 22, 2015; however a stabilized water level of 0.66 mBGS (381.15 mAMSL) was measured by MTE staff on January 3, 2015 in the temporary PVC riser.

Soil samples were collected from MTE-BH101-15 through to MTE-BH103-15 and CVD-201-15 through to CVD-206-15. Select samples were submitted under chain of custody to Maxxam Analytics located in Mississauga, ON for analysis of pH, metals, F1-F4, VOCs, BTEX, OC Pesticides, and polychlorinated biphenyls (PCBs). The analytical results for submitted soil samples did not indicate the presence of environmental impacts on the property.

Groundwater samples were collected from MTE-BH102-15, CVD-BH201-15, and CVD-BH202-15. Samples were submitted under chain of custody to Maxxam Analytics located in Mississauga, ON for analysis of pH, metals, F1-F4, VOCs, and BTEX. The analytical results for submitted groundwater samples did not indicate the presence of environmental impacts on the property.

Geotechnical Investigation - CVD (January 27, 2016)

CVD completed a geotechnical investigation for the extension of Thorndale Drive, currently known as the Boardwalk, located on the property at 87 Ira Needles Boulevard, Waterloo, ON. As part of this investigation, six boreholes were advanced (CVD-BH201-15 through to CVD-BH206-15) to depths ranging from 3.66 to 5.18 mBGS. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of clayey silt with some sand and frequent saturated sand seams, extending down to the maximum drilling depth of 5.18 mBGS. Fill material generally comprised of sand, clayey silt, gravel, and brick was encountered at CVD-BH201-15, extending down to a depth of 1.8 mBGS. A brown to grey layer of organic silt with rootlets and peat layers was encountered at CVD-BH205-15, extending to a depth of 2.2 mBGS. CVD borehole logs have been provided in **Appendix E**.

Monitoring wells were not installed as part of the geotechnical investigation. Groundwater conditions were monitored following the completion of the sampling of the boreholes. Water levels at CVD-BH201-15 and CVD-BH203-15 through to CVD-BH205-15 were measured at depths ranging from 1.5 mBGS to 4.3 mBGS (378.18 to 382.03 mAMSL). The clayey silt was reported to have numerous saturated sand seams which released water at variable rates. Perched water was interpreted to be present in the fill and organic silt layers. No free water was reported in CVD-BH202-15 and CVD-BH206-15 upon completion.

Geotechnical Investigation - CVD (February 10, 2016)

CVD completed a geotechnical investigation for the medical building located at 101 Ira Needles Boulevard, Waterloo, ON. As part of this investigation, six boreholes were advanced (CVD-BH104-15 through to CVD-BH-109-15) to depths ranging from 5.18 to 8.23 mBGS. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of fill material, underlain by sand, sand silt, and silty soils to maximum depths of 6.9 mBGS. These soils were reported to be underlain by brown to grey clayey silt extending down to 8.23 mBGS with some sand to sandy silt with occasion wet/saturated sandy seams. CVD borehole logs have been provided in **Appendix F.**

Monitoring wells were not installed as part of the geotechnical investigation. Groundwater conditions were monitored following the completion of the sampling of the boreholes. Free water was measured at a depth of 6.5 mBGS at CVD-BH105-15. No free water was observed following the completion of the remaining five boreholes. Based upon observations of retrieved soil samples and measured moisture contents, perched water and/or wet to saturated lenses/seams were interpreted to exist within the native deposits.

Phase II Environmental Site Assessment - MTE (April 21, 2017)

MTE completed a Phase II ESA for the commercial development located at 651-663 Erb Street West, Waterloo, ON (currently known as the 'Waterloo Commons'). The purpose of the Phase II was to evaluate the environmental condition of the property for due diligence purposes following the completion of a Phase I ESA. As part of the Phase II ESA, four boreholes were advanced (MTE-MW101-16 through to MTE-MW103-16 and MTE-BH104-16) to depths ranging from 4.57 m to 7.62 mBGS. Three of the four boreholes (MTE-MW101-16 through to MTE-MW103-16) were installed as monitoring wells. Drilling locations are illustrated on **Figure 2b**.

Stratigraphy beneath the property was generally described to consist of fill material to a maximum depth of 2.1 mBGS underlain by native soil generally consisting of silty sand, clayey silt, and silty clay to the maximum depth explored. Wet to saturated conditions were observed at depths ranging from 1.5 m to 4.0 mBGS in the clayey silt and silty clay units. MTE borehole logs have been provided in **Appendix G**.

Groundwater levels were measured to range from 1.6 m to 3.4 mBGS between March 2016 and April 2017. Groundwater elevations indicated that groundwater beneath the property generally flows in the southwesterly direction towards the lower lying stormwater facility.

Soil samples were collected from MTE-MW101-16 through to MTE-BH104-16. Select samples were submitted under chain of custody to Maxxam Analytics located in Mississauga, ON for analysis of pH, metals, F1-F4, VOCs, BTEX, OC Pesticides, Electrical Conductivity (EC), and Sodium Adsorption Ratio (SAR). The analytical results for submitted soil samples did not indicate the presence of environmental concerns on the property.

Groundwater samples were collected from MTE-MW101-16 through to MTE-MW103-16. Samples were submitted under chain of custody to Maxxam Analytics located in Mississauga, ON for analysis of pH, metals, F1-F4, and VOCs. The analytical results for submitted groundwater samples did not indicate the presence of environmental concerns on the property.

Surface water samples were collected from two locations in the storm water management facility. Samples were submitted under chain of custody to Maxxam Analytics located in Mississauga, ON for analysis of general chemistry parameters, metals, Petroleum Hydrocarbons (PHCs), and BTEX compounds. The analytical results for submitted groundwater samples did not indicate the presence of environmental concerns on the property.

4.0 STUDY AREA DESCRIPTION

The Study Area comprises an area of approximately 42.6 ha (105 acres) and is located southwest of the intersection of Erb Street West and Ira Needles Boulevard in Waterloo, Ontario. The Study Area for the Subject Lands, including property boundaries, geological cross-section locations, monitoring well locations and existing features is illustrated on **Figures 2b** and **3**. The locations of boreholes completed as part of previous investigations have also been illustrated on these figures and are discussed in **Section 3.0**.

The land use within the Study area is considered to be commercial, employment and open space. Currently, the Study Area generally includes a portion of the Region of Waterloo's Landfill at 925 Erb Street West, the Hydro One corridor, 101 Ira Needles Boulevard, 87 Ira Needles Boulevard, 73 Ira Needles Boulevard, 65 Ira Needles Boulevard, the Westhill Meadows Golf Course at 41 Ira Needles Boulevard, and the Waterloo Commons commercial development at 651-663 Erb Street West. The City of Waterloo Official Plan classifies the East portion of the Study Area as being a "Designated Greenfield Area" and the west portion to be a "Built Up Area". The Official Plan also classifies the northeast portion of the Study Area as "Mixed-Use Neighborhood Commercial", the southeast portion as "Business Employment", and the remaining portions as "Parks and Open Space"; with the landfill being indicated as a "Landfill".

GRCA mapping does not indicate the presence of any surface water courses transecting the Study Area. According to the GRCA mapping, there are eight surface water features present within the Study Area, illustrated on **Figure 2b**. These surface water features are identified to include:

- One Stormwater Management Facility (SWM) facility located at 925 Erb Street West (the Region of Waterloo's Landfill);
- One surface water/stormwater management feature located at 651-663 Erb Street West (Waterloo Commons - Erb Street Pond);
- One SWM facility (forebay) servicing Ira Needles Boulevard (up-gradient of surface water feature located at 651 Erb Street west);
- Four surface water features located at 41 Ira Needles Boulevard (the Westhill Meadows Golf Course); and
- One surface water feature located at between 73 and 87 Ira Needles Boulevard.

GRCA mapping identifies a total of five wetland features to be located within the Study Area. These wetlands are described to be "unevaluated" and therefore are unnamed. These surface water features will be referred to as:

- Waterloo Commons Wetland – located adjacently west of 651 Erb Street West (Waterloo Commons)
- HEPC North Wetland – located in the north portion of the Hydro One corridor;
- HEPC-South Wetland – located in the south portion of the Hydro One corridor;
- The Former Cressman East Wetland – located between 73 and 87 Ira Needles Boulevard; and
- Cressman West Wetland – located at 87 Ira Needles Boulevard.

MNRF mapping only displays four wetland features (HEPC North, HEPC South, the Former Cressman East, and Waterloo Commons) to be located within the Study Area and classifies the wetlands to be "unevaluated". GRCA and MNRF mapping currently illustrate the presence of the Former Cressman East wetland within the Study Area. This wetland feature was approved to be removed by the GRCA in 2016 and is no longer a wetland present on the property. The surface water feature which remains is a proposed SWM retention area. A copy of the GRCA wetland removal permit and the SWM facility design drawing has been provided in **Appendix H**. Based on this information, the outlined Former Cressman East wetland (hereby referred to as "the SWM Retention Area") will not be considered throughout this hydrogeological assessment.

The locations of the remaining four wetland features (Waterloo Commons, HEPC North, HEPC South, and Cressman West) are illustrated on **Figure 2b.**

5.0 WATER WELL RECORD SEARCH

Hydrogeological data related to water supply wells within 500m of the Study Area was obtained from the MECP water well records on file with the MECP. Based on data in the MECP well database, a total of 66 well records were located within 500m of the Study Area. Of the 66 wells identified:

- 17 wells were identified as being irrigation, livestock, or domestic water supply wells;
- 31 wells were identified as being monitoring wells and/or test holes;
- Five wells were identified as being municipal wells;
- Nine wells were identified as abandoned or "not used"; and
- Four wells records did not specify the well use.

Further investigation into the wells classified as municipal wells determined that three of the wells (Well ID #'s: 7213873, 7213876, and 7213877) were installed as municipal observation wells and one of the wells (Well ID #: 7213879) was abandoned. Well ID # 6503773 is classified by the MECP as a municipal supply well, however 6503773 is not illustrated to be present on the GRCA online mapping and is not referenced within the Lake Erie Source Protection: Grand River Assessment Report (LESPR, 2015) as being part of the municipal well systems for the Waterloo Area. Based on the water well record search and available GRCA mapping tools, there are no municipal production wells identified to exist within 500 m of the Study Area.

The closest municipal well fields (MWF) are identified to be the Erb Street MWF, the Strange Street MWF, and the William Street MWF which are located approximately 1.9 km west, 2.5 km southeast, and 2.5 km northeast of the Study Area. The Erb Street MWF wells include W06A, W06B, W07, and W08 with screen depths ranging from 32 to 56 mBGS. The Strange Street MWF wells include K10A, K11A, K13, K18 and K19 with screen depths ranging from 17 to 38 mBGS. The William Street MWF wells include W01B, W01C, W02, and W03 with screen depths ranging from 20 to 34 mBGS (LESPR, 2015).

6.0 REGIONAL GEOLOGY AND HYDROGEOLOGY

6.1 Physiography

The Study Area is located within the physiographic region known as the Waterloo Hills, as shown on **Figure 4a**. This region primarily consists of sandy hills, some of which are ridges of sandy till and others are kame or kame moraines, with outwash sands in between (Chapman and Putnam, 1984). **Figure 4b** illustrates the Study Area as being located within kame moraines deposits; consistent with the Waterloo Hills region.

6.2 Quaternary Deposits

The Quaternary Geology Map (**Figure 5)** identifies the presence of ice-contact stratified deposits of sand and gravel across the most of the City of Waterloo. The Study Area is shown to be located completely within an underlying till unit known as the Maryhill Till. The Maryhill Till, described as a fine textured clay rich till, is closely associated with glaciolacustrine sediments and is subdivided into three units (Upper, Middle, and Lower Maryhill Till). The Maryhill Till is considered to be a significant regional aquitard and will “act as a significant barrier to vertical water movement where present in a thickness greater than five metres” (Terraqua Ltd., 1995). The Maryhill Till is compositionally distinct and can be observed to a large degree across the RMOW (Farvolden et. al., 1987).

6.3 Paleozoic Bedrock Geology

The City of Waterloo is underlain by the Salina Formation (**Figure 6**), composed of carbonate rocks and minor evaporitic sequences of the Salina Formation. The Salina Formation is a shale unit that is grey-brown in colour and can be heavily weathered and/or fractured.

6.4 Regional Cross-Section

Regional Cross-Section (A-A’) (**Figure 7)** was generated using the Cross-Section Viewer (Versions 1.1) developed by the Ontario Geological Survey (OGS, 2008). The cross-section extends approximately 900 m southeast through the Study Area along the Waterloo Commons, Westhill Meadows Golf Course, 73 and 87 Ira Needles Boulevard, stopping at the Boardwalk terminus. Major geological units beneath the Study Area include bedrock, Canning Drift (ATE1), Catfish Creek Sand and Gravel (AFC1), Lower Maryhill Till (ATC1), Middle Maryhill Till (ATB2), the Waterloo Moraine (AFB1), and the Upper Maryhill Till/ Port Stantley Till/ Tavistock Till deposits (ATB1). Upper Maryhill Till deposits are illustrated to range from 10 to 50 mBGS across the Study Area.

6.5 Regional Groundwater Table

The interpreted regional groundwater flow direction was determined using publically available groundwater data from the GRCA completed as part of a watershed scale study, shown on **Figure 8**. Groundwater elevations contours are identified to range between 377 m and 381 mAMSL within the Study Area. Shallow groundwater flow direction is generally interpreted to be southerly beneath the Study Area, with the exception of the northern portion where groundwater flow is interpreted to be northeasterly.

7.0 FIELD PROGRAM

A scoped hydrogeological investigation was completed in order to identify and evaluate the hydrogeological features located with the Study Area. Field work completed was oriented towards assessing geological and hydrogeological conditions surrounding the wetland features located within the Study Area. Field work was primarily focused on the Waterloo Commons wetland feature based on the size of the wetland feature and the presence of a surface water feature identified on GRCA mapping.

7.1 Borehole Advancement and Monitoring Well

Borehole (BH) advancement and monitoring well (MW) construction was conducted on June 22, 2018 and included the advancement of two boreholes (labelled MTE-MW101-18 and MTE-MW102-18) to depths of approximately 6.1 mBGS. Boreholes were completed by a licensed drilling contractor and were observed by MTE staff. Both boreholes were completed as 50 mm diameter PVC groundwater monitoring wells with 1.5 m length slotted and filtered screens. Bentonite seals were placed to near ground surface and protective casings were cemented in place as per Ontario Regulation 903 (as amended). The monitoring well locations and ground surface elevations were surveyed and referenced to a geodetic datum by MTE.

The monitoring wells allowed for the continued assessment of the geological and hydrogeological characteristics of the Study Area, including stabilized groundwater elevations and groundwater flow direction interpretations. Monitoring well locations are illustrated on **Figure 3**. Borehole logs are provided in **Appendix I**.

Soil conditions observed during borehole advancement at the Study Area generally consist of topsoil ranging from 0.3 to 0.6 mbgs, underlain by native silt till material ranging from 4.6 m to 5.8 m in thickness; observed to the maximum investigated depth of 6.1 mBGS. A 0.9 m layer of silt was observed to overlay the till unit at MTE-MW101-18 ranging from 0.3 m to 1.5 mBGS. Observed subsurface conditions encountered during borehole advancement are generally consistent with the observed regional geology for the Study Area. Bedrock was not encountered in any of the boreholes advanced in the Study Area.

7.2 Mini-Piezometer Installation

Mini-piezometer (MP) installation was completed on June 22, 2018 and included the installation of one mini-piezometer (MTE-MP101-18) within close proximity to MW101-18. MTE-MP101-18 was installed to depth an approximate depth 1.4 mBGS within the footprint of the Waterloo Commons wetland; as outlined by the GRCA online mapping tool. The mini-piezometer was installed by MTE staff and was completed using a Solinst 25 mm stainless steel drive-point piezometer with 0.3 m length filtered screen. Soil conditions observed during the installation of MTE-MP101-18 generally consisted of approximately 0.3 m of topsoil underlain by clayey silt extending to 1.3 mBGS.

The mini-piezometer allows for the further assessment of the local scale hydrogeological characteristics of the Waterloo Commons wetland through the collection of stabilized water levels. The location and groundwater surface elevation of MTE-MP101-18 was surveyed and referenced to a geodetic datum by MTE. The location of MTE-MP101-18 is illustrated on **Figure 3**.

7.3 Surface Piezometer Installation

Surface piezometers (installation was completed on June 22, 2018 and included the installation of five surface piezometers (230P through to 235P) within the footprints of the Waterloo Commons, HEPC North, Cressman West, the SWM Retention Area, HEPC South, and Region of Waterloo Landfill SWM pond,

respectively. Surface piezometers were installed by MTE staff and were completed using perforated PVC pipe tethered to steel bars for support. The steel bars were driven into the underlying soil, while the surface piezometers were placed at the base of the feature and tethered to the steel bars. The surface piezometer locations and ground elevations were surveyed and referenced to a geodetic datum by MTE. Surface piezometer locations are illustrated on **Figure 3**.

7.4 Groundwater Levels

MTE completed multiple rounds of manual groundwater level measurements between June 22, 2018 and November 23, 2018. Manually measured groundwater levels and elevations within the monitoring wells and mini-piezometer are presented in **Table 7.4a, Table 7.4b**, and **Table7.4c.** In addition, pressure transducers (data loggers) were installed within MTE-MW101-18, MTE-MW102-18, and MTE-MP101-18. A data logger was also installed in the pre-existing MTE-MW102-16 based on its close proximity to MTE-MW101-18. Data loggers measure the pressure (in centimeters of water) above the logger at a predetermined time interval, which can then be used to calculate a groundwater level and elevation. The data loggers installed in the monitoring wells and mini-piezometer were set to record a pressure at a one hour time interval. Hydrographs illustrating continuous groundwater elevations within the monitoring wells are provided in **Appendix J**. It is noted that data displayed on these hydrographs has been reviewed and filtered to present data consistent with manual water level measurements. Data collected immediately following the installation and sampling of monitoring wells and the mini-piezometer (i.e. recovery curves) has not been included as it does not accurately reflect stabilized groundwater levels.

Supplementary water levels were collected from the pre-existing MTE-MW101-16 and MTE-MW103-16 during the September and November, 2018 monitoring events. The manual water level measurements were collected from these locations to provide additional water level elevation data used to generate local groundwater table elevation contours and interpret the direction of shallow groundwater flow within the Study Area. Manual water levels collected from MTE-MW101-16, MTE-MW102-16, MTE-MW103-16 (including historical levels collected by MTE during the previously completed Phase II and the 2018 monitoring events) are presented in **Table 7.4a, Table 7.4b**, and **Table7.4c**.

7.5 Surface Water Levels

MTE completed multiple rounds of manual surface water level measurements between June 22, 2018 and November 23, 2018. In addition, pressure transducers (data loggers) were installed within all five surface piezometers. Data loggers measure the pressure (in centimeters of water) above the logger at a predetermined time interval, which can then be used to calculate a surface water level and elevation. The data loggers installed in the surface piezometers were set to record a pressure at one hour time intervals. Hydrographs illustrating continuous surface elevations within the surface piezometers are provided in the Surface Water Monitoring Technical Memorandum.

7.6 Groundwater and Surface Water Sampling

MTE collected groundwater samples from MTE-MW101-18 and MTE-MW102-18 and surface water samples from 230 P (the Waterloo Commons wetland) and 233P on July 5, 2018. A supplementary round of surface water samples was collected from 230P, 233P, and 235P (the Region of Waterloo SWM pond) on August 10, 2018. Prior to the collection of groundwater samples, MTE-MW101-18 and MTE-MW102-18 were developed using Waterra™ Surge Blocks to remove any accumulated sediments from the bottom of the well and to remove fine materials from the well screen and sand pack. A minimum of five well volumes was purged from MTE-MW101-18 and MTE-MW102-18 based on the recorded water levels.

The groundwater and surface water samples were placed in laboratory supplied sample containers and transported on ice, under chain-of-custody to ALS Laboratories in Waterloo, Ontario. Standard QA/QC protocols were followed as outlined by the (MECP) guidance documents.

Sampling of MTE-MP101-18 could not be completed due to an insufficient water column being present in the mini-piezometer. Furthermore, surface water samples could not be collected from the remaining wetlands (HEPC North, HEPC South, and Cressman West) as no standing water was observed to be present by MTE field staff during the sampling events.

7.7 Hydraulic Conductivity Testing

Qualitatively, hydraulic conductivity (K) is a parameter describing the ease with which groundwater flows through a porous medium. Relatively high K values are attributed to permeable units, i.e. sand and gravel, while low values are attributed to less permeable material, i.e. silt or clay. Representative values for hydraulic conductivity for various soil types are presented in Freeze and Cherry (1979).

Following installation, MTE-MW101-18 and MTE-MW102-18 were measured to be dry. A review of hydrograph data measured using data loggers suggests a relatively slow recovery rate. MTE therefore conducted single well hydraulic response tests on MTE-MW101-18 and MTE-MW102-18 on July 5, 2018 following development and well sampling. Based on the relatively slow recovery rate, each well was purged dry and the water level in the well was then allowed to recover as a means of inducing an immediate groundwater level response (rising head test). Groundwater level recovery was monitored using a data logger programmed to collect groundwater levels every hour.

Each recovery test from MTE-MW101-18 and MTE-MW102-18 was selected and analyzed using the Hvorselv model in the AquiferTest© Pro software program (Waterloo Hydrogeologic Inc., 2016) to estimate the horizontal hydraulic conductivity (K) of the unconfined saturated materials beneath the Study Area.

7.8 Infiltration Rate Estimation

Soil samples were collected from MTE-MW101-18 and MTE-MW102-18 during drilling and submitted to MTE's Canadian Council of Independent Laboratories (CCIL) certified geotechnical laboratory for grain size distribution analysis and hydraulic conductivity estimates. Infiltration rates were then calculated based on estimated hydraulic conductivity values determined from grain size analysis. Soil samples selected for grain size analysis were collected from depths ranging between approximately 4.6 and 5.6 mBGS, which were selected based on soil conditions encountered in the field. Infiltration rates as a result of grain size analysis are presented later in this report.

8.0 STUDY AREA HYDROGEOLGICAL SETTING

8.1 Study Area Cross-Sections

Boreholes and monitoring wells installed by CMT, CVD, Genivar, MTE, and MECP Water Well Records were used to interpret local scale hydrostratigraphic units and generate two cross-sections.

Local scale geological-sections (Cross-section B-B' and Cross-section C-C') are presented on **Figures 9 and 10, respectively.** The cross-section stratigraphy was drawn using HydroGeo Analyst (HGA), which is a relational database system used to store and query the project database to create cross-sections.

*Geological Cross-section B-B' (**Figure 9**):*

- Extends approximately 215 m from the northwest to the southeast through the Waterloo Commons wetland feature;
- Illustrates flat undulating topography gradually increasing in elevation towards the southeast, with the exception of the elevated topography in the northwest direction due to the presence of the Erb Street West roadway;
- Illustrates a fine grained (clayey silt and sandy silt till) unit extending from ground surface to maximum explored depths of approximately 6 mBGS (372 mAMSL) throughout the entire length of the cross-section;
- Illustrates the presence of coarse sand and gravel fill and sand overlaying the till unit in the northwest; likely associated with municipal services installed below the Erb Street West Roadway; and
- Infers the shallow groundwater table elevation at the northeast portion of the Study Area to range between elevations of approximately 377 mAMSL and 381 mAMSL.

This local cross-section is therefore generally consistent with regional geology and the Regional Cross-Section A-A' discussed in **Section 6.5**.

*Geological Cross-section C-C' (**Figure 10**):*

- Extends approximately 415 m from the southwest to the northeast through the Waterloo Commons wetland feature;
- Illustrates flat undulating topography gradually decreasing in elevation from the southwest and northeast towards the low-lying Waterloo Commons wetland feature;
- Illustrates the presence of coarse sand unit in the southwest and northeast directions extending from ground surface to approximately 1 mBGS;
- Illustrates a fine grained (clayey silt and sandy silt till) unit underlying the sand unit and appearing at ground surface below the Waterloo Commons wetland feature. This silt till unit is illustrated to extend to maximum explored depths of approximately 6 mBGS (372 mAMSL) throughout the entire length of the cross-section; and
- Infers the shallow groundwater table elevation at the northeast portion of the Study Area to range between elevations of approximately 377 mAMSL and 381 mAMSL.

This local cross-section is therefore generally consistent with regional geology and the Regional Cross-Section A-A' discussed in **Section 6.5**.

8.2 Groundwater Levels

Groundwater elevations in close proximity of the Waterloo Commons wetland (MTE-MW102-16, MTE-MW101-18, and MTE-MP101-18) were measured to range between approximately 376.56 mAMSL and 379.81 mAMSL. The average groundwater levels at MTE-MW102-16, MTE-MW101-18 and MTE-MP101-18 were calculated to be 2.47 mBGS (379.55 mAMSL), 0.86 mBGS (377.69 mAMSL), and 0.46 mBGS (377.15 mAMSL), respectively.

Water levels collected using the continuous data logger in MTE-MP101-18 were observed to steadily increase over time, resembling a water level recovery curve, and reached a maximum elevation of 377.55 mAMSL on November 23, 2018. **Hydrograph 3** suggests the water level in MTE-MP101-18 is beginning to generally stabilize at the recorded maximum level of 0.06 mbgs (377.55 mAMSL). This elevation is therefore interpreted to be representative of the stabilized water level at the MTE-MP101-18 monitoring location.

Groundwater elevations in MTE-MW102-18 were measured to range between approximately 378.75 mAMSL and 380.27 mAMSL. The average groundwater level at MTE-MW102-18 was calculated to be 1.94 mBGS (379.55 mAMSL).

Continuous monitoring of groundwater elevation data will allow for the assessment of seasonal fluctuations of the water table and provide additional information on the short-term responses to precipitation events.

8.3 Surface Water Levels

Table 8.3 provides a summary of surface water elevations measured across the Study Area within the four wetland features (Waterloo Commons, HEPC North, Cressman West, and HEPC South), the SWM Retention Area and the Region of Waterloo Landfill SWM pond. Average surface water elevations ranged between 377.26 mAMSL (Waterloo Commons) and 382.28 mAMSL (Cressman West).

TABLE 8.3: MEASURED SURFACEWATER LEVELS – STUDY AREA

Station Number	Location	Surface Water Elevations (mAMSL)			
		Max	Min	Average	Ground
230P	Waterloo Commons	377.66	377.16	377.28	376.95
231P	HEPC North	379.69	379.67	379.68	379.68
232P	Cressman West	382.34	382.23	382.28	382.28
233P	SWM Retention Area	380.24	379.89	380.02	279.95
234P	HEPC South	382.35	381.99	382.08	382.01
235P	RoW Landfill SWMP	379.70	378.74	379.36	378.74

- 231P and 233P were noted to be frozen on November 23, 2018. As a result, data from 231P and 233P ranges from June, 2018 to Sept, 2018.

A comparison of measured average surface water elevations and ground surface elevations at HEPC North, Cressman West, SWM Retention Area, and HEPC South determined that these features remained generally dry during the monitoring period (i.e. standing water levels of <0.08 m). This suggests that these unevaluated features are likely topographic depressions which temporarily retain water following

precipitation events. Standing water was observed at the Waterloo Commons wetland feature which suggests the need for further evaluation of this location (**Section 9.0**). The Region of Waterloo Landfill pond is a known man-made SWM facility which drains into the wetland/SWM facility which straddles the Waterloo Commons and hydro lands. Further discussion regarding the measured surface water levels is provided in the Surface Water Monitoring Technical Memorandum.

8.4 Hydraulic Conductivity

The single well hydraulic response test analysis results in K values ranging from $1.7x10^{-8}$ m/sec (MTE-MW101-18) to $6.6x10^{-8}$ m/sec (MTE-MW102-18). Estimated K values determined using the single well hydraulic response test analysis were compared to K values determined by MTE's CCIL certified geotechnical laboratory which were estimated using grain size distribution analysis and empirical formulas. Estimated K values using grain size distribution analysis ranged from $2.7x10^{-9}$ m/sec (MTE-MW101-18) to $1.3x10^{-7}$ m/sec (MTE-MW102-18). **Table 8.4** summarizes the hydraulic conductivity estimates for each monitoring well location. A geometric mean hydraulic conductivity of $2.5x10^{-8}$ m/sec for the Study area was calculated and is consistent with the average published values for silt till soils (Freeze and Cherry, 1979). **Appendix K** provides the Aquifer Test Pro data analysis summary sheets.

TABLE 8.4: HYDRAULIC CONDUCTIVITY VALUES (M/SEC) – JULY 2018

Analysis	Estimated K Value Determined Using Single Well Response Test (m/sec)	Estimated K Value Determined Grain Size Distribution Analysis (m/sec)
MTE-MW101-18	$1.7x10^{-8}$	$2.7 x10^{-9}$
MTE-MW102-18	$6.6 x10^{-8}$	$1.3 x10^{-7}$
Geometric Mean	$2.5x10^{-8}$	

Notes: Hydraulic conductivity values determined using grain size distribution analysis were estimated using the Kaubisch, method where applicable.

Hydraulic conductivity results between the two monitoring well locations are generally consistent (i.e. MTE-MW101-18 has a higher K value than MTE-MW102-18), however there is some variability between the two estimation methods. The difference between the estimated K values determined using the single well hydraulic response test and the grain size analysis is attributed to the method of testing. Conductivity values determined through single well response testing are based on recorded in-situ water level recovery rates observed in the field, while estimated infiltration rates provided by the geotechnical laboratory are based on the results of grain size analysis and the application of empirical formulas.

8.5 Groundwater Flow Direction

Local scale groundwater elevation contours, illustrated on **Figure 11**, were generated for the Study Area using available current and historical water level data. Groundwater elevation data was further supplemented using a historical water level identified from a MECP monitoring well (MECP ID#: 7239926) located adjacent to the Region of Waterloo Landfill SWM pond. MECP records describe 7239926 as being completed to a depth of 8.5 mBGS in 2016 with a water level of approximately 2.1 mBGS (279.3 mAMSL).

Interpreted groundwater elevation contours were estimated to range between 377 m and 382.5 mAMSL within the Study Area. Groundwater elevation contours generally follow surface topography of the Study Area, which ranges between 377 m and 394 mAMSL. Based on this information, local scale shallow

groundwater flow was interpreted to generally be in the northwesterly direction converging towards the Waterloo Commons SWM/wetland feature.

Local scale groundwater elevations are generally consistent with the regional groundwater table elevations discussed in **Section 6.5**. However, the interpreted local scale shallow groundwater flow direction is noted to vary from the regional groundwater flow direction beneath the Study Area. The variability between the interpreted groundwater flow directions is attributed to the scale used to generate each set of groundwater flow contours. Groundwater contours generated using GRCA data are based on a watershed scale study and therefore reflect regional groundwater elevations and general flow directions across the GRCA limits. Groundwater contours generated for the Study Area are based on multiple sets of water levels located with the bounds of the Study Area and are therefore more representative of local scale groundwater contours and topography.

Local scale groundwater contours were integrated with the GRCA regional groundwater table contours discussed in **Section 6.5**, as shown in **Figure 12**, to further infer the direction of groundwater flow surrounding the Study Area. Based on this, groundwater was inferred to generally flow in the northeasterly direction towards Clair Creek, with the exception of groundwater in the southeastern portion of the property which was inferred to generally flow in the southeasterly direction due to an interpreted groundwater divide. Integrated groundwater contours (MTE and GRCA Data) are based on an interpretation of available groundwater level data sources and may vary from actual groundwater elevations observed throughout the year.

8.6 Average Linear Groundwater Velocity

The horizontal hydraulic gradient is a measurement of the slope of the water table surface which is simply the change in hydraulic head over the change in distance between two or more monitoring points. The estimated horizontal hydraulic gradient for the Study Area determined using average groundwater elevations from MTE-MW101-18 (377.69 mAMSL) and MTE-MW102-18 (379.55 mAMSL) was approximately 0.003 m/m, based on the local scale groundwater flow map (**Figure 11**).

The average linear groundwater velocity was estimated based on three variables: hydraulic conductivity, horizontal hydraulic gradient and effective porosity. The equation for calculating groundwater velocity is:

$$q = (-KI_h)/n_e \qquad \text{[Eq.1.]}$$

Where:

q = groundwater flux (m^3/m^2/time)

K = effective hydraulic conductivity ($2.5x10^{-8}$ m/sec)

$\mathbf{I_h}$ = horizontal hydraulic gradient (dh/dl) (0.003 m/m)

$\mathbf{n_e}$= effective soil porosity (0.2 typical for a silt and clay soil, Freeze and Cherry, 1979)

With respect to the above values, the average linear groundwater velocity (q) using Darcy's Law (Eq.1.) within the shallow groundwater at the Study Area was estimated to be approximately less than 0.1 m/year, based on the local scale groundwater flow map (**Figure 11**).

8.7 On-site Infiltration

A summary of the calculated infiltration rates based soil samples collected by MTE, from MTE-MW101-18 and MTE-MW102-18, is presented in **Table 8.7**, below. Infiltration rates were estimated to range between 4 and 11 mm/hr and are based on the estimated hydraulic conductivity values discussed in **Section 8.4**. Particle grain size distributions are provided in **Appendix L**.

TABLE 8.6: SUMMARY OF INFILTRATION RATES (mm/hr)

Test Location	Test Depth Interval (mbgs)	Dominant Soil Type	Observed Unit Thickness (m)	Applied Factor of Safety	Estimated Infiltration Rate Provided by MTE Geotechnical Laboratory (mm/hr)
MTE-MW101 - 18	4.6-5.6	Silt Till	>4.6*	2.5	4
MTE-MW102 - 18	4.6-5.3	Silt Till	>5.8*	2.5	11

* Based on interpolation from drilling program

8.8 Groundwater Chemistry

Groundwater samples were submitted and analyzed for general chemistry in order to determine the background groundwater chemistry in close proximity to the Waterloo Commons and the SWM Retention Area. The analytical results are summarized in **Table 8.8.** Laboratory Certificates of Analysis are provided in **Appendix M**.

8.8.1 Waterloo Commons SWM/Wetland Feature

Anions and Nutrients

As shown, detectable concentrations of Ammonia (0.28 mg/L), Chloride (527 mg/L), Fluoride (0.12 mg/L), and Sulfate (79.4 mg/L) were reported for the sample collected from MTE-MW101-18. Alkalinity (as $CaCO_3$) was reported to be 363 mg/L. All other reported results for Anion and Nutrient compounds were below their detectable limits for the MTE-MW101-18 sample collected.

Total Metals

The followings compounds were detected in the MTE-MW101-18 groundwater sample collected:

- Antimony (0.00029 mg/L)
- Arsenic (0.00048 mg/L)
- Barium (0.191 mg/L)
- Boron (0.028 mg/L)
- Cadmium (0.000079 mg/L)
- Calcium (198 mg/L)
- Cesium (0.000019 mg/L)
- Cobalt (0.00105 mg/L)
- Copper (0.0123 mg/L)
- Lead (0.0003 mg/L)
- Magnesium (82.2 mg/L)
- Manganese (0.153 mg/L)
- Molybdenum (0.00358 mg/L)
- Nickel (0.0076 mg/L)

- Potassium (6.67 mg/L)
- Rubidium (0.00269 mg/L)
- Selenium (0.000596 mg/L)
- Silicon (7.88 mg/L)
- Sodium (156 mg/L)
- Strontium (0.477 mg/L)
- Sulfur (30.2 mg/L)
- Thallium (0.000029 mg/L)
- Tin (0.00092 mg/L)
- Uranium (0.00613 mg/L)
- Vanadium (0.00088 mg/L)
- Zinc (0.0105 mg/L)

All other reported results for Total Metals compounds were below their detectable limits for the sample collected from MTE-MW101-18. The elevated concentrations of sodium and chloride are interpreted to be a result of road salt application on the roadways located and north and east of the Waterloo Commons wetland feature.

8.8.2 SWM Retention Area

Anions and Nutrients

As shown, detectable concentrations of Ammonia (0.094 mg/L), Chloride (6.5 mg/L), Fluoride (0.12 mg/L), and Sulfate (58.1 mg/L) were reported for the sample collected from MTE-MW101-18. Alkalinity (as $CaCO_3$) was reported to be 337 mg/L. All other reported results for Anion and Nutrient compounds were below their detectable limits for the MTE-MW102-18 sample collected.

Total Metals

The followings compounds were detected in the MTE-MW102-18 groundwater sample collected:

- Aluminum (0.016 mg/L)
- Antimony (0.00016 mg/L)
- Arsenic (0.00063 mg/L)
- Barium (0.199 mg/L)
- Boron (0.011 mg/L)
- Cadmium (0.000028 mg/L)
- Calcium (102 mg/L)
- Cobalt (0.00046 mg/L)
- Copper (0.0044 mg/L)
- Lead (0.00024 mg/L)
- Magnesium (34.3 mg/L)
- Manganese (0.0727 mg/L)
- Molybdenum (0.00304 mg/L)
- Nickel (0.00145 mg/L)
- Potassium (1.69 mg/L)
- Rubidium (0.00093 mg/L)
- Selenium (0.000186 mg/L)
- Silicon (7.32 mg/L)
- Sodium (12.8 mg/L)
- Strontium (0.227 mg/L)
- Sulfur (19.4 mg/L)
- Thallium (0.000011 mg/L)
- Tin (0.00038 mg/L)
- Uranium (0.00227 mg/L)
- Vanadium (0.00063 mg/L)
- Zinc (0.0067 mg/L)

All other reported results for Total Metals compounds were below their detectable limits for the sample collected from MTE-MW102-18. It is noted that total metal concentrations at MTE-102-18 were generally lower than groundwater samples collected from MTE-MW101-18. However, there are no other consistent trends observed between these two sample locations.

8.9 Surface Water Chemistry

Surface water samples were submitted and analyzed for general chemistry in order to determine the background surface water chemistry in the Waterloo Commons wetland feature, SWM Retention Area, and the Region of Waterloo Landfill's SWM pond. Analytical results for the surface water sample collected from the Waterloo Commons were compared to the analytical results from groundwater samples (**Section 8.7**) in order to identify potential surface water and groundwater interactions. The analytical results are summarized in **Table 8.7.** Laboratory Certificates of Analysis are provided in **Appendix M**.

8.9.1 Waterloo Commons SWM/Wetland Feature

Anions and Nutrients

As shown, detectable concentrations of Ammonia (0.02 mg/L), Chloride (344-767 mg/L), Fluoride (0.12 mg/L), Nitrate (as N) (0.11 mg/L), Phosphorus (0.135 mg/L), Orthophosphate (as P) (0.0099 mg/L) and Sulfate (15.2 mg/L) were reported for the samples collected from monitoring location 230P. Alkalinity (as $CaCO_3$) was reported to be 198 mg/L. All other reported results for Anion and Nutrient compounds were below their detectable limits for the 230P samples collected.

Total Metals

The followings compounds were detected in the 230P surface water samples collected:

- Aluminum (1.73 mg/L)
- Arsenic (0.0051 mg/L)
- Barium (0.117 mg/L)
- Calcium (102 mg/L)
- Cesium (0.000018 mg/L)
- Cobalt (0.0011 mg/L)
- Copper (0.0025 mg/L)
- Iron (4.86 mg/L)
- Lead (0.00069-0.00414 mg/L)
- Magnesium (21.6 mg/L)
- Manganese (0.56 mg/L)
- Molybdenum (0.00253 mg/L)
- Phosphorus (0.0545-0.74 mg/L)
- Potassium (3.9 mg/L)
- Rubidium (0.0036 mg/L)
- Silicon (7.1 mg/L)
- Sodium (409 mg/L)
- Strontium (0.386 mg/L)
- Uranium (0.00096 mg/L)
- Vanadium (0.0074 mg/L)
- Zinc (0.0087 mg/L)

All other reported results for Total Metals compounds were below their detectable limits for the sample collected from MTE-MW101-18. There are no noted trends observed between the surface water sample collected from the 230P and the groundwater sample collected from MTE-MW101-18, with the exception of elevated sodium and chloride concentrations. The elevated concentrations of sodium and chloride are interpreted to be a result of road salt application on the roadways located and north and east of the Waterloo Commons wetland feature.

8.9.2 SWM Retention Area

Anions and Nutrients

As shown, detectable concentrations of Ammonia (0.023 mg/L), Chloride (3.11-30.1 mg/L), Fluoride (0.076 mg/L), Nitrate (as N) (0.066 mg/L), Phosphorus (0.815 mg/L), and Sulfate (2.12 mg/L) were reported for the samples collected from monitoring location 233P. Alkalinity (as $CaCO_3$) was reported to be 192 mg/L. All other reported results for Anion and Nutrient compounds were below their detectable limits for the 233P samples collected.

Total Metals

The followings compounds were detected in the 233P surface water samples collected:

- Aluminum (0.035 mg/L)
- Antimony (0.00012 mg/L)
- Arsenic (0.0023 mg/L)
- Barium (0.0188 mg/L)
- Boron (0.03 mg/L)
- Calcium (54.2 mg/L)
- Cobalt (0.00015 mg/L)
- Copper (0.036 mg/L)
- Iron (0.941 mg/L)
- Lead (0.0168 mg/L)
- Magnesium (13 mg/L)
- Manganese (0.0641 mg/L)
- Molybdenum (0.000402 mg/L)
- Phosphorus (0.059-0.0766 mg/L)
- Potassium (3.93 mg/L)
- Rubidium (0.00063 mg/L)
- Selenium (0.000123 mg/L)
- Silicon (0.6 mg/L)
- Sodium (17.5 mg/L)
- Strontium (0.175 mg/L)
- Sulphur (0.86 mg/L)
- Uranium (0.000482 mg/L)
- Zinc (0.109 mg/L)

All other reported results for Total Metals compounds were below their detectable limits for the sample collected from 233P. It is noted that total metal concentrations at 233P were generally lower than samples collected from MTE-MW102-18 and 230P. However, there are no other consistent trends observed between these three sample locations.

8.9.3 Region of Waterloo Landfill SWM Pond

The Region of Waterloo Landfill (ROW) SWM pond was sampled analyzed for select anions, nutrients, and metals. This location was sampled for comparative purposes as the SWM pond is located hydraulically up-gradient of the Waterloo Commons wetland features (i.e. drains into the Waterloo Commons wetland feature). A summary of these results is provided below:

Anions and Nutrients

As shown, detectable concentrations of Chloride (293 mg/L) and Phosphorus (0.0785 mg/L) were reported for the sample collected from the ROW SWM pond. All other reported results for Anion and Nutrient compounds were below their detectable limits for the ROW SWM pond sample collected.

Total Metals
The followings compounds were detected in the ROW SWM pond sample collected:

- Copper (0.0021 mg/L)
- Lead (0.00088 mg/L)
- Phosphorus (0.0155 mg/L)
- Zinc (0.0099 mg/L)

It is noted that total metal concentrations at the ROW SWM pond were generally lower the surface water sample collected from 230P. However, there are no other consistent trends observed between these two sample locations.

Overall trends identified from water quality samples collected from the Study Area suggest the following:

- Groundwater concentrations of anions, nutrients, and total metals are generally lower than surface water concentrations;
- Surface water concentrations of anion, nutrients, and total metals generally increase across the Study Area moving in the north to northeasterly direction; and
- Groundwater concentrations of anion, nutrients, and total metals generally increase across the Study Area moving in the north to northeasterly direction.

These trends are consistent with topography, surface water drainage patterns, and the interpreted groundwater flow direction for the Study Area discussed in **Section 8.5**.

9.0 GROUNDWATER – WETLAND INTERACTION ASSESSMENT

The interaction between groundwater and surface water in wetlands represents an important factor in site characterization as it can provide insight into whether groundwater recharge is occurring or whether groundwater is discharging to the wetland (Scott & Winter, 2006). A groundwater–wetland interaction assessment was therefore completed for the Waterloo Commons wetland feature based on groundwater and surface water data collected from the Study Area.

An in depth assessment of the remaining unevaluated wetland features (HEPC North, HEPC South, and Cressman West) and the SWM Retention Area was not completed based on review of collected surface water level data and the relatively small footprints of the features. Surface water level data at these locations suggest that these features would generally behave as depressional features, retaining water following precipitations events and then becoming dry as a result of evapotranspiration and infiltration losses. Further discussion regarding the remaining wetland features is provided in the Surface Water Monitoring Technical Memorandum.

9.1 Waterloo Commons SWM/Wetland Feature

The interaction between groundwater and the Waterloo Commons wetland feature was assessed by comparing available continuous surface water and groundwater elevation data collected from the 230P surface piezometer, MTE-MW101-18, MTE-MP101-18, and GRCA precipitation data, as shown in **Hydrograph 5**. Average surface water elevations in 230P and MTE-MW101-18 have been calculated and

summarized in **Table 9.1** below. Water levels collected using the continuous data logger in MTE-MP101-18 were observed to steadily increase over time and reached a maximum elevation of 377.55 mAMSL on November 23, 2018. **Hydrograph 3** suggests the water level in MTE-MP101-18 is beginning to generally stabilize at the recorded maximum elevation (377.55 mAMSL).

TABLE 9.1: AVERAGE WATER LEVELS (WATERLOO COMMONS)

Location	Water Level Elevation (mAMSL)
230P Surface Piezometer	377.28
MTE-MW101-18	377.69
MTE-MP101-18	377.55*

* A maximum observed water level was used for MTE-MP101-18 as this value was interpreted to be more representative of the stabilized water table elevation at this location.

Surface water and groundwater levels are generally consistent between the three monitoring locations with the average groundwater elevation in MTE-MW101-18 being measured to be approximately 0.41 m higher than the average surface water elevation in the 230P surface piezometer. Surface water and groundwater levels in 230P and MTE-MW101-18 were noted to express similar fluctuations following precipitation events.

The interaction of groundwater and surface water is inferred to vary throughout the year, as shown in **Hydrograph 5**. Groundwater and surface water elevations measured during dry periods were observed to be generally consistent, therefore implying minimal volumes of groundwater being contributed to the wetland during these periods. Groundwater levels were measured to temporarily increase above surface water levels following significant precipitation events and then gradually recover to lower levels more consistent with surface water levels, therefore resulting in the potential for groundwater to temporarily discharge into the wetland feature.

Surface water elevations were measured to fluctuate around 377.20 mAMSL being controlled by the elevation of the pond outlet orifice located adjacent to the 230P surface piezometer. Measured surface water levels may therefore inaccurately reflect surface water levels within the pond due to the presence of this drainage feature.

A vertical hydraulic gradient was calculated to further assess the interpreted interaction of groundwater and the Waterloo Commons wetland feature. Vertical hydraulic gradients provide insight into whether the wetland was gaining (i.e. receiving groundwater from below) or losing (i.e. recharging the shallow groundwater table through infiltration).

The vertical hydraulic gradient between MTE-MW101-18 and intermediate MTE-MP101-18 was calculated using the following equation:

[Eq.2.]

$$I_v = (MWL - MPL) / (MWS-MPS)$$

Where:

I_v = hydraulic gradient (m/m)

MWL =Average water level inside monitoring well (measured using continuous data logger) (377.69 mAMSL)
MPL =Maximum water level inside mini-piezometer (measured using continuous data logger) (377.55 mAMSL)
MWS = Mid-Screen elevation of monitoring well (373.29 mAMSL)
MPS = Mid-Screen elevation of mini=piezometer (376.40 mAMSL)

* A maximum observed water level was used for MTE-MP101-18 as this value was interpreted to be more representative of the stabilized water table elevation at this location.

The vertical hydraulic gradient within the Waterloo Commons SWM/wetland feature was calculated to be approximately - 0.045 m/m therefore suggesting an upward flow direction (i.e. gaining-receiving groundwater from below).

A survey of the Waterloo Commons SWM/wetland bathymetry determined the maximum lowest elevation of the wetland feature to approximately 376.84 mAMSL. Using the average groundwater elevation in MTE-MW101-18 (377.69 masl), the wetland intersects below the shallow groundwater table by approximately 0.85 m. GRCA mapping data determines the area of the wetland to be approximately 10000 m^2, resulting in a contributing surface area of approximately 10450 m^2 and a wetland volume of approximately 8500 m^3. The volume of water within the wetland was therefore estimated to be approximately 5100 m^3 using the following approach:

[Eq.3.]

$$V_w = V_s + V_p$$

Where:

V_w = Volume of water in wetland
V_s = Volume of standing water in wetland (based on field observations, approximately half the wetland volume is considered to be made up of standing water; 4250 m^2)
V_p = Volume of water in soil pores (the remaining volume of the wetland (850 m^2) x effective porosity of clayey silt material (0.2); 1200 m^3)

The soils surrounding the wetland feature were found to consist of sandy silt and clayey silt, with an estimated infiltration rate of approximately 4 mm/hr. The groundwater discharge rate at this wetland feature is therefore expected to be very low. A preliminary assessment of the potential groundwater contribution to the Waterloo Commons wetland feature was calculated using a variation of the Darcy Flux approach and is presented in the equation below:

[Eq.4.]

$$Q = - (K I_v A) / n_e$$

Where:

Q = Groundwater discharge (m^3/ unit of time)
K = Hydraulic conductivity (2.2 x 10^{-3} m/day)
I_v = vertical hydraulic gradient (-0.045 m/m)
A = Surface area of wetland below groundwater table (an approximate area of 10,000 m^2 and a conservatively high intersection depth of 0.6; 10260 m^3)
n_e = effective porosity of clayey silt material (0.2)

A Darcy flux based on the total surface area of the wetland intersecting the shallow groundwater table was used to estimate the discharge seepage (groundwater contribution to the wetland). Based on a conductivity value of 2.2 x 10^{-3} m/day (2.5 x 10^{-8} m/sec) and an effective porosity of 0.2, the resulting groundwater discharge is estimated to be approximately 5.1m^3/day (0.1% of the total estimated volume of the wetland). This can alternatively be expressed a 0.5 L/m^2 of groundwater discharge occurring within the boundaries of the wetland. Losses occurring through evapotranspiration (ET) were calculated to be approximately 7.5m^3/day based on the published Ministry of Environment (MOE) SWM Design Manual average ET rate for the Region of Waterloo (approximately 550 mm/year) and a conservatively low contributing surface area of 5000 m^2 (half the area of the wetland feature). Water losses in the wetland feature as a result of ET are therefore estimated to be approximately equal to or greater than volumes generated from groundwater discharge.

Based on this information, it is interpreted that the Waterloo Commons SWM/wetland feature receives minor volumes of groundwater discharge and is primarily sustained by surface water runoff. Surface water runoff directed to the wetland feature is generally conveyed from the surrounding Subject Lands, Ira Needles Boulevard, and the hydraulically up-gradient Region of Waterloo Landfill's SWM pond.

10.0 SOURCE WATER PROTECTION

10.1 Wellhead Protection Areas

Wellhead Protection Areas (WHPAs) are established for each municipal supply well through the delineation of well "capture zones". These capture zones are defined as:

> *"the projection onto the land surface of the portion of the three-dimensional volume through which groundwater travels towards a water supply well within a defined period of time."* (AquaResource Inc., 2010)

WHPAs are divided into four categories based on travel time to the well, and are summarized in the table below.

Category	Description
WHPA-A	A radius of 100 m from the outer boundary of the well
WHPA-B	Time-of-travel to the well ≤2 years (not including WHPA-A)
WHPA-C	Time-of-travel to the well is >2 years, but ≤ 5 years
WHPA-D	Time-of-travel to the well is >5 years, but ≤ 25 years

A review of the MECP online interactive Source Water Protection Information Atlas (MECP, 2018) and the GRCA online mapping tool found that the Study Area is not located within a WHPA, shown on **Figure 13**.

10.2 Intrinsic Vulnerability

MTE reviewed the GRCA Grand River Information Network (GRIN) interactive on-line map for information pertaining to the aquifer Intrinsic Vulnerability. The Intrinsic Vulnerability of an aquifer is based on the nature of the soil and/or bedrock and how easily surface water can reach the aquifer. Intrinsic Vulnerability is ranked as low, medium or high and does not take into consideration the properties of the contaminant itself (Liggett, Lapcevic, & Miller, May 2011).

As shown on **Figure 14**, the majority of Study Area is classified as having a low intrinsic vulnerability. It is noted that a small portion of the Study Area located in the east is classified as having a medium intrinsic vulnerability; however this portion is primarily comprised of the roadways which already make up Ira Needles Boulevard and the Boardwalk Avenue.

10.3 WHPA Vulnerability

WHPA vulnerability scores are assigned by overlaying the WHPAs with the intrinsic vulnerability of the aquifer (LERSPC, 2015). Vulnerability scores range from 2 to 10, with 10 representing the highest vulnerability. Vulnerability adjustments are made based on the presence of transport pathways which can provide easier routes of access between a contaminant and an aquifer, increasing the aquifers susceptibility to contamination.

As shown in **Figure 13**, the Study does not fall within a WHPA and therefore does not have a WHPA vulnerability score.

10.4 Significant Groundwater Recharge Area

Groundwater recharge occurs where precipitation and snowmelt infiltrate into the ground to feed aquifers, watercourses and wetlands. SGRAs are typically associated with coarse-grained soils (i.e. sands and gravels) or very shallow overburden material covering upland areas on the landscape.

The MECP on-line interactive Source Water Protection Information Atlas and GRCA online mapping tool show the Study Area to not be located within a SGRA. Quaternary geology in the area illustrate the Study Area to be located with a fine-textured glaciolacustrine silt and clay unit known as the Maryhill Till, which poorly facilitates infiltration and percolation of surface water to groundwater. The calculated infiltration rates for the MTE-MW101-18 and MTE-MW102-18 support the identification that the Study Area is not within a SGRA. This is further supported by the presence of the Region of Waterloo Landfill being located adjacently west of the Study Area.

10.5 Issue Contributing Areas (ICAs)

ICAs are developed by identifying areas where the current or trending concentration of a contaminant within the groundwater may deteriorate the quality of the groundwater used as a drinking water source (LERSPC, 2015). An ICA is defined by the Grand River Source Protection Plan as:

> "*The area within which activities have or are likely to contribute to the elevated contaminant at the well...in most cases, an ICA is the 25 year time-of-travel capture zone."* (Grand River Conservation Authority, 2015)

The MECP online interactive Source Water Protection Information Atlas GRCA online mapping tool show that the Study Area is not located within an ICA area**.**

11.0 CONCLUSIONS

Based on this scope hydrogeological investigation, MTE offers the following findings:

Study Area Hydrogeological Characteristics

- Stratigraphic conditions beneath the Study Area primarily consist of fine grained cohesive (silt and clayey silt till) materials;
- Topography across the Study Area was determined to range between 377.0 mAMSL and 394.0 mAMSL, decreasing in elevation along the northwesterly direction;
- Groundwater levels in the Study Area were measured to range from 377.19 mAMSL to 380.27 mAMSL in installed monitoring wells and the mini-piezometer;
- The local scale groundwater table elevation, interpreted based on collected water levels, regional groundwater elevation contours, and historical levels, was interpreted to generally follow the Study Area topography and ranged between 377.0 m and 382.5 mAMSL with the direction of groundwater flow being inferred to be northwesterly towards Clair Creek;
- The horizontal gradient of shallow groundwater table beneath the Study Area is estimated to be 0.003 m/m;
- Maximum and minimum hydraulic conductivity values for the groundwater table beneath the Study Area were calculated to range between $1.3x10^{-7}$ m/sec and $2.7x10^{-9}$ with a geometric mean of $2.5x10^{-8}$ m/sec; and
- The average linear groundwater velocity beneath the Study Area was estimated to be less than 0.10 m/year.

Continuous monitoring of groundwater elevation data will allow for the assessment of seasonal fluctuations of the water table and determine the seasonal high groundwater table.

An in depth groundwater-wetland interaction assessment of the smaller unevaluated wetland features (HEPC North, HEPC South, and Cressman West) was not completed based on review of collected surface water level data and the relatively small areas of the wetland features. Surface water level data at these locations suggest that the wetland features would generally behave as depression features, retaining water following precipitations events and then becoming dry as a result of evapotranspiration and infiltration losses. The Former Cressman East wetland feature was approved to be removed by the GRCA in 2016 and is no longer present on the property. The surface water feature which remains is a proposed SWM Retention Area which was not assessed as part of this hydrogeological assessment.

Surface water samples were collected from the Waterloo Commons and SWM Retention Area to assess background surface water quality in the Study Area. A supplementary surface water sample was also collected from the Region of Waterloo Landfill's SWM pond. Groundwater samples were collected from MTE-MW101-18 and MTE-MW102-18 to assess background groundwater quality data in the Study Area. Results did not provide conclusive evidence regarding groundwater and surface water interactions.

Overall trends identified from samples collected from the Study Area suggest the following:

- Groundwater concentrations of anions, nutrients, and total metals are generally lower than surface water concentrations;
- Surface water concentrations of anion, nutrients, and total metals generally increase across the Study Area moving in the north to northeasterly direction, following the inferred direction of surface water drainage;
- Groundwater concentrations of anion, nutrients, and total metals generally increase across the Study Area moving in the north to northeasterly direction, following the inferred direction of groundwater flow; and
- The elevated concentrations of sodium and chloride at the Waterloo Commons wetland feature are interpreted to be a result of road salt application on the roadways located and north and east of the Waterloo Commons wetland feature.

A more detailed groundwater–wetland interaction assessment was therefore completed for the Waterloo Commons and based on groundwater and surface water data collected from the Study Area. Based on the available information, MTE offers the following finds:

Waterloo Commons SWM/Wetland Feature

- The average groundwater elevation in MTE-MW101-18 (377.69 mAMSL) was measured to be approximately 0.41 m higher than the average surface water elevation in the 230P surface piezometer (377.28 mAMSL);
- The soils surrounding the wetland feature were found to consist of sandy silt and clayey silt till with an infiltration rate of 4 to 11 mm/hr;
- The vertical hydraulic gradient within the Waterloo Commons wetland was calculated to be approximately - 0.045 m/m therefore suggesting an upward flow direction (i.e. gaining- receiving groundwater from below);
- The total volume of water within the Waterloo Commons wetland feature was estimated to be approximately 5100 m^3 based on available GRCA mapping tools and field observations;
- Based on a Study Area conductivity value of 2.5 x 10^{-8} and an effective porosity of 0.2 for silt material, the resulting groundwater discharge was estimated to be approximately 5.1m^3/day (0.1% of the total estimated volume of the wetland); and
- Losses occurring through evapotranspiration (ET) were calculated to be approximately 7.5 m^3/day based on an average ET rate of approximately 550 mm/year and a contributing surface area of 5000 m^2.

Based on this information, it is interpreted that the Waterloo Commons SWM/wetland feature receives minor volumes of groundwater discharge and is primarily sustained by surface water runoff. Surface water runoff directed to the wetland feature is generally conveyed from the surrounding Subject Lands, Ira Needles Boulevard, and the hydraulically up-gradient Region of Waterloo Landfill's SWM pond.

12.0 REFERENCES

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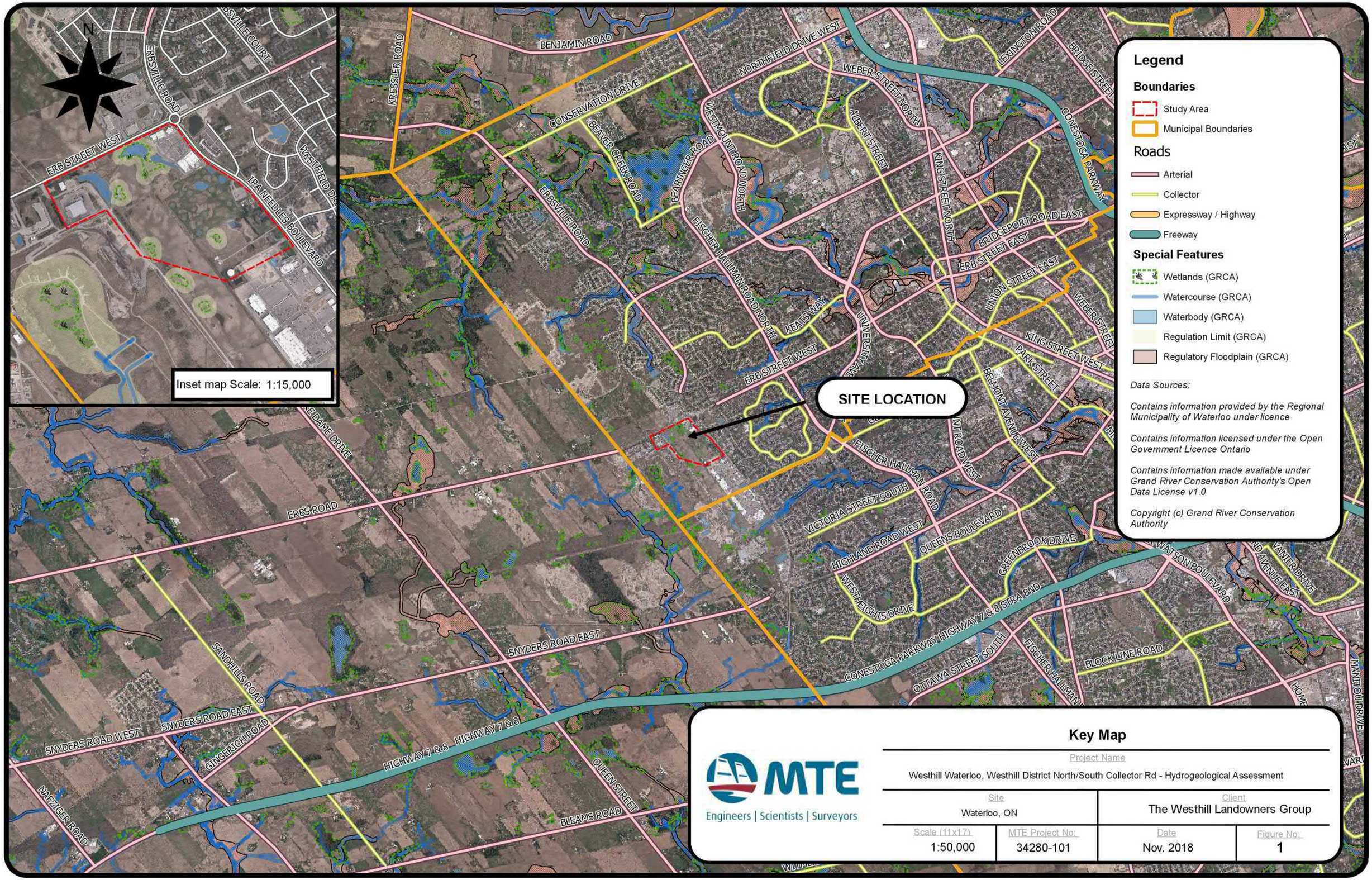
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Phone: 519-743-6500
Fax: 519-743-6513

FIGURES



Legend

Boundaries

- Study Area
- Municipal Boundaries

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulation Limit (GRCA)
- Regulatory Floodplain (GRCA)

Data Sources:

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Key Map

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:50,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 1

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 QGIS.qgs
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N

ST MORITZ AVENUE
BRANDENBURG BOULEVARD
ERBSVILLE ROAD
PARADISE CRESCENT
ROYAL BEECH DRIVE
ERBSVILLE COURT
BEECHWOOD DRIVE
ERB STREET WEST
BERNAY DRIVE
PARIS BOULEVARD
PINEROW CRESCENT
WILMOT LINE
ERBS ROAD
WESTFIELD DRIVE
THORNDALE DRIVE
CARDIFF STREET
BAKER STREET
PENNY LANE
IRA NEEDLES BOULEVARD
COUNTRYSTONE DRIVE
RESURRECTION DRIVE

6508344
7287726
7217850
6507781
7217851
6509436
6503093
6509919
7261566
7261568
7234539
7111295
6509435
7261567
6501390
7234537
7140394
6501309
6503952
6501391
6503346
7050641
7287730
7239929
6507997
7114304
7234538
7177568
7239926
6503773
6502879
7234540
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6504166
6504153
6501388
6503643
7239927
6507206
7162785
7162784
7119476
7119473
7213873
7213876
7281491
7281492
7213879
7115869
6503015

Legend

Boundaries
- Study Area
- Study Area - 500 m Radius

Roads
- Arterial
- Collector
- Local / Street

Special Features
- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Monitoring Locations

MECP Monitoring Locations
- Domestic
- Irrigation
- Livestock
- Monitoring
- Monitoring and Test Hole
- Municipal
- Not Used
- Other
- Test Hole

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Study Area

Project Name: Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment

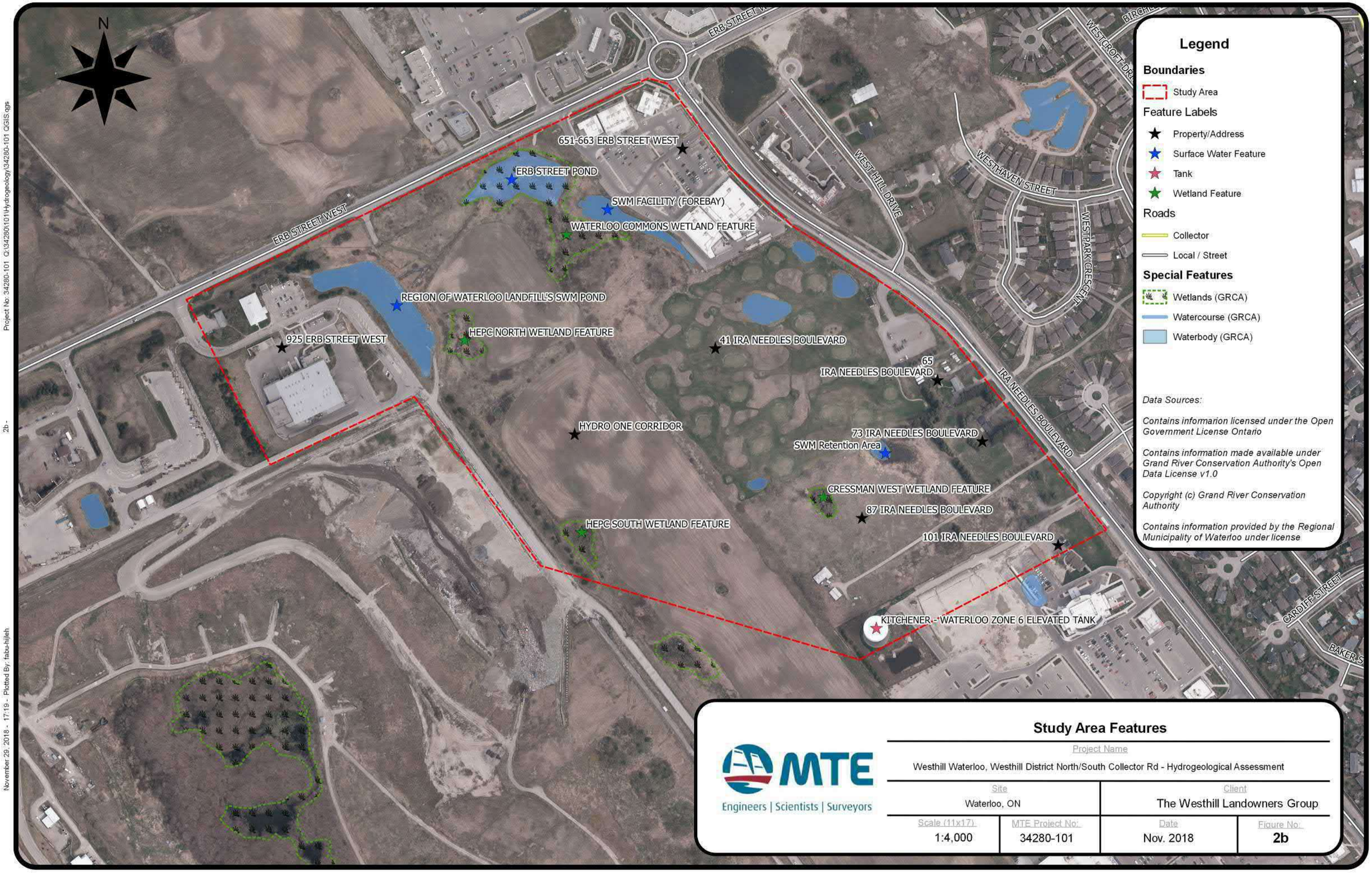
Site	Client
Waterloo, ON	The Westhill Landowners Group

Scale (11x17)	MTE Project No:	Date	Figure No:
1:10,000	34280-101	Nov. 2018	**2a**

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS.qgs

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2a -



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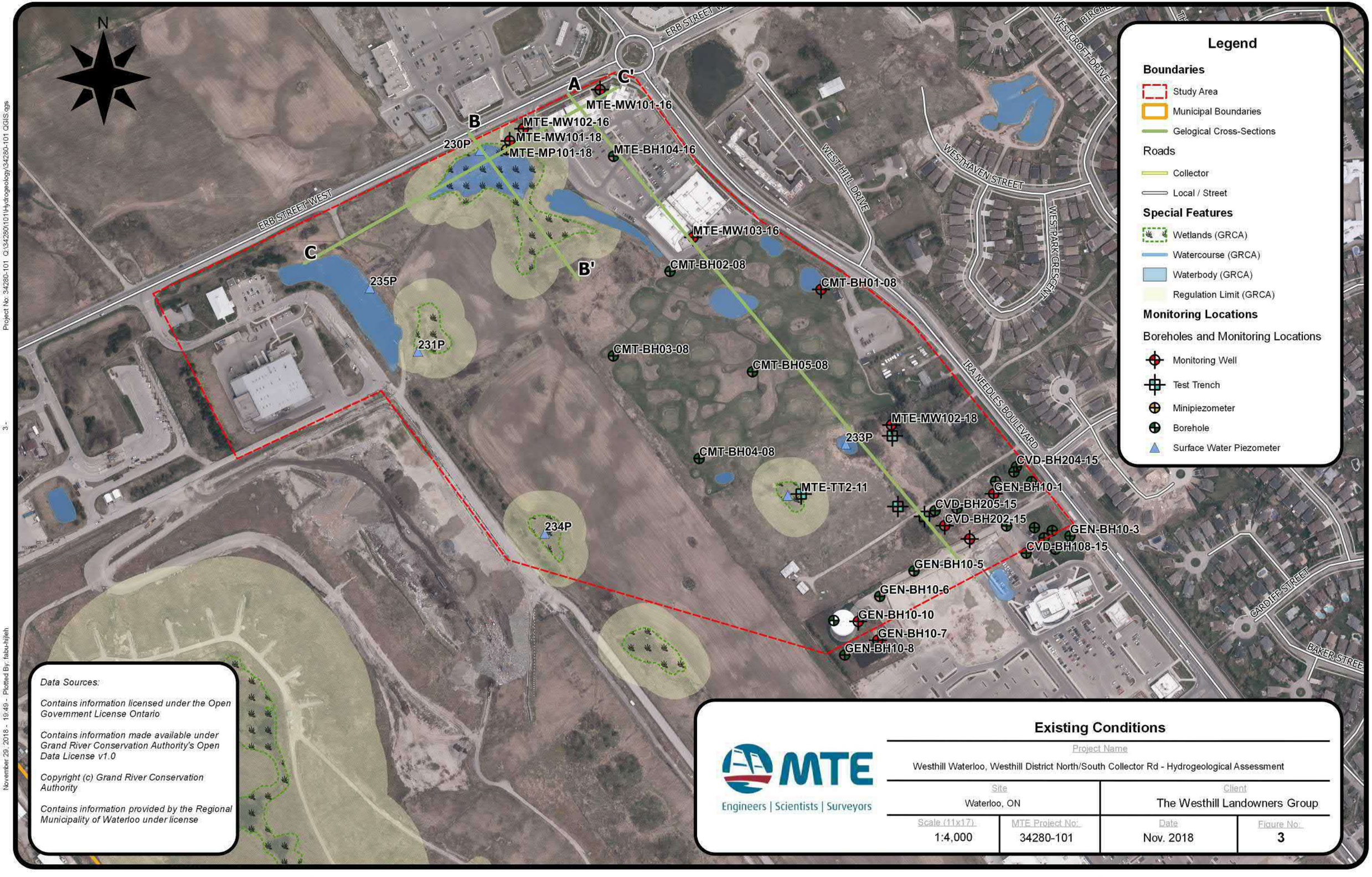
2b -

November 29, 2018 - 17:19 - Plotted By: fatou-hijleh

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Study Area Features

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:4,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: **2b**



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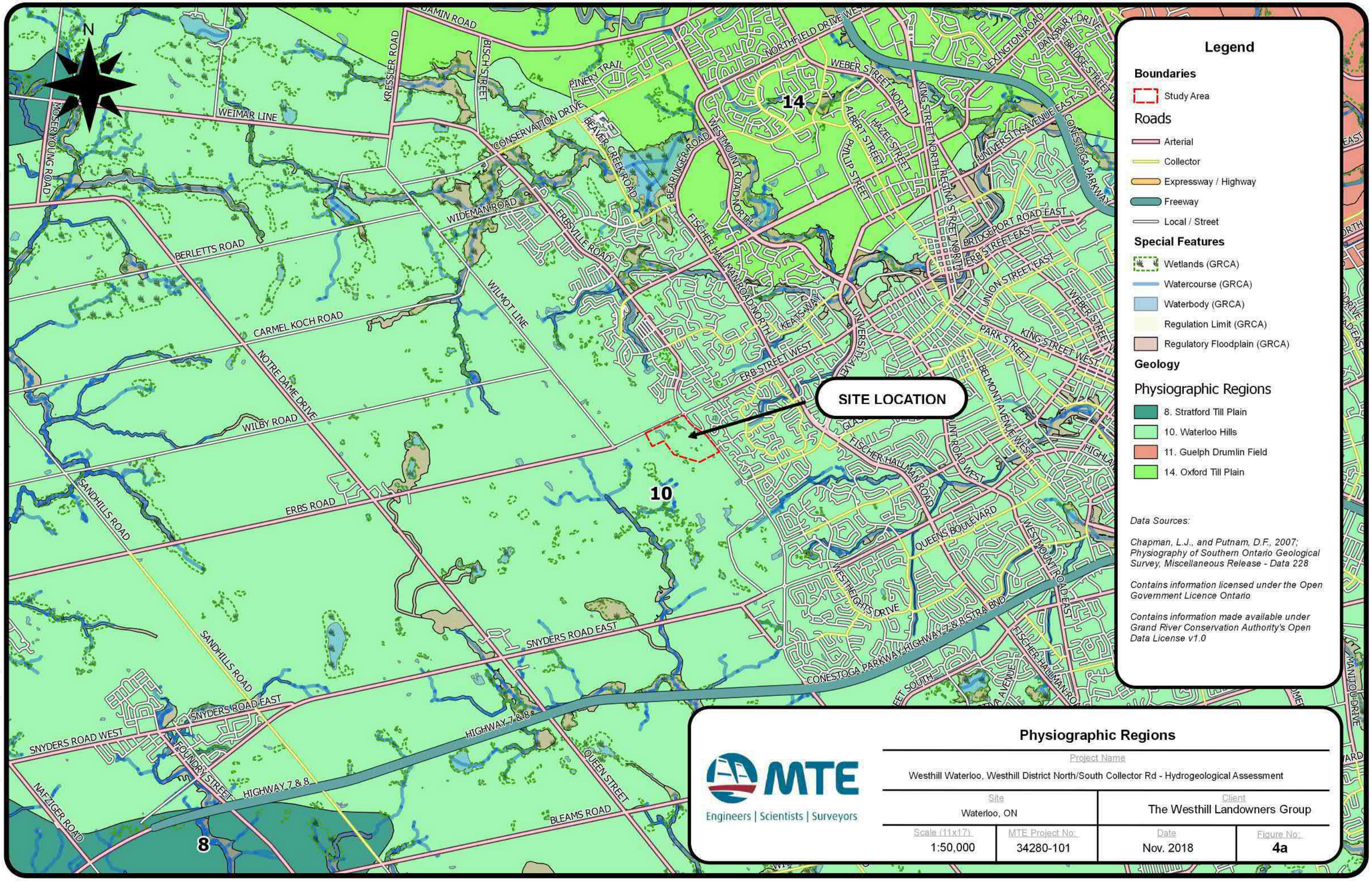
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Existing Conditions

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:4,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 3

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS.qgs
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Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway
- Local / Street

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulation Limit (GRCA)
- Regulatory Floodplain (GRCA)

Geology

Physiographic Regions

- 8. Stratford Till Plain
- 10. Waterloo Hills
- 11. Guelph Drumlin Field
- 14. Oxford Till Plain

Data Sources:

Chapman, L.J., and Putnam, D.F., 2007; Physiography of Southern Ontario Geological Survey, Miscellaneous Release - Data 228

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Physiographic Regions

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:50,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 4a

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS\.qgs
4a -
November 29, 2018 - 17:34 - Plotted By: fabu-hijleh

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SITE LOCATION

Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway
- Local / Street

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulation Limit (GRCA)
- Regulatory Floodplain (GRCA)

Geology

Physio Landforms

- 3. Spillways
- 4. Kame Moraines
- 5. Till Plains (Undrumlinized)
- 6. Till Plains (Drumlinized)

Data Sources:

Chapman, L.J., and Putnam, D.F., 2007; Physiography of Southern Ontario; Ontario Geological Survey, Miscellaneous Release - Data 228

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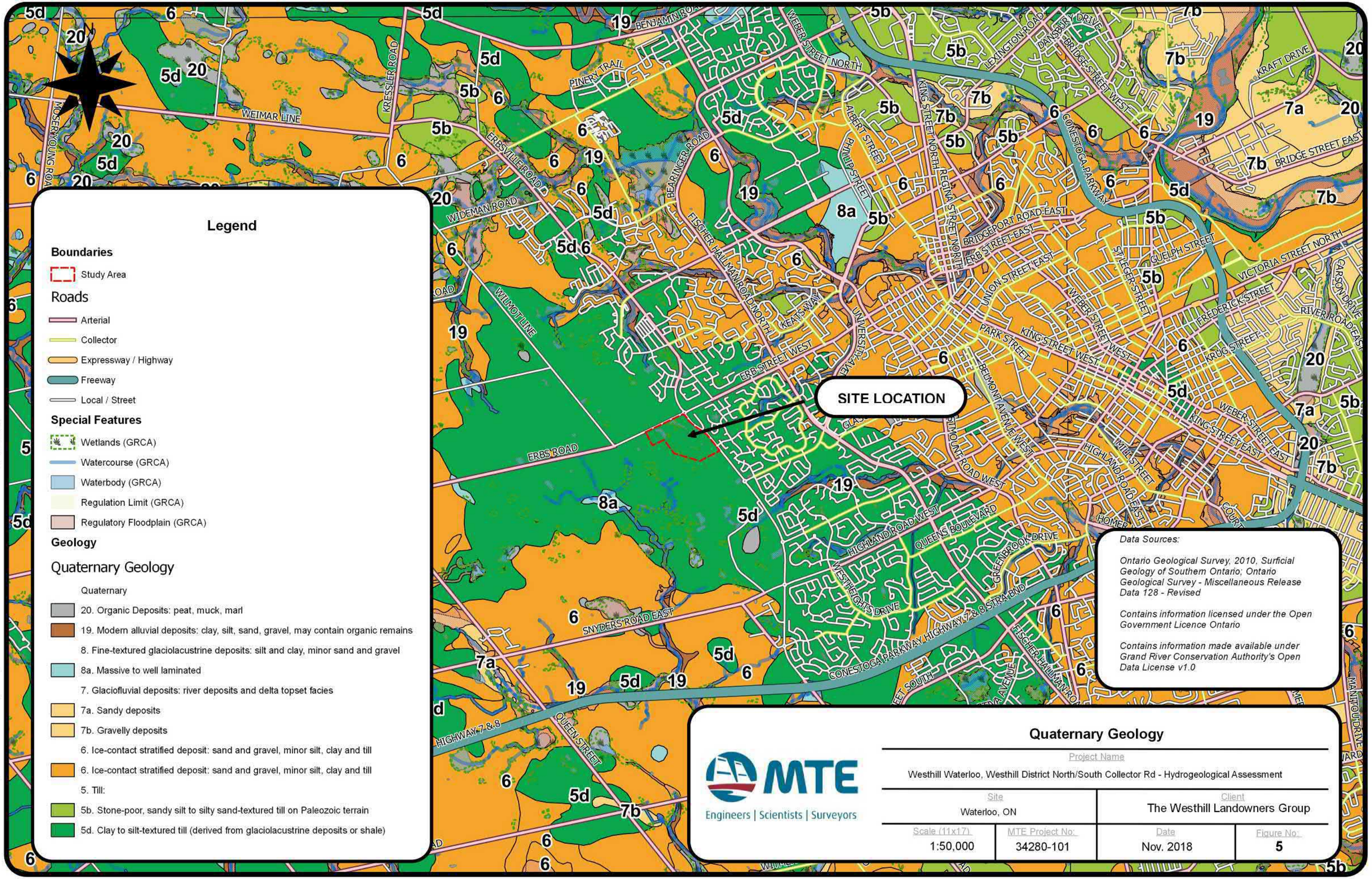
Physiographic Landforms

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:50,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: **4b**

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 QGIS.qgs

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4b -



Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway
- Local / Street

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulation Limit (GRCA)
- Regulatory Floodplain (GRCA)

Geology

Quaternary Geology

Quaternary

- 20. Organic Deposits: peat, muck, marl
- 19. Modern alluvial deposits: clay, silt, sand, gravel, may contain organic remains
- 8. Fine-textured glaciolacustrine deposits: silt and clay, minor sand and gravel
- 8a. Massive to well laminated
- 7. Glaciofluvial deposits: river deposits and delta topset facies
- 7a. Sandy deposits
- 7b. Gravelly deposits
- 6. Ice-contact stratified deposit: sand and gravel, minor silt, clay and till
- 6. Ice-contact stratified deposit: sand and gravel, minor silt, clay and till
- 5. Till:
- 5b. Stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain
- 5d. Clay to silt-textured till (derived from glaciolacustrine deposits or shale)

Data Sources:

Ontario Geological Survey, 2010, Surficial Geology of Southern Ontario; Ontario Geological Survey - Miscellaneous Release Data 128 - Revised

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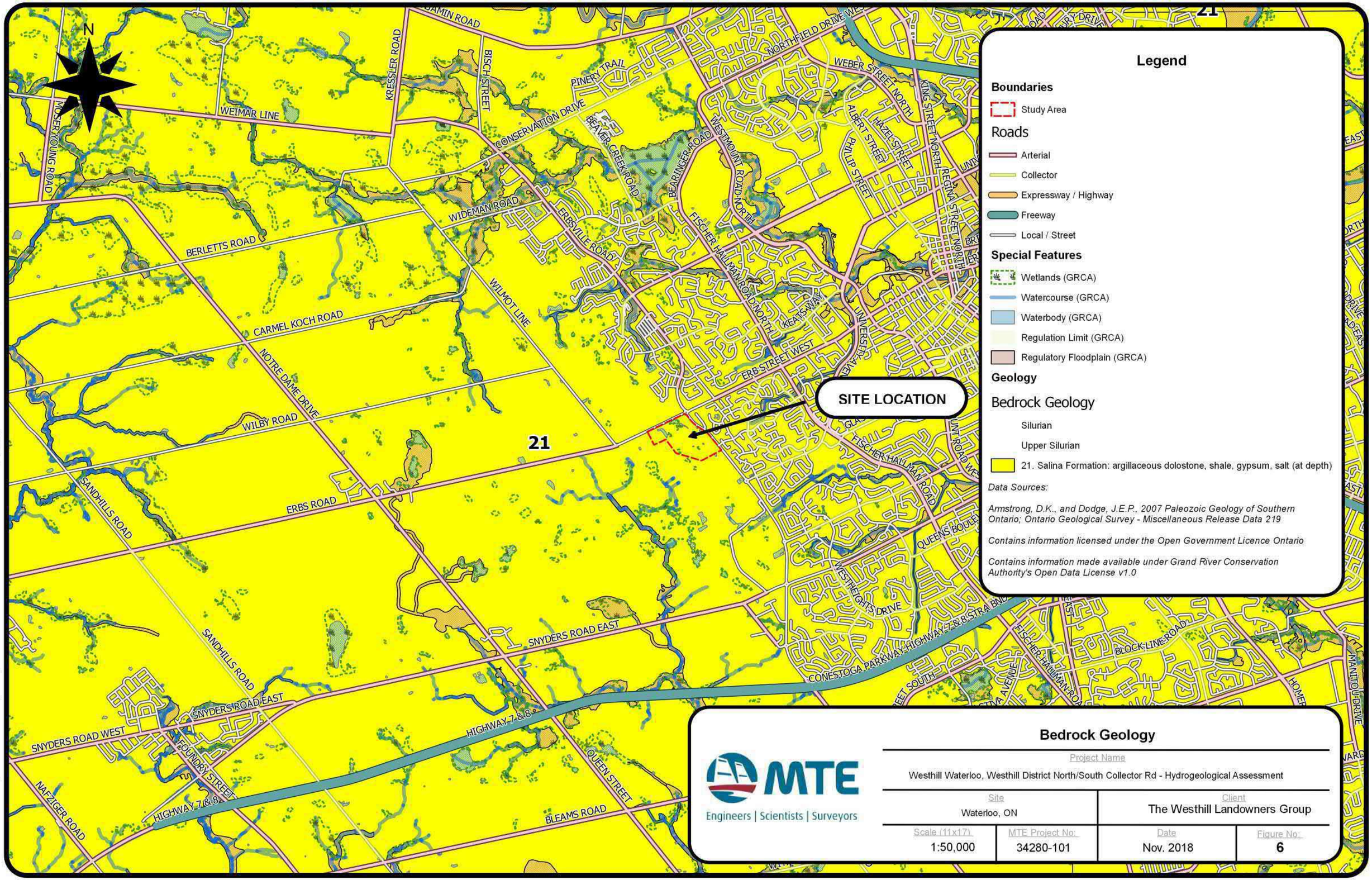
Quaternary Geology

Project Name: Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment

Site	Client
Waterloo, ON	The Westhill Landowners Group

Scale (11x17)	MTE Project No:	Date	Figure No:
1:50,000	34280-101	Nov. 2018	5

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 QGIS.qgs
5 - Quaternary
November 29, 2018 - 17:39 - Plotted By: fabu-hijleh



Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway
- Local / Street

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulation Limit (GRCA)
- Regulatory Floodplain (GRCA)

Geology

Bedrock Geology

- Silurian
- Upper Silurian
- 21. Salina Formation: argillaceous dolostone, shale, gypsum, salt (at depth)

Data Sources:

Armstrong, D.K., and Dodge, J.E.P., 2007 Paleozoic Geology of Southern Ontario; Ontario Geological Survey - Miscellaneous Release Data 219

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Bedrock Geology

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:50,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 6

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS\.qgs

6 - Bedrock

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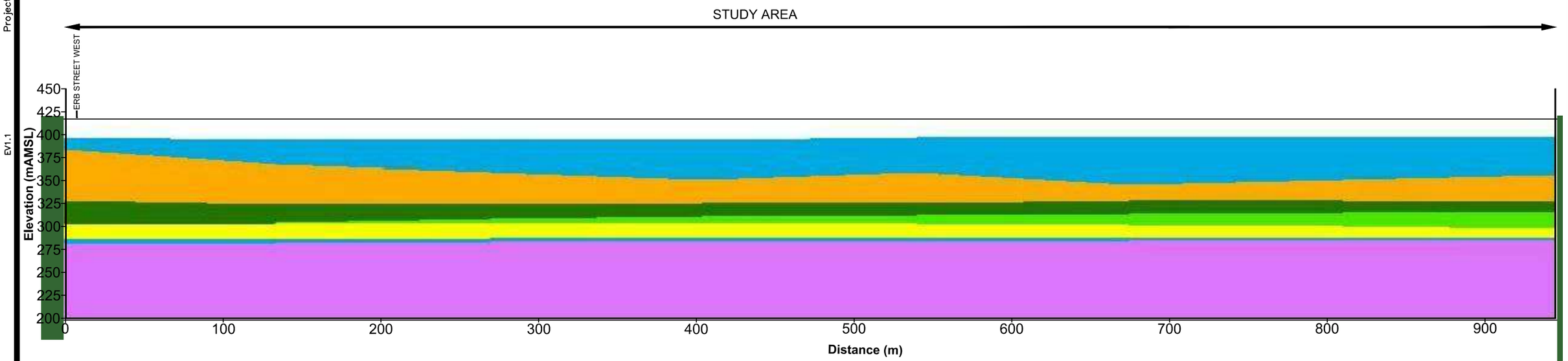
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LEGEND

- UPPER MARYHILL TILL / PORT STANLEY TILL / TAVISTOCK TILL
  (Silty to clayey tills)
- WATERLOO MORAINE
  (Aquifer and equivalents. Consists primarily of fine to medium sand with localized accumulations of gravel)
- MIDDLE MARYHILL TILL
  (Fine grained units of till or glacio lacustrine sediments)
- LOWER MARYHILL TILL
  (Fine textured glacio lacustrine sediments)
- CATFISH CREEK SAND & GRAVEL
  (Glaciofluvial deposits that contains stratified sand & gravel deposits)
- CANNING DRIFT
  (Till and associated fine textured lake deposits that are silty to clayey in texture)
- BEDROCK
  (Carbonates and shales)

Source: Bajc and Shirota, 2007.

STUDY AREA



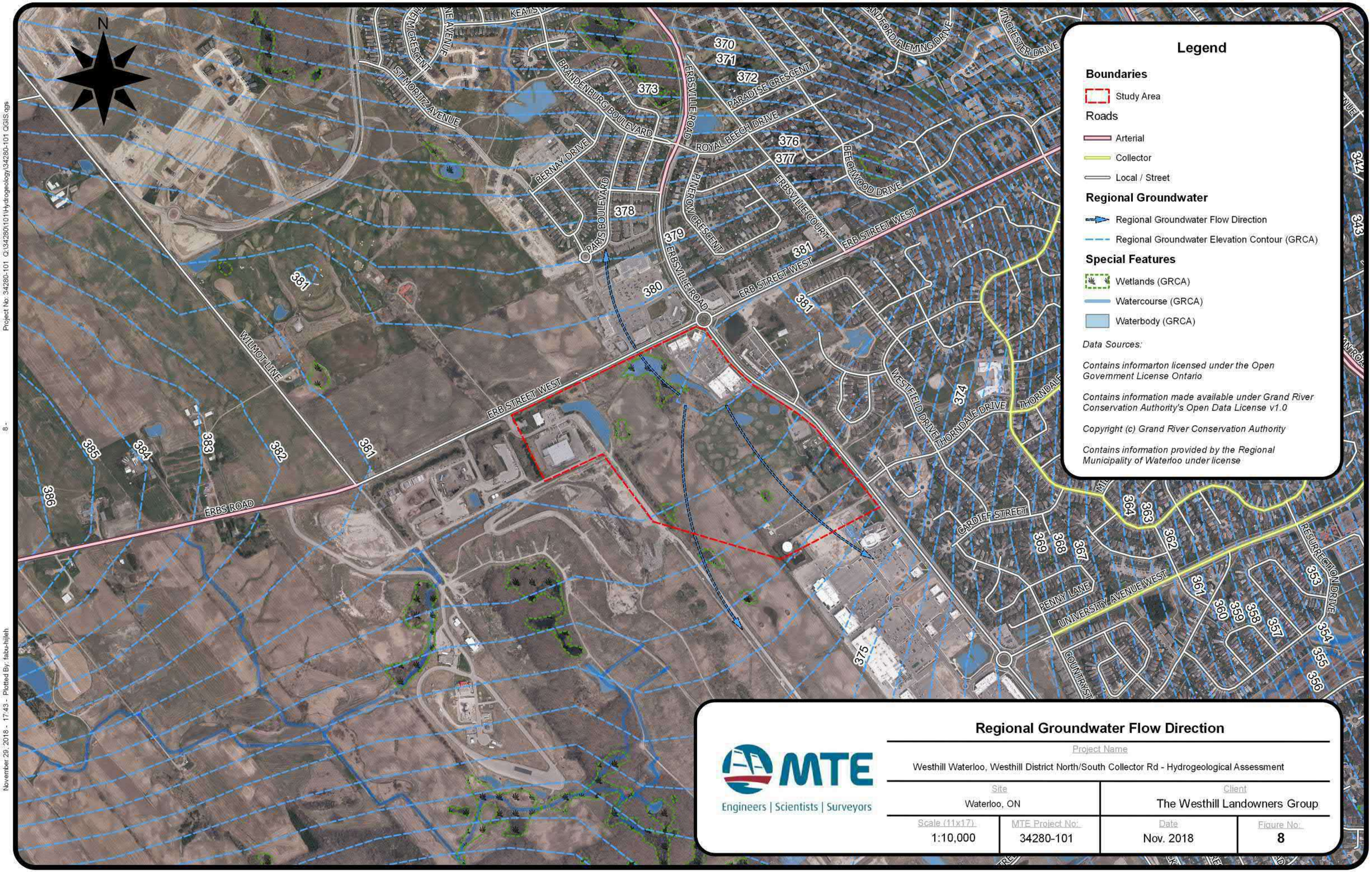
Notes:

This cross-section was generated using the Cross-Section Viewer (Version 1.1) developed by the Ontario Geological Survey (OGS, 2008)

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Geological Cross-Section A-A'

Project Name			
West Waterloo Westhill District North / South Collector Rd - Hydrogeological Investigation			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale: As shown	MTE Project No.: 34280-101	Date: Nov 2018	Figure No.: 7



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Regional Groundwater Flow Direction

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:10,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 8

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS.qgs

November 29, 2018 - 17:43 - Plotted By: fabu-hiljeh

Project: 44000-200 CAD: P:\P\34280\101\34280-101-EV2.DWG EV1.2

LEGEND

Borehole Lithology

- Topsoil
- Fill
- Sand
- Silty Sand
- Silt
- Clayey Silt
- Clay
- Silt Till

Inferred Geology

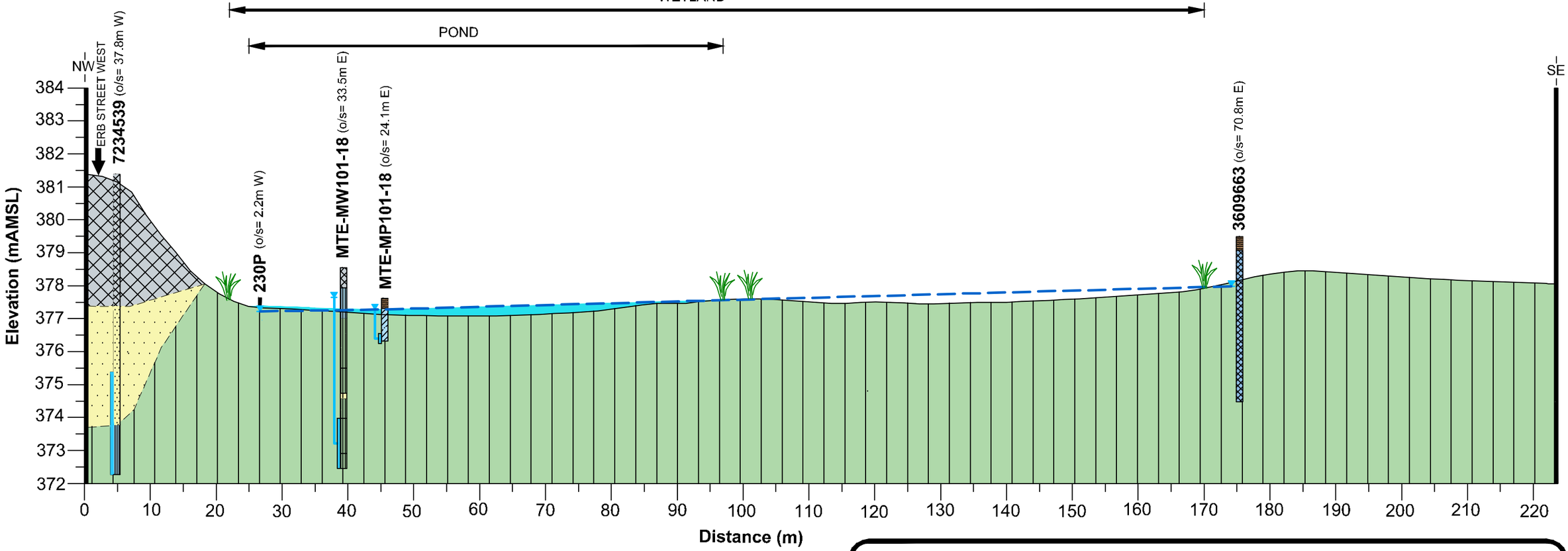
- Fill
- Sand
- Silt Till

- Ground Surface (Inferred)
- Water Table (Inferred)
- 230P — Surface Water Station
- 3609663 (o/s= 70.8m E) — Well ID; Offset Distance (m) and Direction
- Static Water Level (as of Sept. 5/18)
- Monitoring Well / Minipiezometer
- Well Screen

STUDY AREA

WETLAND

POND



Vertical Exaggeration (5X)

Notes:

Geological sequence is based on professional interpretation from the soils encountered during drilling and geological descriptions provided from the MECP online well records database. Actual geological conditions may vary between the tested locations.

The interpreted groundwater surface has been projected on the geological cross-section. Differences between the groundwater surface and wells presented on the geological cross-section is a result of offset distances.

MTE Engineers | Scientists | Surveyors

Geological Cross-Section B-B'

Project Name			
West Waterloo Westhill District North / South Collector Rd - Hydrogeological Investigation			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale: As shown	MTE Project No.: 34280-101	Date: Nov 2018	Figure No.: 9

Project: 44000-200 CAD: P:\P\34280\101\34280-101-EV2.DWG EV1.3

LEGEND

Borehole Lithology

- Topsoil
- Fill
- Sand
- Silty Sand
- Silt
- Clayey Silt
- Silty Clay
- Silt Till

Inferred Geology

- Fill
- Sand
- Silt Till

- Ground Surface (Inferred)
- Water Table (Inferred)

– 230P Surface Water Station

3609663 (o/s= 70.8m E) Offset Distance (m) and Direction

Well ID

Static Water Level (as of Sept. 5/18)

Monitoring Well / Minipiezometer

Well Screen

STUDY AREA

651 - 663 ERB STREET WEST

EXISTING BUILDING

EXISTING BUILDING

WETLAND

POND

SW

NE

7239926 (o/s= 190.4m S)

7239929 (o/s= 25.7m S)

– 230P (o/s= 14.8m N)

MTE-MP101-18 (o/s= 0.1m S)

MTE-MW101-18 (o/s= 7.3m N)

MTE-MW102-16 (o/s= 12.1m N)

MTE-MW101-16 (o/s= 7.6m N)

Elevation (mAMSL)

Distance (m)

Vertical Exaggeration (5X)

Notes:

Geological sequence is based on professional interpretation from the soils encountered during drilling and geological descriptions provided from the MECP online well records database. Actual geological conditions may vary between the tested locations.

The interpreted groundwater surface has been projected on the geological cross-section. Differences between the groundwater surface and wells presented on the geological cross-section is a result of offset distances.

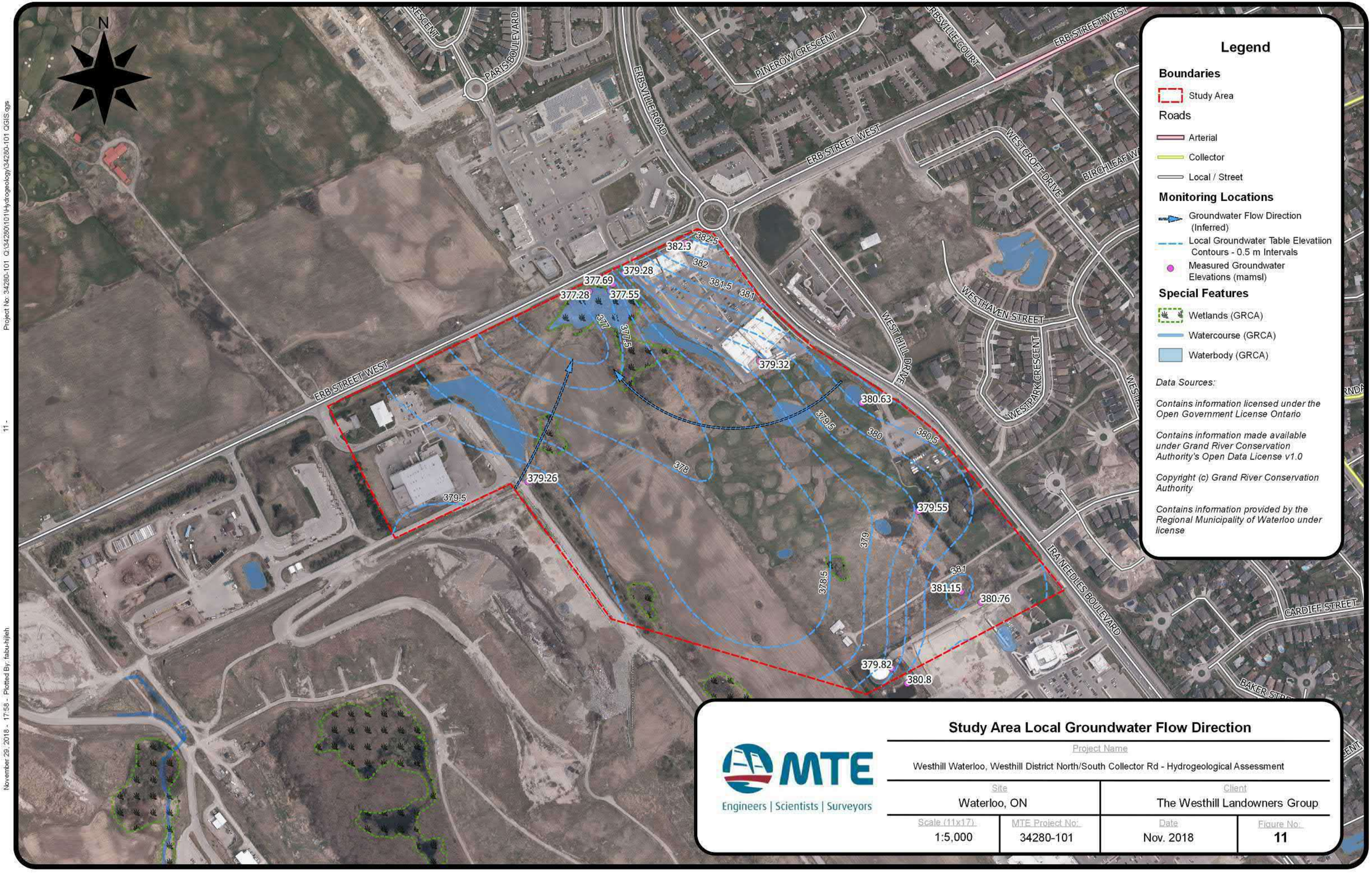
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Geological Cross-Section C-C'

Project Name: **West Waterloo Westhill District North / South Collector Rd - Hydrogeological Investigation**

Site	Client
Waterloo, ON	The Westhill Landowners Group

Scale	MTE Project No.	Date	Figure No.
As shown	34280-101	Nov 2018	10



Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Local / Street

Monitoring Locations

- Groundwater Flow Direction (Inferred)
- Local Groundwater Table Elevatiion Contours - 0.5 m Intervals
- Measured Groundwater Elevations (mamsl)

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Data Sources:

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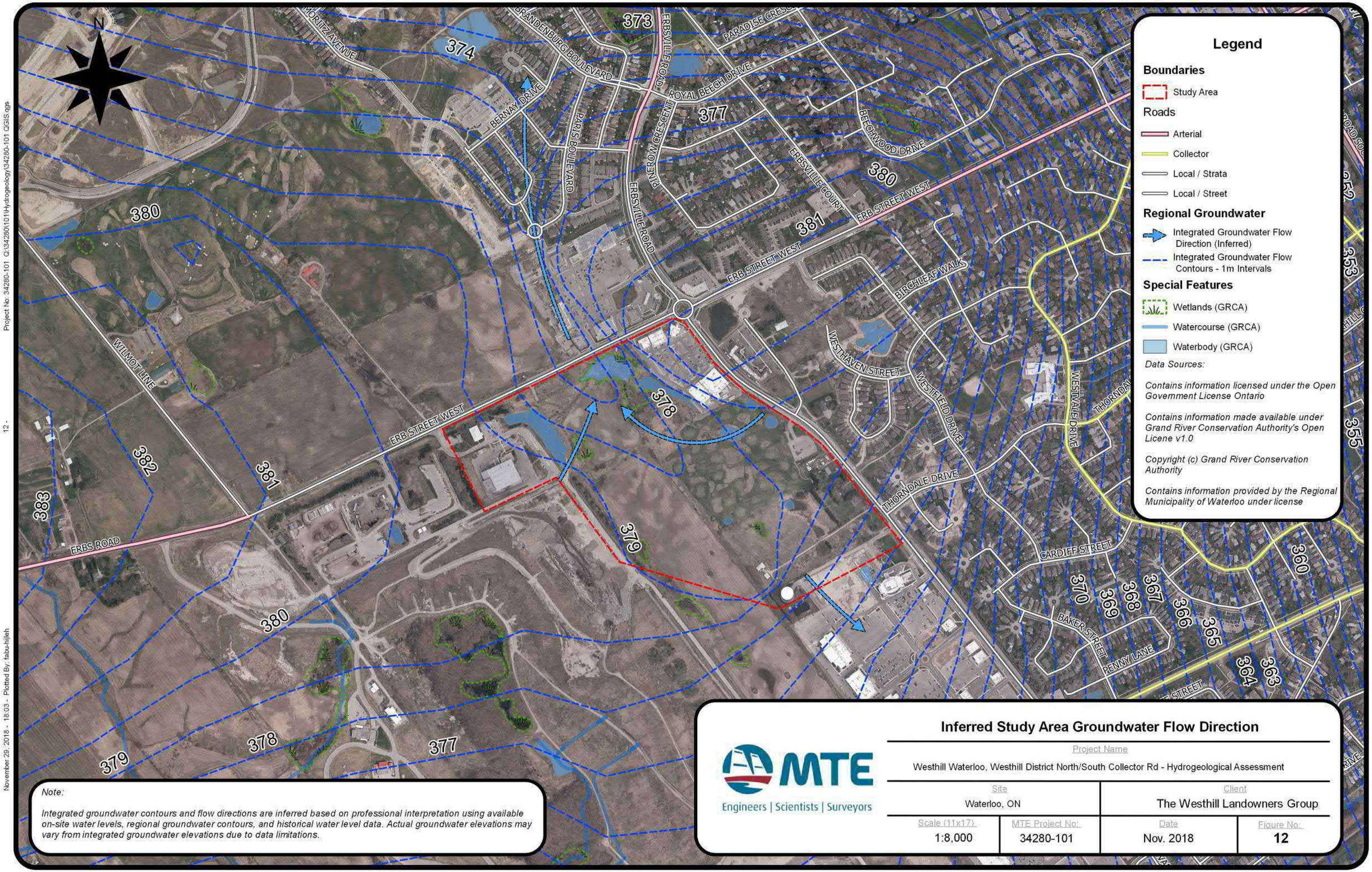
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Study Area Local Groundwater Flow Direction

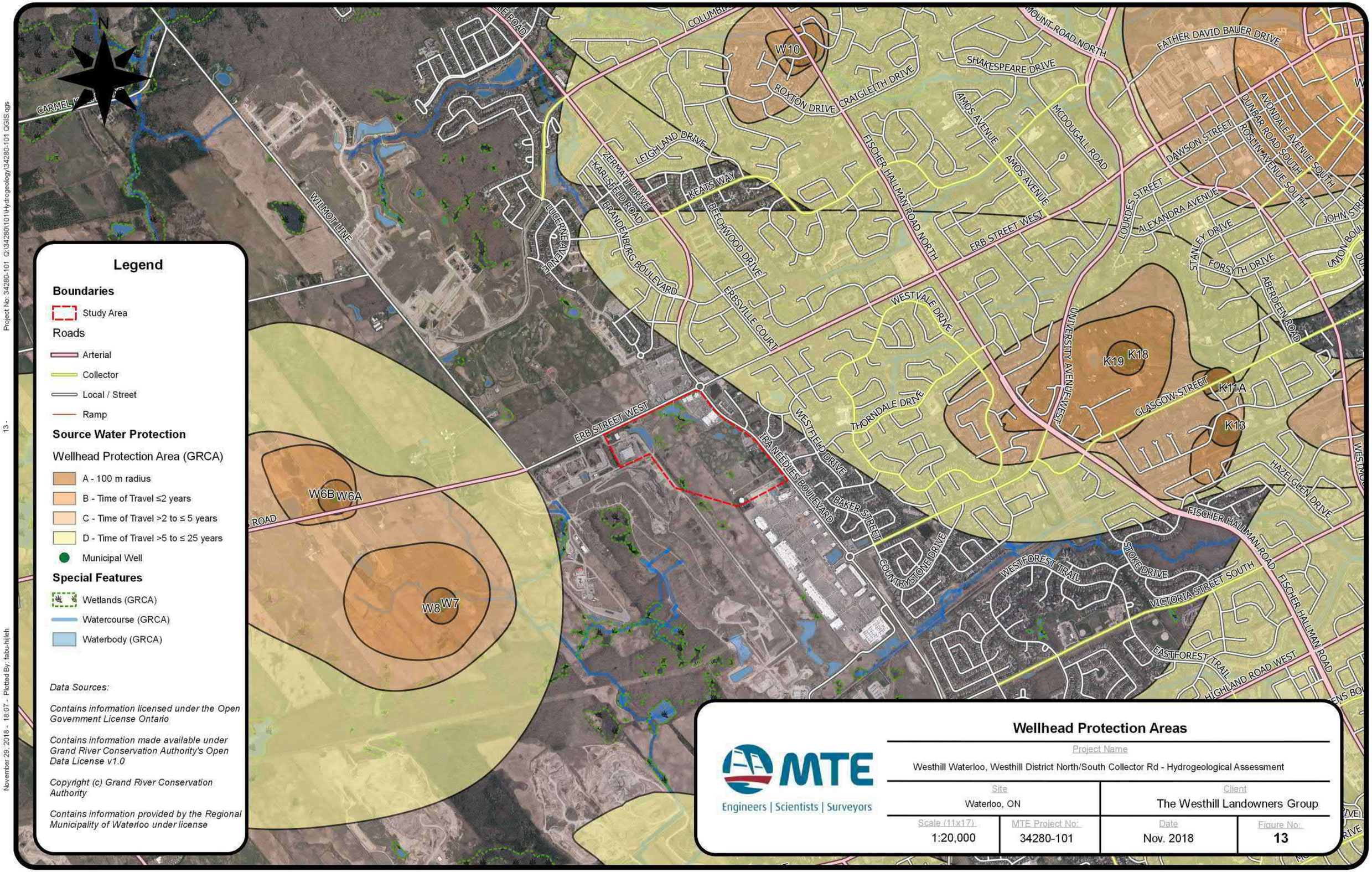
Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:5,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: **11**

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS\.qgs
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11 -



Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS\.gps

November 29, 2018 - 16:03 - Plotted By: fatou-hijleh



Legend

Boundaries

- Study Area

Roads

- Arterial
- Collector
- Local / Street
- Ramp

Source Water Protection

Wellhead Protection Area (GRCA)

- A - 100 m radius
- B - Time of Travel ≤2 years
- C - Time of Travel >2 to ≤ 5 years
- D - Time of Travel >5 to ≤ 25 years
- Municipal Well

Special Features

- Wetlands (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Data Sources:

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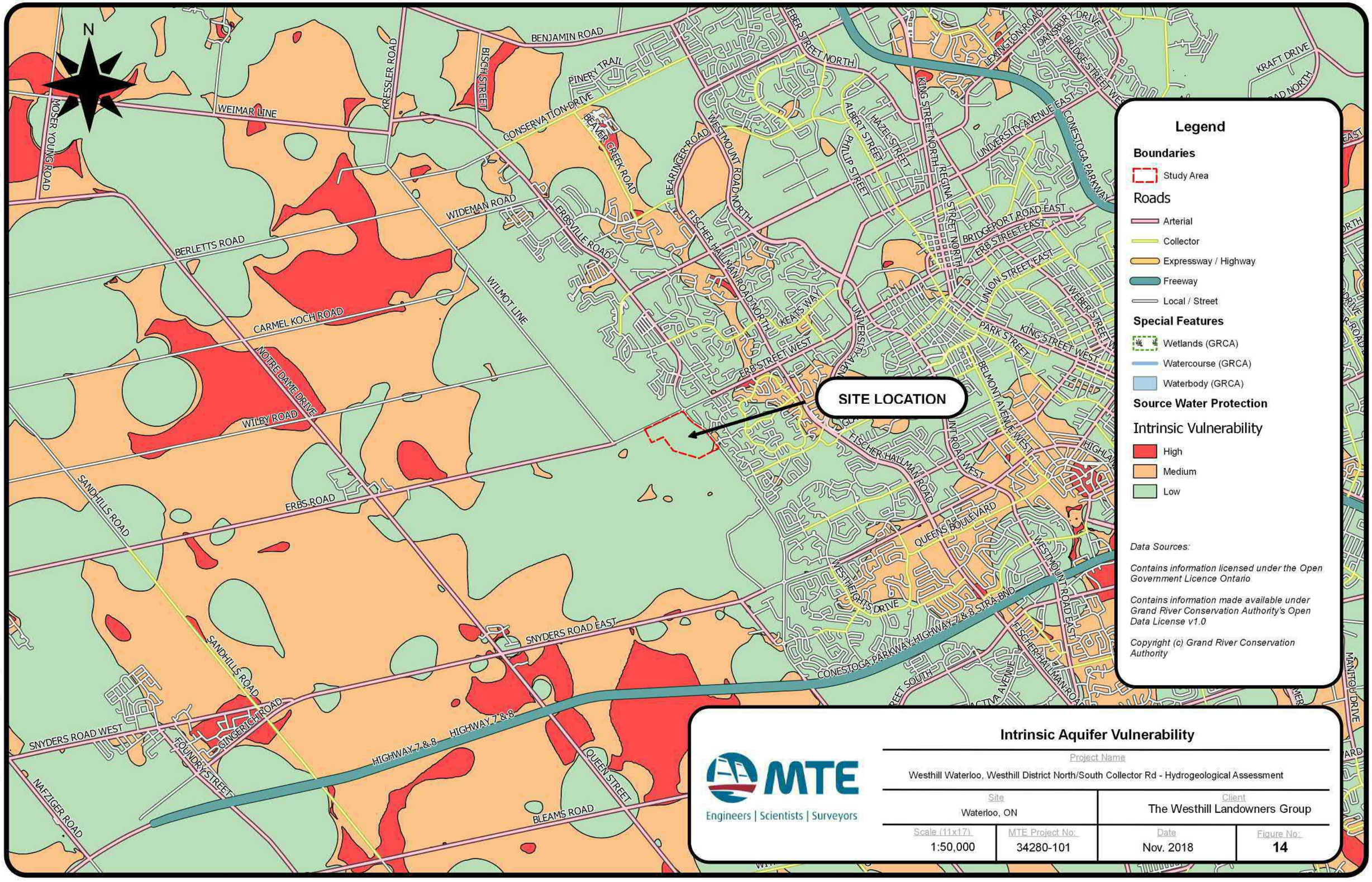
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Wellhead Protection Areas

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:20,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 13

Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS.qgs
November 29, 2018 - 18:07 - Plotted By: fabu-hijleh



Project No: 34280-101 Q:\34280\101\Hydrogeology\34280-101 GIS\.qgs

14 - Intrinsic

November 29, 2018 - 18:09 - Plotted By: fabu-hijleh

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Intrinsic Aquifer Vulnerability

Project Name			
Westhill Waterloo, Westhill District North/South Collector Rd - Hydrogeological Assessment			
Site: Waterloo, ON		Client: The Westhill Landowners Group	
Scale (11x17): 1:50,000	MTE Project No: 34280-101	Date: Nov. 2018	Figure No: 14

TABLES

Table 7.4a: Groundwater Levels (mBPVC)

Date	Well ID						
	MTE-MW101-16	MTE-MW102-16	MTE-MW103-16	MTE-MW101-18	MTE-MW102-18	MTE-MP101-18 (in)	MTE-MP101-18 (out)
21-Mar-16	2.08	2.78	3.30	NI	NI	NI	NI
4-Apr-17	1.44	1.95	1.79	NI	NI	NI	NI
22-Jun-18	-	2.63	-	dry	dry	dry	dry/damp
5-Jul-18	-	2.92	-	2.13	2.35	2.45	dry/damp
26-Jul-18	-	3.16	-	2.10	2.80	2.36	dry/damp
7-Aug-18	-	3.31	-	2.23	3.11	2.10	dry/damp
5-Sep-18	2.56	3.34	3.12	1.83	3.10	1.77	dry/damp
23-Nov-18	2.04	2.33	2.58	1.29	2.25	1.45	dry/damp

Notes: mBTPVC= metres below top of PVC pipe
NI = Not Installed
- = no measurement

Table 7.4b: Groundwater Levels (mBGS)

Date	Well ID						
	MTE-MW101-16	MTE-MW102-16	MTE-MW103-16	MTE-MW101-18	MTE-MW102-18	MTE-MP101-18 (in)	MTE-MP101-18 (out)
Stick up (m)	-0.16	-0.05	-0.09	0.92	1.01	1.43	1.43
21-Mar-16	2.24	2.83	3.39	NI	NI	NI	NI
4-Apr-17	1.60	2.00	1.88	NI	NI	NI	NI
22-Jun-18	-	2.68	-	dry	dry	dry	dry/damp
5-Jul-18	-	2.97	-	1.21	1.34	1.02	dry/damp
26-Jul-18	-	3.21	-	1.18	1.79	0.93	dry/damp
7-Aug-18	-	3.36	-	1.31	2.10	0.67	dry/damp
5-Sep-18	2.72	3.39	3.21	0.91	2.09	0.34	dry/damp
23-Nov-18	2.20	2.38	2.67	0.37	1.24	0.02	dry/damp

Notes: mBGS= metres below top of PVC pipe
NI = Not Installed
- = no measurement

Table 7.4c: Groundwater Elevation (mAMSL)

Date	Well ID						
	MTE-MW101-16	MTE-MW102-16	MTE-MW103-16	MTE-MW101-18	MTE-MW102-18	MTE-MP101-18 (in)	MTE-MP101-18 (out)
TPVC Elevation (mamsl)	384.328	381.967	382.05	379.47	382.49	379.05	379.05
21-Mar-16	382.24	379.19	378.75	NI	NI	NI	NI
4-Apr-17	382.88	380.02	380.26	NI	NI	NI	NI
22-Jun-18	-	379.34	-	dry	dry	dry	dry/damp
5-Jul-18	-	379.05	-	377.34	380.14	376.60	dry/damp
26-Jul-18	-	378.81	-	377.37	379.69	376.69	dry/damp
7-Aug-18	-	378.66	-	377.24	379.38	376.95	dry/damp
5-Sep-18	381.77	378.63	378.93	377.64	379.39	377.28	dry/damp
23-Nov-18	382.29	379.64	379.47	378.18	380.24	377.60	dry/damp

Notes: mAMSL = metres above mean sea level
TPVC = top of PVC Pipe
NI = Not Installed
- = no measurement

Table 8.8: Groundwater and Surface Water Chemistry Summary - 2018

Parameter	Units	DL	MW101-18	MW102-18	Waterloo Commons Wetland (230)		SWM Retention Area (233)		Region of Waterloo SWMP (235)
			L2124640-1	L2124640-2	L2124641-1	L2143413-1	L2124641-2	L2143413-2	L2143413-3
			7/5/2018 2:10:00 PM	7/5/2018 3:00:00 PM	7/5/2018 1:45:00 PM	8/8/2018 10:00:00 AM	7/5/2018 1:45:00 PM	8/8/2018 10:00:00 AM	8/8/2018 2:00:00 PM
			Groundwater	Groundwater	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
Physical Tests									
Colour, Apparent	CU	2	37.2	33.6	295	-	62.4	-	-
Conductivity	umhos/cm	3	2340	755	2670	-	447	-	-
Hardness (as CaCO3)	mg/L	10	834	395	344	-	189	-	-
pH	pH units	0.1	7.71	7.89	7.89	-	8.13	-	-
Total Suspended Solids	mg/L	2	19700	4630	87.1	15.6	4.8	273	15.5
Total Dissolved Solids	mg/L	20	1640	570	1600	-	274	-	-
Turbidity	NTU	0.1	>4000	>4000	113	-	13.3	-	-
Anions and Nutrients									
Alkalinity, Total (as CaCO3)	mg/L	10	363	337	198	-	192	-	-
Ammonia, Total (as N)	mg/L	0.02	0.283	0.094	0.02	-	0.023	-	-
Chloride (Cl)	mg/L	0.5	527	6.5	767	344	30.1	3.11	293
Fluoride (F)	mg/L	0.02	0.12	0.12	0.12	-	0.076	-	-
Nitrate (as N)	mg/L	0.02	<0.10	<0.020	<0.10	0.11	<0.020	0.066	<0.020
Nitrite (as N)	mg/L	0.01	<0.050	<0.010	<0.050	-	<0.010	-	-
Total Phosphorus	mg/L	0.003	-	-	-	0.135	-	0.815	0.0785
Orthophosphate-Dissolved (as P)	mg/L	0.003	<0.0030	<0.0030	0.0099	-	<0.0030	-	-
Sulfate (SO4)	mg/L	0.3	79.4	58.1	15.2	-	2.12	-	-
Total Metals									
Aluminum (Al)-Total	mg/L	0.01	<0.010	0.016	1.73	-	0.035	-	-
Antimony (Sb)-Total	mg/L	0.0001	0.00029	0.00016	<0.0010	-	0.00012	-	-
Arsenic (As)-Total	mg/L	0.0001	0.00048	0.00063	0.0051	-	0.0023	-	-
Barium (Ba)-Total	mg/L	0.0002	0.191	0.199	0.117	-	0.0188	-	-
Beryllium (Be)-Total	mg/L	0.0001	<0.00010	<0.00010	<0.0010	-	<0.00010	-	-
Bismuth (Bi)-Total	mg/L	0.00005	<0.000050	<0.000050	<0.00050	-	<0.000050	-	-
Boron (B)-Total	mg/L	0.01	0.028	0.011	<0.10	-	0.03	-	-
Cadmium (Cd)-Total	mg/L	0.00001	0.000079	0.000028	<0.000050	-	<0.000010	-	-
Calcium (Ca)-Total	mg/L	0.5	198	102	102	-	54.2	-	-
Cesium (Cs)-Total	mg/L	0.00001	0.000019	<0.000010	0.00018	-	<0.000010	-	-
Chromium (Cr)-Total	mg/L	0.0005	<0.00050	<0.00050	<0.0050	-	<0.00050	-	-
Cobalt (Co)-Total	mg/L	0.0001	0.00105	0.00046	0.0011	-	0.00015	-	-
Copper (Cu)-Total	mg/L	0.001	0.0123	0.0044	<0.010	0.0025	<0.0010	0.036	0.0021
Iron (Fe)-Total	mg/L	0.05	<0.050	<0.050	4.86	-	0.941	-	-
Lead (Pb)-Total	mg/L	0.0001	0.0003	0.00024	0.00414	0.00069	<0.00010	0.0168	0.00088
Magnesium (Mg)-Total	mg/L	0.05	82.2	34.3	21.6	-	13	-	-
Manganese (Mn)-Total	mg/L	0.0005	0.153	0.0727	0.56	-	0.0641	-	-
Molybdenum (Mo)-Total	mg/L	0.00005	0.00358	0.00304	0.00253	-	0.000402	-	-
Nickel (Ni)-Total	mg/L	0.0005	0.0076	0.00145	<0.0050	-	0.00057	-	-
Phosphorus (P)-Total	mg/L	0.05	<0.050	<0.050	0.74	0.0545	0.059	0.0766	0.0155
Potassium (K)-Total	mg/L	0.05	6.76	1.69	3.9	-	3.93	-	-
Rubidium (Rb)-Total	mg/L	0.0002	0.00269	0.00093	0.0036	-	0.00063	-	-
Selenium (Se)-Total	mg/L	0.00005	0.000596	0.000186	<0.00050	-	0.000123	-	-
Silicon (Si)-Total	mg/L	0.1	7.88	7.32	7.1	-	0.6	-	-
Silver (Ag)-Total	mg/L	0.00005	<0.000050	<0.000050	<0.00050	-	<0.000050	-	-
Sodium (Na)-Total	mg/L	0.5	156	12.8	409	-	17.5	-	-
Strontium (Sr)-Total	mg/L	0.001	0.477	0.227	0.386	-	0.175	-	-
Sulfur (S)-Total	mg/L	0.5	30.2	19.4	<5.0	-	0.86	-	-
Tellurium (Te)-Total	mg/L	0.0002	<0.00020	<0.00020	<0.0020	-	<0.00020	-	-
Thallium (Tl)-Total	mg/L	0.00001	0.000029	0.000011	<0.00010	-	<0.000010	-	-
Thorium (Th)-Total	mg/L	0.0001	<0.00010	<0.00010	<0.0010	-	<0.00010	-	-
Tin (Sn)-Total	mg/L	0.0001	0.00092	0.00038	<0.0010	-	<0.00010	-	-
Titanium (Ti)-Total	mg/L	0.0004	<0.00030	0.00289	<0.060	-	<0.0010	-	-
Tungsten (W)-Total	mg/L	0.0001	<0.00010	<0.00010	<0.0010	-	<0.00010	-	-
Uranium (U)-Total	mg/L	0.00001	0.00613	0.00227	0.00096	-	0.000482	-	-
Vanadium (V)-Total	mg/L	0.0005	0.00088	0.00063	0.0074	-	<0.00050	-	-
Zinc (Zn)-Total	mg/L	0.003	0.0105	0.0067	<0.030	0.0087	<0.0030	0.109	0.0099
Zirconium (Zr)-Total	mg/L	0.0003	<0.00030	<0.00030	<0.0030	-	<0.00030	-	-

Notes:
DL = Detection Limit

APPENDIX A

CMT BOREHOLE LOGS (2008)

BOREHOLE 1

Date Drilled: September 29, 2008
Rig: Geoprobe 6620DT
Contractor: CMT Engineering Inc.
Drilling Method: SPT

Elevation: 381.17m
Logged by: D.T.

Project No.: 08-337
Project: Golf Course on Ira Neddles Blvd.
Location: Waterloo, ON

Depth (ft/m)	Sample Type	Recovery (%) / Sample Number	Symbols	SOIL DESCRIPTION	Elevation / Depth	Well Installation	Moisture Content % Wp [----X----] Wl (10 20 30 40)	Pocket Penetrometer kPa (100 300) / SPT (N) Blows/0.3 m (10 30 50 70 90)
0 ft / 0 m				Ground Surface (m)	381.17			
				TOPSOIL Loose, moist, black silty topsoil with rootlets (150mm)	0.00			
1	SS	1		***FILL*** Loose, moist, dark brown silty sand fill, trace rootlets and organics	380.57 / 0.60		10.9	9
2	SS	2		- becoming compact			Elev. - 380.66m Oct. 8/08	
3 / 1							14.9	11
4	SS	3		- becoming loose, very moist	379.97 / 1.20		23.6	9
5								
6					379.27			
7 / 2	SS	4		***PEAT*** Very loose, saturated, black peat with organics	1.90		45.03	
8					378.57			
9	SS	5		***SILTY CLAY*** Loose, moist, greyish silty clay, trace gravel	2.60		11.8	5
10 / 3					378.17			
11	SS	6		- becoming very loose	3.00		12.3	0
12					377.47			
13 / 4	SS	7		- becoming compact	3.70		11.4	12
14								
15	SS	8					11.6	21
16					376.27			
17 / 5				End of Borehole	4.90			

Well Installation: Flushmount cover; Bentonite seal; #3 Industrial sand filter; Pre-packed screen

CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
phone 519-699-5775 fax 519-699-4664
www.cmtinc.net

BOREHOLE 2

Date Drilled: September 29, 2008
Rig: Geoprobe 6620DT
Contractor: CMT Engineering Inc.
Drilling Method: SPT

Elevation: 378.55m
Logged by: D.T.

Project No.: 08-337
Project: Golf Course on Ira Needles Blvd.
Location: Waterloo, ON

Depth (ft/m)	Sample Type	Recovery (%) / Sample Number	Symbols	SOIL DESCRIPTION	Elevation / Depth	Well Installation	Moisture Content % Wp [----X----] Wl (10 20 30 40)	Pocket Penetrometer kPa (100 300) / SPT (N) Blows/0.3 m (10 30 50 70 90)
0 ft / 0 m				Ground Surface (m)	378.55			
				TOPSOIL Very loose, damp, brown silty sandy topsoil with rootlets and organics (150mm)	0.00			
1	SS	1					20.2	3
				FILL Loose, damp, brown silty sand fill with rootlets, some reddish staining and topsoil				
2								
3	SS	2					23.6	6
1 m								
4								
					377.05			
5	SS	3		**SAND** - 150mm sand layer	1.50		11.0	14
6				**CLAYEY SILT TILL** Compact, moist, greyish-brown clayey silt with some sand, trace gravel				
2 m	SS	4		- becoming loose			9.6	8
					376.15			
8				- becoming compact	2.40			
9	SS	5					13.4	27
					375.55			
10 3 m				- occasional small sand layers	3.00			
	SS	6			375.20		12.7	19
11				**SILTY CLAY** Compact, moist, grey silty clay, trace gravel	3.35			
12								
13 4 m	SS	7					13.5	13
14								
15	SS	8					13.4	23
16					373.65			
5 m				End of Borehole Borehole experienced wet cave at 1.2m upon completion	4.90			
17								

CMT ENGINEERING INC.
1011 Industrial Crescent, Unit 1
St. Clements, Ontario N0B 2M0
phone 519-699-5775 fax 519-699-4664
www.cmtinc.net

BOREHOLE 3

Date Drilled: September 29, 2008
Rig: Geoprobe 6620DT
Contractor: CMT Engineering Inc.
Drilling Method: SPT

Elevation: 379.61m
Logged by: D.T.

Project No.: 08-337
Project: Golf Course on Ira Neddles Blvd.
Location: Waterloo, ON

Depth (ft/m)	Sample Type	Recovery (%) / Sample Number	Symbols	SOIL DESCRIPTION	Elevation / Depth	Well Installation	Moisture Content % Wp [----X----] Wl (10 20 30 40)	Pocket Penetrometer kPa (100 300) / SPT (N) Blows/0.3 m (10 30 50 70 90)
ft 0 / m 0				Ground Surface (m)	379.61			
				TOPSOIL Loose, moist, dark brown silty sandy topsoil with trace rootlets (130mm)	0.00			
1	SS	1					16.0	4
2				***FILL*** Loose, moist, brown silty sand fill, trace gravel, rootlets and organics	378.81 0.80			
3 / 1	SS	2					14.9	10
				CLAYEY SILT TILL Compact, moist, brown clayey silt	378.51 1.10			
4				***SAND*** - 100mm sand seam				
5	SS	3					14.0	24
				CLAYEY SILT TILL Compact, moist, brown clayey silt, some sand, trace gravel, some staining	377.81 1.80			
6 / 2				- trace staining				
7	SS	4					13.1	19
8								
	SS	5			376.91		13.2	26
9				***SILTY CLAY*** Compact, damp, grey silty clay, trace gravel	2.70			
10 / 3								
11	SS	6					14.3	13
12					375.91			
				- becoming loose, occasional sand pockets	3.70			
13 / 4	SS	7					14.4	5
14					375.31			
				- becoming compact	4.30			
15	SS	8					13.5	12
16					374.71			
5				End of Borehole	4.90			
17				Borehole experienced dry cave at 3.7m upon completion				

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BOREHOLE 4

Date Drilled: September 29, 2008
Rig: Geoprobe 6620DT
Contractor: CMT Engineering Inc.
Drilling Method: SPT

Elevation: 383.14m
Logged by: D.T.

Project No.: 08-337
Project: Golf Course on Ira Neddles Blvd.
Location: Waterloo, ON

Depth (ft/m)	Sample Type	Recovery (%)	Sample Number	Symbols	SOIL DESCRIPTION	Elevation	Depth	Well Installation	Moisture Content % Wp [----X----] Wl 10 20 30 40	Pocket Penetrometer kPa 100 300 / SPT (N) Blows/0.3 m 10 30 50 70 90
					Ground Surface (m)	383.14				
0					***TOPSOIL*** Loose, moist, dark brown silty sandy topsoil with trace rootlets (150mm)		0.00		16.6	4
1	SS	1								
2					***FILL*** Loose, moist, brown silty sand fill, trace gravel and rootlets	382.04	1.10		19.8	6
3	SS	2			***CLAYEY SILT TILL*** Loose, moist, brown clayey silt, some sand, trace gravel, some staining, occasional sand layers	381.34	1.80		11.1	7
4					- becoming compact	380.74	2.40		13.2	16
5	SS	3			- becoming dense				13.8	28
6									11.2	32
7	SS	4								
8										
9	SS	5							11.5	13
10									11.1	20
11	SS	6								
12						379.34	3.80		13.8	21
13	SS	7			***SILTY CLAY*** Compact, moist, grey silty clay, trace gravel, occasional small sand pockets				15.0	15
14										
15	SS	8							11.7	5
16										
17	SS	9							10.6	11
18										
19	SS	10								
20						377.04	6.10			
21	SS	11			- becoming loose	376.44	6.70			
22					- becoming compact					
23	SS	12				375.84	7.30			
24					End of Borehole Borehole experienced dry cave at 6.9m upon completion					
25										

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BOREHOLE 5

Date Drilled: September 29, 2008
Rig: Geoprobe 6620DT
Contractor: CMT Engineering Inc.
Drilling Method: SPT

Elevation: 384.03m
Logged by: D.T.

Project No.: 08-337
Project: Golf Course on Ira Neddles Blvd.
Location: Waterloo, ON

Depth (ft/m)	Sample Type	Recovery (%) / Sample Number	Symbols	SOIL DESCRIPTION	Well Installation	Moisture Content % Wp [----X----] Wl 10 20 30 40	Pocket Penetrometer kPa 100 300 / SPT (N) Blows/0.3 m 10 30 50 70 90
				Ground Surface (m) 384.03			
0				**TOPSOIL** 0.00 Loose, moist, brown silty sandy topsoil with rootlets (180mm)			
1	SS	1		**FILL** Loose, moist, brown silty sand fill, trace rootlets, staining and organics		10.9	8
2	SS	2				12.1	11
3				382.83 1.20			
4	SS	3		**CLAYEY SILT TILL** Compact, moist, brown clayey silt, some sand, trace gravel		12.0	26
5							
6	SS	4				13.5	17
7							
8	SS	5				12.6	28
9							
10	SS	6				12.4	23
11							
12				380.33 3.70			
13	SS	7		**SILTY CLAY** Compact, moist, grey silty clay, trace gravel		13.2	12
14							
15	SS	8				12.5	14
16				379.13 4.90			
17				End of Borehole Borehole experienced dry cave at 4.8m upon completion			

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APPENDIX B

MTE TEST TRENCH LOGS (2011)

Client: RBJ Schlegel Holdings Inc.

Project: Hydrogeology Study

Location: 87 Ira Needles Blvd, Waterloo, ON

Test Trench Number: TT1-11

Job Number: 34280-300

Date: January 25, 2011

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Headspace (ppm)	Comments
0.0	0.00	Ground Elevation					
	0.00	**TOPSOIL** dark brown clayey silt, trace sand with rootlets and organcis, frozen		1	GS		
	-0.30 0.30	**SILT TILL** brown clayey silt till, moist occasional grey clayey layers between 0.5 m and 1.2 m					
	-0.61 0.61			2	GS		
10.0		Test Trench Terminated at 3 m.					Upon Completion Test Trench Walls Stable. No Free Groundwater

Reviewed By: ALB

Method: Backhoe

Notes:

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Logged By: ALB

Sheet: 1 of 1

Client: RBJ Schlegel Holdings Inc.

Project: Hydrogeology Study

Location: 87 Ira Needles Blvd, Waterloo, ON

Test Trench Number: TT2-11

Job Number: 34280-300

Date: January 25, 2011

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Headspace (ppm)	Comments
0.0	0.00	Ground Elevation					
0.0	0.00	**TOPSOIL** dark brown clayey silt, trace sand with rootlets and organics, frozen		1	GS		
2.0		**SILT TILL** brown clayey silt till, moist					
6.0				2	GS		
12.0		Test Trench Terminated at 3.6 m.					Upon Completion Test Trench Walls Stable. Minor Groundwater Infiltration Encountered at 3.3m.

ft / m: 0.0 / 0.0; 2.0 / 4.0; 4.0 / 6.0; 6.0 / 8.0; 8.0 / 10.0; 10.0 / 12.0; 12.0 / 14.0; 14.0 / 16.0; 16.0 / 18.0; 18.0 / 20.0

Reviewed By: ALB

Method: Backhoe

Notes:

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Logged By: ALB

Sheet: 1 of 1

Client: RBJ Schlegel Holdings Inc.

Project: Hydrogeology Study

Location: 87 Ira Needles Blvd, Waterloo, ON

Test Trench Number: TT3-11

Job Number: 34280-300

Date: January 25, 2011

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Headspace (ppm)	Comments
0.0	0.00	Ground Elevation					
	0.00	**TOPSOIL** dark brown clayey silt, trace sand with rootlets and organcis, frozen		1	GS		
2.0		**SILT TILL** brown clayey silt till, moist					
4.0	-1.22 1.22	Some sand and trace gravel encountered					
6.0				2	GS		
8.0							
10.0							Upon Completion Test Trench Walls Stable. No Free Groundwater
12.0		Test Trench Terminated at 3.6 m.					
14.0							
16.0							
18.0							
20.0							

ft / m: 0.0 / 0.0; 2.0 / 2.0; 4.0 / 4.0; 6.0 / 6.0

Reviewed By: ALB

Method: Backhoe

Notes:

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Sheet: 1 of 1

Client: RBJ Schlegel Holdings Inc.

Project: Hydrogeology Study

Location: 87 Ira Needles Blvd, Waterloo, ON

Test Trench Number: TT4-11

Job Number: 34280-300

Date: January 25, 2011

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Headspace (ppm)	Comments
0.0	0.00	Ground Elevation					
	0.00	**FILL** Topsoil along with clayey silt and some clay moist to very moist		1	GS		
4.0	-1.22 1.22	**SILT TILL** brown clayey silt till, moist		2	GS		Upon Completion Test Trench Walls Stable. No Free Groundwater
10.0		Test Trench Terminated at 3 m.					

ft / m: 0.0, 2.0, 4.0, 6.0

Reviewed By: ALB

Method: Backhoe

Notes:

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Sheet: 1 of 1

APPENDIX C

GENIVAR BOREHOLE LOGS (2011)

BOREHOLE NO. BH10-1

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 387.9 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0	TOPSOIL: DARK BROWN TOPSOIL, MOIST										
0.2	SILTY CLAY: DARK BROWN SILTY CLAY, TRACE SAND, OCCASIONAL GRAVEL, MOIST, STIFF			SS1	9	14.1	57				MONITOR MW10-1
1.0				SS2	4	19.4	100				
1.1	SILT TO SANDY SILT: BROWN LAYERS OF SILT TO SANDY SILT, SOME SEAMS OF CLAYEY SILT AND SILTY SAND, COMPACT, MOIST TO WET			SS3	7	16.4	94				
2.0											GROUNDWATER LEVEL IN MONITOR AT 1.98 m BELOW GROUND SURFACE ON MAY 26, 2010
				SS4	8	15.9	94				SS4 GSA: GRAVEL 1% SAND 46% SILT 37 % CLAY 16%
3.0				SS5	11	13.8	50				
3.8	CLAYEY SILT: BROWN CLAYEY SILT, TRACE TO SOME SAND, APL, , SOFT TO STIFF, SOME SEAMS OF SILT, WET, COMPACT										
4.0											
5.0				SS6	14	13.7	100				
6.0											
6.6	END OF HOLE			SS7	3	13.9	100				BOREHOLE OPEN AND DRY TO 6.1 m DEPTH UPON COMPLETION
7.0											
8.0											

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BOREHOLE NO. BH10-2

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 386.1 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0											
0.2	TOPSOIL: DARK BROWN TOPSOIL, MOIST										
	CLAYEY SILT: BROWN CLAYEY SILT, SOME SAND, OCCASIONAL GRAVEL, MOIST, SOME LAYERS SILT AND SANDY SILT VERY STIFF TO HARD			SS1	4		53				
1.0				SS2	9		100				
				SS3	9		100				
2.0											
				SS4	12		100				
3.0											
3.2	SANDY SILT: BROWN SANDY SILT, OCCASIONAL COARSE SAND, TRACE CLAY, MOIST, COMPACT			SS5	17		100				
4.0											
4.1	SILTY CLAY: GREY SILTY CLAY, TRACE SAND, OCCASIONAL GRAVEL, A.T.P.L., MOIST, HARD TO VERY STIFF			SS6	22		89				
5.0											
6.0											
				SS7	8		100				
6.6	END OF HOLE										BOREHOLE OPEN TO 6.1 m DEPTH UPON COMPLETION, DRY
7.0											
8.0											

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GENIVAR

BOREHOLE NO. BH10-3

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00
CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010
BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT
EX. GRADE C/L: 388.3 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0											
0.2	TOPSOIL: DARK BROWN TOPSOIL, OCCASIONAL GRAVEL, MOIST										
	SILTY CLAY - CLAYEY SILT: BROWN LAYERS SILTY CLAY TO CLAYEY SILT SEAMS VERY STIFF TO HARD, OCCASAIONAL GRAVEL, OCCASIONAL SILT, A.T.P.L. TO W.T.P.L.			SS1	3	17.6	60				
1.0				SS2	5	24.3	100				
				SS3	9	21.9	100				
2.0											
				SS4	14	11.5	100				SS4 ATTERBERG: LIQUID LIMIT 20% PLASTIC LIMIT 13% PLASTICITY INDEX 7%
3.0											
				SS5	17	18.5	94				
4.0											
4.4	GRAVELLY SAND: BROWN GRAVELLY SAND (MEDIUM AND COARSE) SOME SILT, TRACE CLAY, SATURATED			SS6	20	14.4	78				BOREHOLE CAVED AT 4.6 m DEPTH UPON COMPLETION, WATER IN OPEN HOLE BELOW 3.1 m DEPTH SS6 GSA: GRAVEL 35% SAND 53% SILT 12% CLAY 0%
5.0											
6.0											
6.2	SILTY CLAY: GREY SILTY CLAY, SOME SAND, W.T.P.L., HARD			SS7	21	12.5	100				
6.6	END OF HOLE										
7.0											
8.0											

GENIVAR

BOREHOLE NO. BH10-4

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 381.9 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0	TOPSOIL: DARK BROWN TOPSOIL, MOIST										MONITOR MW10-4 INSTALLED
0.3	SILTY CLAY: GREY SILTY CLAY, SOME SAND, W.T.P.L.			SS1	3		60				
0.9	CLAYEY SILT: GREY WITH ORANGE CLAYEY SILT, SOME SAND, OCCASIONAL GRAVEL, W.T.P.L., VERY STIFF			SS2	6		100				GROUNDWATER LEVEL IN MONITOR AT 1.14 m BELOW GROUND SURFACE ON MAY 26, 2010
1.8	SILTY SAND: BROWN SILTY FINE SAND TO SANDY SILT, WET			SS3	11		100				
2.1	CLAYEY SILT: GREY, WITH SOME ORANGE MOTTLING CLAYEY SILT, TRACE SAND, OCCASIONAL GRAVEL, W.T.P.L. TO A.T.P.L., STIFF			SS4	4		67				
				SS5	5		100				
4.1	SILTY CLAY: GREY SILTY CLAY, TRACE SAND, W.T.P.L., VERY SITFF			SS6	11		100				
				SS7	10		100				
6.6	END OF HOLE										

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GENIVAR

BOREHOLE NO. BH10-5

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 383.2 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0	TOPSOIL: DARK BROWN TOPSOIL, MOIST										
0.3	SILTY CLAY: LIGHT BROWN SILTY CLAY, FISSURED, MOIST, HARD			SS1	5	18.4	60				
1.0				SS2	13	12.3	100				
1.3	SANDY SILT: LIGHT BROWN SANDY SILT, TRACE CLAY, MOIST, COMPACT			SS3	13	15.2	100				
2.0											
2.0	SILTY CLAY: LIGHT BROWN SILTY CLAY, FISSURED, MOIST, HARD			SS4	13	16.8	100				
3.0											
3.1	SANDY SILT - SILTY CLAY: BROWN TO GREY LAYERS SANDY SILT TO SILTY CLAY, WET, COMPACT OR VERY STIFF			SS5	10	14.9	89				
4.0											
4.3	SILTY CLAY: GREY SILTY CLAY, FISSURED, VERY STIFF TO STIFF			SS6	10	11.4	100				SS6 ATTERBERG: LIQUID LIMIT 18% PLASTIC LIMIT 13% PLASTICITY INDEX 5%
5.0											
6.0				SS7	8	17.1	100				
6.6	END OF HOLE										BOREHOLE OPEN TO 6.5 m DEPTH UPON COMPLETION, DRY
7.0											
8.0											

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BOREHOLE NO. BH10-6

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 382.5 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0	TOPSOIL: DARK BROWN TOPSOIL, MOIST			SS1	2		60				
0.5	SILTY CLAY: GREY TO BROWN SILTY CLAY, A.T.P.L. TO W.T.P.L., FISSURED, STIFF SILTY SAND - SANDY SILT: LIGHT BROWN LAYERS GRAVELLY SILTY SAND TO SANDY SILT, MOIST, COMPACT			SS2	6		100				
1.0											
2.0				SS3	7		100				
2.4	CLAYEY SILT: LIGHT BROWN CLAYEY SILT, SOME SEAMS SANDY SILT, WET, VERY SILT OR COMPACT			SS4	17		78				
3.0											
3.1	SILTY CLAY: GREY SILTY CLAY, OCCASIONAL GRAVEL, A.T.P.L., FISSURED, STIFF			SS5	13		100				OPEN HOLE WATER LEVEL AT 3.1 m BELOW GROUND SURFACE IN COMPLETION
4.0											
5.0				SS6	19		83				
6.0											BOREHOLE CAVED TO 6 m BELOW GROUND SURFACE ON COMPLETION
6.6	END OF HOLE			SS7	16		89				
7.0											
8.0											

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GENIVAR

BOREHOLE NO. BH10-7

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 385.6 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0											
0.2	TOPSOIL: DARK BROWN TOPSOIL, MOIST										
	CLAYEY SILT - SILTY CLAY: BROWN CLAYEY SILT TO SILTY CLAY, OCCASIONAL GRAVEL, A.T.P.L. TO W.T.P.L., FISSURED, STIFF TO HARD			SS1	5	21.3	60				MOINTOR MW10-7 INSTALLED
1.0				SS2	4	26	100				
				SS3	12	19	0				
2.0											
				SS4	15	11.7	100				SS4 GSA: GRAVEL 2% SAND 28% SILT 46% CLAY 24%
2.9											
3.0	CLAYEY SILT: BROWN CLAYEY SILT, SOME SILT SEAMS, MOIST, HARD										
				SS5	19	15	94				
3.8											
4.0	SILTY CLAY: GREY SILTY CLAY, OCCASIONAL COARSE SAND, A.T.P.L., SOME SILT AND CLAYEY SILT SEAMS, FISSURED, VERY STIFF										SS6 GSA: GRAVEL 4% SAND 26% SILT 46% CLAY 24%
				SS6	13	12.3	100				GROUNDWATER LEVEL IN MONITOR AT 4.8 m BELOW GROUND SURFACE ON MAY 26. 2010
5.0											
6.0											
				SS7	10	15.2	100				
6.6	END OF HOLE										
7.0											
8.0											

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GENIVAR

BOREHOLE NO. BH10-8

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 386.9 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0	TOPSOIL: DARK BROWN TOPSOIL, MOIST			SS1	5		30		50/1		
0.6	CLAYEY SILT: BROWN CLAYEY SILT, SOME SAND, OCCASIONAL GRAVEL, D.T.P.L, WITH SEAMS OF SILTY CLAY, FISSURED, HARD			SS2	9		100				
1.0				SS3	20		100				SS3 GSA: GRAVEL 7% SAND 30% SILT 45% CLAY 18%
2.0				SS4	21		100				
3.0				SS5	28		100				SS5 GSA: GRAVEL 4% SAND 23% SILT 46% CLAY 27%
4.0											
4.7	SAND - CLAYEY SILT: LIGHT BROWN LAYERS SILTY FINE SAND, SANDY SILT AND CLAYEY SILT, HARD OR COMPACT, OCCASIONAL GRAVEL, MOIST TO DRY			SS6	34		100				
5.0											
6.0				SS7	44		100		44		BOREHOLE CAVED TO5.8 m BELOW GROUND SURFACE, DRY ON COMPLETION SS7 GSA: GRAVEL 0% SAND 65% SILT 19% CLAY 16%
6.6	END OF HOLE										
7.0											
8.0											

JHL GEOLOGIC B/W (METRIC) 3090996.00.GPJ JAGGER HIMS BASIC.GDT 11/10/10

GENIVAR

BOREHOLE NO. BH10-9

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

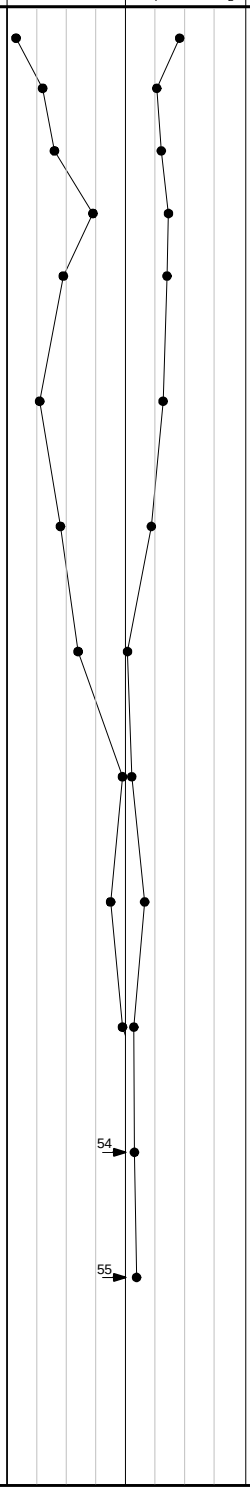
BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 386.2 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	N VALUE	% WATER	% RECOVERY	RQD (%)	REMARKS
0.0									
0.9	TOPSOIL: DARK BROWN TOPSOIL, OCCASIONAL GRAVEL, MOIST			SS1	3	18	60		
1.0	CLAYEY SILT: BROWN CLAYEY SILT, OCCASIONAL GRAVEL, MOIST, FISSURED, HARD			SS2	12	10.4	100		
2.0				SS3	16	11.9	100		
2.6				SS4	29	14.3	100		
3.0	SILTY CLAY: BROWN TO GREY SILTY CLAY, OCCASIONAL GRAVEL, A.T.P.L., FISSURED, HARD TO VERY STIFF			SS5	19	13.8	100		SS5 ATTERBERG: LIQUID LIMIT 23% PLASTIC LIMIT 13% PLASTICITY INDEX 9%
4.0									
5.0				SS6	11	12.5	100		SS6 ATTERBERG: LIQUID LIMIT 21% PLASTIC LIMIT 13% PLASTICITY INDEX 8%
6.0									
6.2	SILTY SAND: LIGHT BROWN FINE SAND, TRACE TO SOME SILTY FINE SAND, MOIST, DENSE TO VERY DENSE			SS7	18	8.6	89		
7.0									
8.0				SS8	24	0.7	78		SS8 GSA: GRAVEL 0% SAND 59% SILT 37% CLAY 7%
9.0									
10.0				SS9	39	2.1	89		
11.0				SS10	35	6.4	61		SS10 GSA: GRAVEL 0% SAND 50% SILT 43% CLAY 7%
12.0									
13.0				SS11	39	2.8	78		
14.0				SS12	54	3	89		BOREHOLE CAVED AT 14.3 m DEPTH UPON COMPLETION, DRY
15.0									
15.0	SANDY SILT: LIGHT BROWN SANDY COARSE SILT, MOIST, VERY DENSE			SS13	55	3.7	94		
15.7	END OF HOLE								
16.0									
17.0									
18.0									

CONE PENETRATION "N" VALUE 10 20 30 — SHEAR STRENGTH

WATER CONTENT % 10 20 30 — W_P W_L



JHL GEOLOGIC B/W (METRIC) 3090996.00.GPJ JAGGER HIMS BASIC.GDT 11/10/10

GENIVAR

BOREHOLE NO. BH10-10

PROJECT NAME: KITCHENER - WATERLOO ELEVATED TANK
PROJECT NO.: 03090996.00

CLIENT: REGION OF WATERLOO
DATE COMPLETED: May 26, 2010

BOREHOLE TYPE: 110 mm SOLID STEM AUGER / 50 mm O.D. SPLIT SPOON
SUPERVISOR: KMT

EX. GRADE C/L: 385.7 mASL
REVIEWER: REM

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	MONITOR DETAILS	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE RQD (%)	CONE PENETRATION "N" VALUE / SHEAR STRENGTH	WATER CONTENT % (W_P – W_L)	REMARKS
0.0											
0.2	**TOPSOIL:** DARK BROWN TOPSOIL, OCCASIONAL GRAVEL, MOIST			SS1	3		60				MOINTOR MW10-10 INSTALLED
1.0	**SAND - SILT:** LAYERS BROWN SAND, SOME SILT TO SANDY SILT, SOME SEAMS OF CLAYEY SILT			SS2	6		72				
2.0				SS3	7		83				
2.1	**SILTY CLAY:** BROWN SILTY CLAY, TRACE GRAVEL, A.T.P.L., FISSURED, VERY STIFF			SS4	12		78				SS4 ATTERBERG: LIQUID LIMIT 23% PLASTIC LIMIT 14% PLASTICITY INDEX 9%
3.0				SS5	14		94				
4.0											
4.7	**SANDY SILT:** BROWN SANDY SILT, TRACE GRAVEL, WET, COMPACT			SS6	21		94				
5.0											
5.6	**SILTY CLAY:** GREY SILTY CLAY, TRACE GRAVEL, W.T.P.L., FISSURED, STIFF TO HARD										WATER LEVEL IN MONITOR AT 5.88 m BELOW GROUND SURFACE ON MAY 26, 2010, PERCHED WATER
6.0				SS7	8		61				SS7 ATTERBERG: LIQUID LIMIT 19% PLASTIC LIMIT 13% PLASTICITY INDEX 6%
7.0											
8.0				SS8	24		83				
9.0											
10.0				SS9	13		100				
10.2	**SAND - SILTY SAND:** LIGHT BROWN SAND, TRACE SILT TO SILTY SAND, MOIST TO DRY, COMPACT TO DENSE										
11.0				SS10	22		83				
12.0											
13.0				SS11	21		100				
14.0				SS12	34		89				
14.9	**SANDY SILT:** LIGHT BROWN SANDY SILT, MOIST, VERY DENSE										
15.0				SS13	67		94		67 →		
15.6	END OF HOLE										
16.0											
17.0											
18.0											

JHL GEOLOGIC B/W (METRIC) 3090996.00.GPJ JAGGER HIMS BASIC.GDT 11/10/10

APPENDIX D

MTE BOREHOLE LOGS (2016)

Client: The INCC Corp. & 1130814 Ontario Inc.

Borehole Number: BH101-15

Project: Phase II ESA

Job Number: 34280-401

Location: 87 & 101 Ira Needles Blvd., Waterloo, ON

Drill Date: December 11, 2015

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Borehole
ft / m								
0.0 / 0.0	0.00	Ground Elevation						
0.0	0.00	**TOPSOIL**						
		FILL silty sand, soft, brown, some clay, moist, no noticeable staining or odours		1	DP	80	0.0	
4.0	-1.52 1.52	light brown						
6.0 / 2.0		**SAND** compact, brown, some silt and stones, saturated, no noticeable staining or odours		2	DP	95	0.2	Backfilled with Bentonite
8.0	-2.59 2.59	**SANDY SILT** firm, brown, some stones, moist, no noticeable staining or odours						
10.0	-3.05 3.05	light brown, some saturated sand seams, increasing silt content with depth Borehole terminated at 3.1 m bgs.						
12.0								
14.0 / 4.0								
16.0								
18.0								
20.0 / 6.0								
22.0								
24.0								
26.0 / 8.0								

Reviewed By: RJF

Method: GeoProbe 7822DT

Notes: Standing water in borehole at 1.7 m bgs

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(519) 743-6500

Logged By: FMK

Sheet: 1 of 1

Client: The INCC Corp. & 1130814 Ontario Inc.

Borehole Number: BH102-15

Project: Phase II ESA

Job Number: 34280-401

Location: 87 & 101 Ira Needles Blvd., Waterloo, ON

Drill Date: December 11, 2015

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Borehole
ft / m		Ground Elevation						
0.0 / 0.0	0.00	**TOPSOIL**						
		FILL silty sand, soft, brown, some clay, moist, no noticeable staining or odours		1	DP	75	0.0	
4.0	-1.22 / 1.22	coarse grained sand						
	-1.52 / 1.52	**SAND** compact, brown, with silt and stones, moist, no noticeable staining or odours						
6.0 / 2.0		saturated		2	DP	80	0.4	Backfilled with Bentonite
8.0	-2.29 / 2.29	**SANDY SILT** firm, brown, some stones, moist, no noticeable staining or odours						
10.0	-3.35 / 3.35	saturated sand seams		3	DP	95	0.3	
12.0 / 4.0	-4.11 / 4.11	**CLAYEY SILT** stiff, brown, moist, no noticeable staining or odours						
14.0	-4.42 / 4.42	grey, wet						
16.0				4	DP	95	0.0	
18.0								
20.0 / 6.0	-6.10 / 6.10	Borehole terminated at 6.1 m bgs.						**Groundwater sampled in-situ with PVC screen (1.5 m long) and pipe installed at 2.7 m bgs.**
22.0								
24.0								
26.0 / 8.0								

Reviewed By: RJF

Method: GeoProbe 7822DT

Notes: Standing water in borehole at 1.5 m bgs

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Sheet: 1 of 1

Client: The INCC Corp. & 1130814 Ontario Inc.

Borehole Number: BH103-15

Project: Phase II ESA

Job Number: 34280-401

Location: 87 & 101 Ira Needles Blvd., Waterloo, ON

Drill Date: December 11, 2015

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Borehole
ft / m								
0.0 / 0.0	0.00	Ground Elevation						
	0.00	**TOPSOIL**						
	-0.46 / 0.46	**FILL** silty sand, soft, brown, some stones and clay, moist, no noticeable staining or odours		1	DP	75	0.0	
4.0	-1.52 / 1.52	**SANDY SILT** firm, brown, some clay, moist, no noticeable staining or odours		2	DP	85	0.0	Backfilled with Bentonite
10.0 / 2.0	-3.05 / 3.05	Borehole terminated at 3.1 m bgs						
12.0								
14.0 / 4.0								
16.0								
18.0								
20.0 / 6.0								
22.0								
24.0								
26.0 / 8.0								

Reviewed By: RJF

Method: GeoProbe 7822DT

Notes: No standing water in borehole

MTE Consultants Inc.
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Logged By: FMK

Sheet: 1 of 1

APPENDIX E

CVD BOREHOLE LOGS (2016)
87 IRA NEEDLES

Enclosure No.: 1
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 201

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

SOIL LITHOLOGY

Ground Elevation: **383.53 m**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL
	very loose to compact brown FILL sand, silt, clayey silt, gravel, trace brick moist to saturated	0.5 1.0 1.5	
381.73 1.80	very stiff to firm brown to grey CLAYEY SILT some sand saturated sand seams, saturated gravelly seams moist saturated silty sand at 2.5 m depth	2.0 2.5 3.0 3.5 4.0	
	saturated sand at 4.5 m depth	4.5 5.0	
378.35 5.18	End of Borehole	5.5	

SAMPLE

SAMPLE ID	TYPE	N-VALUE
1	SS	2
2	SS	17
3	SS	10
4	SS	12
5	SS	23
6	SS	7

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

- wet below 1.2 m depth
- water at 1.5 m, cave-in at 4.1 m depth below existing grade on removal of augers.
- grey below 4.3 m
- water at 1.5 m depth in well installed by MTE Consultants Inc. December 22, 2016

PROJECT MANAGER: **EYC**

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 10/2/16

Enclosure No.: 2
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 202

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
	Ground Elevation: **381.81 m**					
	very soft to very stiff brown to grey CLAYEY SILT some sand, trace to some gravel saturated sand seams, saturated gravelly seams moist	0.5		1	SS	1
		1.0		2	SS	4
		1.5		3	SS	8
		2.0				
		2.5		4	SS	21
		3.0				
378.15		3.5		5	SS	11
3.66	End of Borehole					

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

- grey below 2.8 m depth
- no free water in open borehole on removal of augers
- water at 0.6 m depth in well installed by MTE Consultants Inc. December 22, 2016

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 10/2/16

Enclosure No.: 3
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 203

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	SHEAR STRENGTH (kPa) / PENETRATION RESISTANCE	WATER CONTENT (%)	WELL DATA	DEPTH (m)	REMARKS
	Ground Elevation: **382.48 m**						FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200; PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80	W_P W W_L 10 20 30			
	100 mm TOPSOIL										
	soft to very stiff brown CLAYEY SILT some sand, trace gravel, occasional cobble saturated sand seams	0.5		1	SS	2				0.5	
	moist	1.0		2	SS	6				1.0	
	saturated sandy seams at 1.6 m depth	1.5		3	SS	18				1.5	
	saturated sandy seams at 2.4 m depth	2.0		4	SS	10				2.0	
	saturated sandy seams at 3.8 m depth	2.5		5	SS	14				2.5	
	frequent cobbles	3.0								3.0	
		3.5								3.5	wet below 3.7 m depth
		4.0							▼	4.0	water and cave-in at 4.3 m depth in open borehole on removal of augers.
		4.5		6	SS	30				4.5	
377.30		5.0								5.0	
5.18	End of Borehole	5.5								5.5	

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 28/1/16

Enclosure No.: 4
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 204

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

Ground Elevation: **382.80 m**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
	50 mm TOPSOIL					
	soft to stiff			1	SS	3
	brown to grey	0.5				
	CLAYEY SILT some sand					
	saturated sand seams					
	moist	1.0		2	SS	10
		1.5		3	SS	16
		2.0				
		2.5		4	SS	18
	saturated sand seam at 2.7 m depth	3.0				
		3.5		5	SS	16
	saturated sand seam at 3.5 m depth	4.0				
		4.5		6	SS	13
377.62		5.0				
5.18	End of Borehole	5.5				

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

- water and cave-in at 4.1 m depth in open borehole on removal of augers.
- grey below 5 m depth

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 28/1/16

Enclosure No.: 5
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 205

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

SOIL LITHOLOGY

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL
	Ground Elevation: **381.76 m**		
	firm dark brown to grey ORGANIC SILT rootlets, peat layers, moist to saturated	0.5 1.0	
	peat at 1.3 m depth	1.5	
	silt, grey with some sand below 1.8 m depth	2.0	
379.56 2.20	firm grey CLAYEY SILT some sand saturated sand seams moist	2.5 3.0 3.5	
378.10 3.66	End of Borehole	4.0 4.5 5.0 5.5	

SAMPLE

SAMPLE ID	TYPE	N-VALUE
1	SS	13
2	SS	2
3	SS	4
4	SS	9
5	SS	8

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

44.5

WELL DATA

▼ water at 2.4 m depth in open borehole on removal of augers.

DEPTH (m)

REMARKS

- grey and wet below 1.8 m depth

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 28/1/16

Enclosure No.: 6
Sheet 1 of 1

FILE No: G15225

BOREHOLE No. 206

Client: **MTE Consultants Inc.**

Project: **Proposed Thorndale Drive Extension**

Location: **87 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Hollow Stem Augers**
Size: **76 mm ID**
Date: **Jan 04 / 16** TO **Jan 04 / 16**

ELEV./ DEPTH (m)	SOIL LITHOLOGY: DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	SAMPLE TYPE	N-VALUE	SHEAR STRENGTH (kPa) / PENETRATION RESISTANCE	WATER CONTENT (%)	WELL DATA	DEPTH (m)	REMARKS
	Ground Elevation: **382.05 m**						FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200; PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80	W_P W W_L 10 20 30			
	firm to stiff brown to grey CLAYEY SILT some sand, oxidized fissure	0.5		1	SS	5				0.5	
	moist	1.0		2	SS	7				1.0	
		1.5		3	SS	12				1.5	
		2.0								2.0	
		2.5		4	SS	12				2.5	
		3.0								3.0	grey below 2.9 m depth
		3.5		5	SS	13				3.5	no free water in open borehole on removal of augers.
378.39											
3.66	End of Borehole	4.0								4.0	
		4.5								4.5	
		5.0								5.0	
		5.5								5.5	

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15225 MTE 807 IRA NEEDLES.GPJ CVD_ENG.GDT 28/1/16

APPENDIX F

CVD BOREHOLE LOGS (2016)
101 IRA NEEDLES

Enclosure No.: 1
Sheet 1 of 1

FILE No: G15219

BOREHOLE No. 104

Client: **INCC Corporation c/o MTE Consultants Inc.**

Project: **Proposed Medical Building**

Location: **101 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Steel Casing**
Size: **75 mm OD**
Date: **Dec 11 / 15 TO Dec 11 / 15**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
	Ground Elevation: **384.71 m**					
	250 mm TOPSOIL very loose brown FILL silt, some sand and clay moist	0.5 1.0		1 2	SS SS	4 2
383.31 1.40	compact brown Fine SAND trace to some silt moist	1.5		3	SS	10
382.71 2.00	very stiff brown CLAYEY SILT trace to some sand trace gravel damp to moist	2.0 2.5 3.0 3.5 4.0		4 5	SS SS	24 23
	---- grey occ. wet sandy lenses	4.5 5.0 5.5 6.0 6.5		6 7	SS SS	29 17
378.00 6.71	End of Borehole	7.0 7.5 8.0 8.5				

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

REMARKS
no free water in open borehole on removal of steel casing

PROJECT MANAGER: **EYC**

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CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 5/2/16

Enclosure No.: 2
Sheet 1 of 1

FILE No: G15219

BOREHOLE No. 105

Client: **INCC Corporation c/o MTE Consultants Inc.**

Project: **Proposed Medical Building**

Location: **101 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Steel Casing**
Size: **75 mm OD**
Date: **Dec 11 / 15** TO **Dec 11 / 15**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	SHEAR STRENGTH (kPa) / PENETRATION RESISTANCE	WATER CONTENT (%)	WELL DATA	DEPTH (m)	REMARKS
	Ground Elevation: **385.32 m**						FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200; PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80	W_P W W_L 10 20 30			
	loose, brown to dark brown FILL, silt, some sand, clay and topsoil	0.5		1	SS	5		41.4%		0.5	
384.52 0.80	moist										
	very stiff brown SANDY CLAYEY SILT trace gravel	1.0		2	SS	17				1.0	
		1.5								1.5	
		2.0		3	SS	17				2.0	
	moist with wet sandy lenses	2.5		4	SS	15				2.5	
		3.0								3.0	
		3.5		5	SS	18				3.5	
		4.0								4.0	
	----- grey	4.5								4.5	
		5.0		6	SS	17				5.0	
		5.5								5.5	
	moist to wet	6.0								6.0	
		6.5		7	SS	17			▽	6.5	water at 6.5 m depth in open borehole on removal of steel casing
378.61 6.71	End of Borehole										
		7.0								7.0	
		7.5								7.5	
		8.0								8.0	
		8.5								8.5	

PROJECT MANAGER: **EYC**

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
ph. (519) 742-8979, fx. (519) 742-7739

CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 5/2/16

FILE No: G15219

BOREHOLE No. 106

Client: **INCC Corporation c/o MTE Consultants Inc.**

Project: **Proposed Medical Building**

Location: **101 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Steel Casing**
Size: **75 mm OD**
Date: **Dec 11 / 15 TO Dec 11 / 15**

Ground Elevation: **386.24 m**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
386.09	150 mm TOPSOIL					
0.15	loose orangy brown SAND AND SILT trace to some clay moist	0.5 1.0 1.5		1 2	SS SS	5 5
384.64 1.60	loose brown Fine SAND some silt, trace gravel moist to wet	2.0 2.5		3 4	SS SS	7 7
383.34 2.90	stiff to very stiff brown SILT trace to some sand and clay trace gravel grey moist with wet sandy lenses/seams	3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5		5 6 7	SS SS SS	19 12 15
379.34 6.90	very stiff grey CLAYEY SILT trace gravel and sand moist	7.0 7.5 8.0		8	SS	15
378.01 8.23	End of Borehole	8.5				

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

no free water in open borehole on removal of steel casing

PROJECT MANAGER: **EYC**

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
ph. (519) 742-8979, fx. (519) 742-7739

CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 8/2/16

FILE No: G15219

BOREHOLE No. 107

Client: **INCC Corporation c/o MTE Consultants Inc.**

Project: **Proposed Medical Building**

Location: **101 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Steel Casing**
Size: **75 mm OD**
Date: **Dec 11 / 15** TO **Dec 11 / 15**

SOIL LITHOLOGY

Ground Elevation: **386.47 m**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
	280 mm TOPSOIL					
	loose to compact brown FILL clayey silt and sandy silt some gravel moist to damp	0.5		1	SS	4
		1.0		2	SS	21
385.07 1.40		1.5				
	stiff brown SILT trace to some clay and sand moist	2.0		3	SS	12
384.17 2.30		2.5		4	SS	23
	stiff to very stiff brown CLAYEY SILT trace to some sand trace gravel moist	3.0				
		3.5		5	SS	14
		4.0				
		4.5		6	SS	23
	----- grey	5.0				
		5.5				
		6.0		7	SS	29
	moist to wet	6.5				
		7.0				
		7.5				
378.24 8.23		8.0		8	SS	16
	End of Borehole	8.5				

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

no free water in open borehole on removal of steel casing

PROJECT MANAGER: **EYC**

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
ph. (519) 742-8979, fx. (519) 742-7739

CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 5/2/16

FILE No: G15219

BOREHOLE No. 108

Client: **INCC Corporation c/o MTE Consultants Inc.**

Project: **Proposed Medical Building**

Location: **101 Ira Needles Boulevard, Waterloo, ON**

EQUIPMENT DATA

Machine: **Geoprobe 7822DT**
Method: **Steel Casing**
Size: **75 mm OD**
Date: **Dec 11 / 15** TO **Dec 11 / 15**

SOIL LITHOLOGY

Ground Elevation: **386.04 m**

ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE
	330 mm TOPSOIL			1	SS	2
385.44	very loose, brown FILL, clayey silt	0.5				
0.60	firm to very stiff brown CLAYEY SILT trace to some sand trace gravel	1.0		2	SS	6
		1.5		3	SS	11
	moist with occ. wet sandy silt seams/lenses	2.0				
		2.5		4	SS	14
		3.0				
		3.5		5	SS	18
		4.0				
		4.5				
		5.0		6	SS	12
380.86						
5.18	End of Borehole					

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m)

REMARKS

no free water in open borehole on removal of steel casing

PROJECT MANAGER: **EYC**

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
ph. (519) 742-8979, fx. (519) 742-7739

CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 5/2/16

FILE No: G15219

BOREHOLE No. 109

Client: INCC Corporation c/o MTE Consultants Inc.
Project: Proposed Medical Building
Location: 101 Ira Needles Boulevard, Waterloo, ON

EQUIPMENT DATA
Machine: Geoprobe 7822DT
Method: Steel Casing
Size: 75 mm OD
Date: Dec 11 / 15 TO Dec 11 / 15

Ground Elevation: 384.49 m

ELEV./ DEPTH (m)	DESCRIPTION	SAMPLE ID	TYPE	N-VALUE
384.36 / 0.13	130mm Granular Base			
	loose to compact brown SAND and SILT trace clay moist to wet	1	SS	8
		2	SS	6
		3	SS	10
382.29 / 2.20	very soft to firm brown SILT some sand trace clay and gravel wet	4	SS	2
		5	SS	6
		6	SS	7
379.69 / 4.80	firm, grey CLAYEY SILT some sand wet	7	SS	4
		8	SS	5
378.55 / 5.94	End of Borehole			

SHEAR STRENGTH (kPa)
FIELD VANE: Peak ⊗ Rem. ×
LAB TEST: Unc. ■ P.P. □
50 100 150 200
PENETRATION RESISTANCE
STANDARD ● DYN. CONE ○
20 40 60 80

WATER CONTENT (%)
W_P W W_L
10 20 30

WELL DATA

DEPTH (m): 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5

REMARKS
no free water in open borehole on removal of steel casing

PROJECT MANAGER: EYC

CHUNG & VANDER DOELEN ENGINEERING LTD.
311 Victoria Street North
Kitchener, Ontario N2H 5E1
ph. (519) 742-8979, fx. (519) 742-7739

CVD BOREHOLE (2015) G15219 MTE IRA NEEDLES.GPJ CVD_ENG.GDT 5/2/16

APPENDIX G

MTE BOREHOLE LOGS (2017)

Client: Waterloo Commons Joint Venture

Project: Phase II ESA

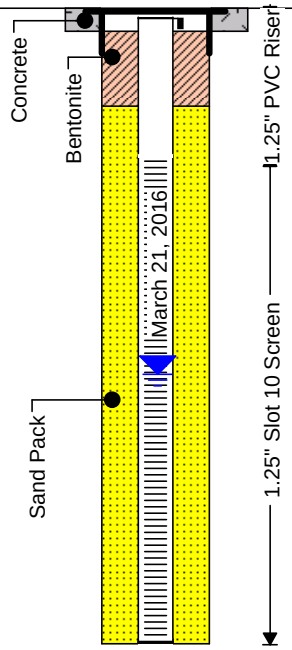
Location: 651-663 Erb Street West, Waterloo

Borehole Number: MW101-16

Job Number: 41179-100

Drill Date: March 14, 2016

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Groundwater Observations and Well Details
ft / m		Ground Elevation						
0.0 / 0.0	99.69 / 0.00	**TOPSOIL**						
		FILL silty sand, compact, brown, trace clay and cobbles, moist, no noticeable staining or odour		1	DP	70	0.1	
2.0	98.78 / 0.91	**SAND** compact, brown, some silt, clay and stones, damp, no noticeable staining or odour						
4.0	98.17 / 1.52	wet at 1.5 m					0.1	
6.0 / 2.0	97.56 / 2.13	**CLAYEY SILT** dense, dark grey from 2.1-2.3 m, brown from 2.3-2.9 m, moist, no noticeable staining or odour		2	DP	60	0.2	
8.0	96.80 / 2.90	**SILTY SAND** compact, brown, trace clay, very wet, no noticeable staining or odour sand and gravel seam from 3.4-3.5 m, saturated		3	DP	100	0.1	
10.0 / 12.0 / 4.0	95.73 / 3.96	**SILTY CLAY** stiff, brown, with grey and red mottling, moist, no noticeable staining or odour					0.1	
14.0				4	DP	100		
16.0								
18.0	94.20 / 5.49	turning grey at 5.5 m						
20.0 / 6.0	93.59 / 6.10	Borehole terminated at 6.1 m bgs						
22.0								
24.0								
26.0								



Reviewed By: RJF

Method: Direct Push

Notes:

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: KMK

Sheet: 1 of 1

Client: Waterloo Commons Joint Venture

Project: Phase II ESA

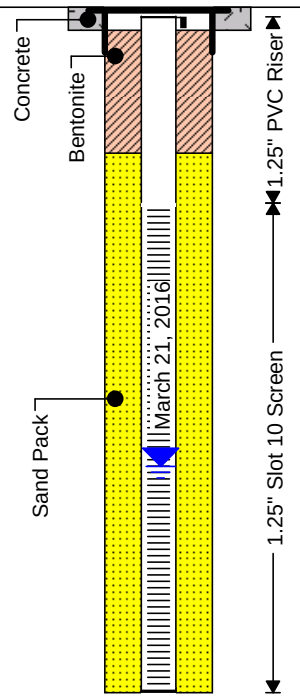
Location: 651-663 Erb Street West, Waterloo

Borehole Number: MW102-16

Job Number: 41179-100

Drill Date: March 14, 2016

Depth (ft)	Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Groundwater Observations and Well Details
		97.26	Ground Elevation						
0.0	0.0	97.26 0.00	**TOPSOIL**						
			FILL silty sand, compact, brown, trace clay and cobbles, moist, no noticeable staining or odour		1	DP	60	0.1	
2.0									
4.0		95.74 1.52	**SILTY SAND** compact, brown grey, some stones, saturated, no noticeable staining or odour					0.2	
6.0	2.0	95.13 2.13	compact, dark brown, with rootlets, moist, no noticeable staining or odour		2	DP	70	0.2	
8.0		94.82 2.44	**CLAYEY SILT** compact, dark brown, moist, no noticeable staining or odour						
10.0		94.52 2.74	**SILTY SAND** loose to compact, brown, very wet, no noticeable staining or odour		3	DP	85	0.1	
12.0	4.0		**SILTY CLAY** stiff, brown, with grey and red mottling, moist, no noticeable staining or odour						
14.0									
16.0								0.2	
18.0					4	DP	90		
20.0	6.0								
22.0					5	DP	75		
24.0		90.25 7.01	turning grey at 7.0 m						
26.0		89.64 7.62	Borehole terminated at 7.6 m bgs						



Reviewed By: RJF

Method: Direct Push

Notes:

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: KMK

Client: Waterloo Commons Joint Venture

Project: Phase II ESA

Location: 651-663 Erb Street West, Waterloo

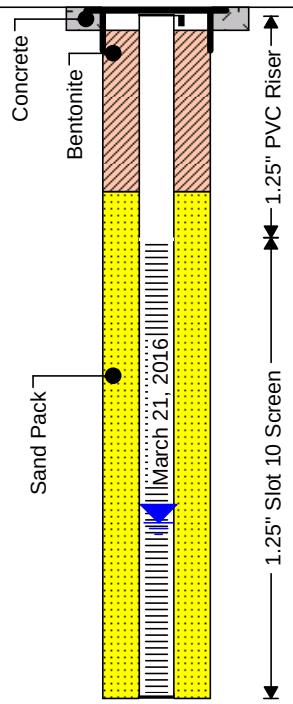
Borehole Number: MW103-16

Job Number: 41179-100

Drill Date: March 14, 2016

Depth (ft)	Depth (m)	Elevation (m)	Soil Description	Number	Type	Recovery (%)	Headspace (ppm)
		97.42	Ground Elevation				
0.0	0.0	0.00	**TOPSOIL**				
			FILL sand and gravel, compact, brown, moist, no noticeable staining or odour	1	DP	70	0.0
2.0		96.50 0.91	sandy silt, compact, brown, grey from 1.2-1.5 m, some stones, damp, no noticeable staining or odour				
4.0							
6.0	2.0	95.28 2.13					0.1
			TOPSOIL sandy silt, compact, brown to dark brown, some rootlets, no noticeable staining or odour	2	DP	85	
8.0			**SILTY SAND** compact, brown, trace clay, moist, no noticeable staining or odour				0.1
10.0		94.06 3.35	saturated				
12.0		93.61 3.81					0.0
	4.0		**SILTY CLAY** stiff, brown, with grey and red mottling, moist, no noticeable staining or odour	3	DP	100	
14.0							0.0
16.0							
18.0				4	DP	100	
20.0	6.0	91.32 6.10	Borehole terminated at 6.1 m bgs				
22.0							
24.0							
26.0	8.0						

Groundwater Observations and Well Details



Reviewed By: RJF

Method: Direct Push

Notes:

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: KMK

Client: Waterloo Commons Joint Venture

Project: Phase II ESA

Location: 651-663 Erb Street West, Waterloo

MTE More Than Engineering

Borehole Number: BH104-16

Job Number: 41179-100

Drill Date: March 14, 2016

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	Recovery (%)	Headspace (ppm)	Borehole
ft / m		Ground Elevation						
0.0 / 0.0	0.00	**ASPHALT**						
		FILL sand and gravel, compact, brown, moist, no noticeable staining or odour					0.0	
2.0	0.61	silty sand, compact, brown, trace clay and cobbles, moist, no noticeable staining or odour		1	DP	60		
	0.91	**SILTY CLAY** stiff, brown, moist, no noticeable staining or odour						
4.0								
6.0 / 2.0				2	DP	100	0.1	Backfilled with Bentonite
8.0								
10.0								
12.0				3	DP	100		
14.0 / 4.0							0.0	
	4.57	Borehole terminated at 4.6 m bgs						
16.0								
18.0								
20.0 / 6.0								

Reviewed By: RJF

Method: Direct Push

Notes:

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: KMK

Sheet: 1 of 1

APPENDIX H

GRCA WETLAND REMOVAL PERMIT AND CIVIL PLANS

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

Phone: 519.621.2761 **Toll free:** 866.900.4722 **Fax:** 519.621.4844 **Online:** www.grandriver.ca

January 19, 2016

1130814 Ontario Inc.
c/o Carol Cressman
1433 Berletts Road,
St. Agatha, ON, N0B 2L0

Dear Ms. Cressman,

Re: Application for Permission No. 755/15, Pursuant to Ontario Regulation 150/06 to construct a roadway and roundabout resulting in 0.8 hectares of wetland loss at 73 and 87 Ira Needles Boulevard, in the City of Waterloo

The Grand River Conservation Authority approved your application on January 19, 2016 to construct a roadway and roundabout resulting in 0.8 hectares of wetland loss at 73 and 87 Ira Needles Boulevard, in the City of Waterloo. We have enclosed the permit with the attached schedules.

The schedules form part of the permit and describe the work approved. Any changes to these plans must be reviewed and approved by the Grand River Conservation Authority. Please note that permission is based on existing information, policies and practices and does not bind or imply that any other permission will be forthcoming. Please notify our office on completion of the work.

If you have any questions regarding this letter or the conditions described on the permit, please contact me.

Yours truly,

Kaitlyn Smith
Resource Planner
Resource Management Division

KS*dg

Encl.

c.c. Clerk, City of Waterloo (letter only)
Building Inspector, City of Waterloo
Walterfedy

Received by
WALTERFEDY

FEB 04 2016

Project No.:
File Name:
Initials:

Permit No. #755/15

Grand River Conservation Authority

Under Ontario Regulation 150/06 made under the Conservation Authorities Act, R.S.O. 1990, Chapter C.27, permission is granted to:

1130814 Ontario Inc.
c/o Carol Cressman

Whose address for purposes pertaining to this project is:

1433 Berletts Road,
St. Agatha, ON
N0B 2L0

To execute proposed works in accordance with the following particulars and conditions:

Location of Work: 73 and 87 Ira Needles Boulevard,
City of Waterloo

Purpose of Work: To construct a roadway and roundabout resulting in 0.8 hectares of wetland loss at 73 and 87 Ira Needles Boulevard, in the City of Waterloo.

Nature of Work: To construct a roadway and roundabout resulting in 0.8 hectares of wetland loss.

This permit is valid from: **January 19, 2016**

and expires on: **January 19, 2018**

The attached Schedules form parts of this permit describing the approved work and must be implemented in order so that the true intent of the permit can be achieved.

The Permittee, by acceptance and in consideration of the issuance of this permit, agrees to the conditions listed on the reverse side of Schedule "A".

Dated at Cambridge, Ontario, this 19th day of January, 2016

GRAND RIVER CONSERVATION AUTHORITY

Joe Farwell

Joe Farwell,
Chief Administrative Officer

Grand River Conservation Authority

Administration Office:
400 Clyde Road, P.O. Box 729, Cambridge, Ontario N1R 5W6
Telephone: 519-621-2761 Fax: (519) 621-4945

GRCA USE ONLY
APPLICATION NUMBER
755/15

Schedule "A" - Application for Development, Interference With Wetlands and Alterations to Shorelines and Watercourses Permit (Pursuant to Ontario Regulation 150/06)

Please read, complete each section as required, attach fee and sign and date this application.

Owner's name: 1130814 Ontario Inc. E-mail: carolcressman@bell.net

Mailing address: 1433 Berletts Road City/Town: St. Agatha Postal Code: N0B 2L0

Telephone: Bus. (519) 885-2020 Res. (____) _____ Fax (____) _____

Agent's name (Consultant/Contractor): Dan Schipper, P.Eng. (WalterFedy)

Mailing address: 675 Queen St. S., Ste 111 City/Town: Kitchener Postal Code: N2M 1A1

Telephone: Bus. (519) 576-2150 Fax: (519) 576-5499 Email: dschipper@walterfedy.com

Location of proposed work:

Lot No. 40RP58R6504 Concession No. _____ Township _____

Municipal address of property: 87 Ira Needles Boulevard

City/Town/Village: Waterloo County/Region: Waterloo
(Circle One)

Application is hereby made for:

For examples of Minor, Standard and Major applications please refer to the Fee Schedule on pages 3 and 4.

- ☐ Minor Development
- ☐ Minor Interference with Wetlands, Alteration to Shorelines & Watercourses
- ☐ Standard Development
- ☐ Standard Interference with Wetlands, Alteration to Shorelines & Watercourses
- ☑ Major Development
- ☐ Major Interference with Wetlands, Alteration to Shorelines & Watercourses

Description of proposed work: Construction of the extension of Thorndale Drive to the west of Ira Needles Boulevard, complete with roundabout and connection to the adjacent development (Boardwalk), which includes placement of fill and adjustment of existing depressions.

This application must include four (4) folded copies of each appropriate plan(s) showing the proposed work.

Land Use: Present Vacant Proposed change (if any) Roadway/Commercial

I declare that I have read and agree to the General Conditions of Permit on the reverse of this form and that all information provided is true.

_____	2015/12/03	_____
Signature of Owner	Date	Signature of Agent

GENERAL CONDITIONS OF PERMIT

1. This permit does not absolve the permittee of the responsibility of obtaining necessary permission from applicable federal and provincial agencies or local municipalities.

2. The permittee agrees by acceptance of the permit:

   (a) to indemnity and save harmless, the Grand River Conservation Authority and its officers, employees, or agents, from and against all damage, injury, loss, costs, claims, demands, actions and proceedings, arising out of or resulting from any act or omission of the permittee or of any of his agents, employees or contractors relating to any of the particular terms or conditions of this permit.

   (b) that this permit shall not release the permittee from any legal liability or obligation and remains in force subject to all limitations, requirements and liabilities imposed by law.

   (c) that all complaints arising from the proposed works authorized under this permit shall be reported immediately by the permittee to the Grand River Conservation Authority. The permittee shall indicate any action which has been taken, or is planned to be taken, with regard to each complaint.

   (d) to provide certification of conformance to ensure compliance with the intent of the permit. This certification must be provided by an accredited professional and is to be submitted as may be specified in the permit.

3. Authorized representatives of the Grand River Conservation Authority will be granted entry at any time into lands and buildings which are the subject of this permit application in order to make such surveys, examinations, investigations, inspections or other arrangements which such representatives deem necessary.

4. The Grand River Conservation Authority may cancel this permit or may change any of the conditions at any time and without prior notice if it is determined that:

   (a) the works are not in conformance to the intent of the permission granted;

   (b) the information presented to obtain a permit is false;

   (c) the works or method of construction have detrimental impacts on the environment.

5. This permit shall not be assigned (non-transferable).

6. Permits are valid for two years. No notice will be issued on expiration of the permit and it is the responsibility of the permittee to ensure a valid permit is in effect at the time work is occurring.

7. The Grand River Conservation Authority may make copies of Schedule A, as required, for the purposes of assessing the proposal and, where approved, to form part of the permit issued.

NOTICE OF COLLECTION

Pursuant to section 29(2) of the Municipal Freedom of Information and Protection of Individual Privacy Act, 1989, the personal information contained on this form is collected under the legal authority of the Conservation Authorities Act, R.S.O. 1980, c85, as amended. This information is used to assess applications for and, where approved, issue the Permit. Information on this form may be disclosed to Government and Municipal Agencies for review and comment. The name of the applicant, location of the work and a description of the project may be published in GRCA documents including agendas, reports and meeting minutes which are posted on the GRCA website. Questions about the collection of personal information should be directed to the Freedom of Information Co-ordinator, Administration Division, Grand River Conservation Authority, 400 Clyde Road, P.O. Box 729, Cambridge, Ontario, N1R 5W6, (519) 621-2761.

PROPOSED AREA OF STORMWATER CATCHMENT
POND DATA
BOTTOM=379.90
TOP=380.62
VOLUME=840m³

GRCA IDENTIFIED BOUNDARY TO BE RETAINED

GRCA IDENTIFIED BOUNDARY (TO BE ELIMINATED)

GRADING LIMIT

FUTURE ROADWAY

THORNDALE ROAD

IRA NEEDLES BLVD.

THORNDALE

ROUNDABOUT ON IRA NEEDLES BLVD BY REGION OF WATERLOO

MATCHLINE TO REGIONAL CONTRACT

FUTURE BUILDING (BY OTHERS) FF=384.20

FUTURE BUILDING BY OTHERS

10m REGIONAL WATER EASEMENT

EXISTING REGIONAL WATER TOWER

THE IRA NEEDLES BOARDWALK DEVELOPMENT

73 IRA NEEDLES BLVD.

INTERLOCKING BRICK

EX. ASPHALT

EX. GRAVEL ROAD

EX. BLDG

SEPTIC TANK

SIDEWALK

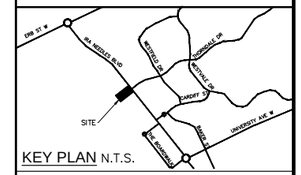
EMBANK. TOP

EMBANK. BOT

P:\2014\(2023)\10\04-DWGS\DWL\2014-0023-10; 44 of 48; 1:25.4; ARCH full sheet D (24.00 x 36.00 inches); ...DWG To PDF on laserjet5; Josh Zehr; 13/04/2016 10:11:00 AM

THE CITY OF Waterloo

KEY PLAN N.T.S.



true north

project north

date	issued
2014.06.04	ISSUED FOR CITY REVIEW
2014.11.03	ISSUED TO MMM GROUP
2014.11.05	ISSUED FOR CIRCULATION
2014.11.13	ISSUED FOR EIS REPORT
2015.11.26	ISSUED FOR REVIEW
2016.01.28	ISSUED FOR CITY REVIEW
2016.02.19	ISSUED FOR MOE APPROVAL
2016.02.23	ISSUED FOR CITY APPROVAL
2016.02.26	ISSUED FOR MOE APPROVAL
2016.02.26	ISSUED FOR TENDER
2016.04.12	ISSUED FOR CONSTRUCTION

SITE BENCHMARK ELEV.=383.28m

IB LOCATED AT OLD FARM FENCE NORTHWEST CORNER OF PROPERTY OF 73 IRA NEEDLES, APPROXIMATELY 9m NORTHWEST CORNER OF SHED.
N:4810045.978m
E:535025.53m

MONUMENT ELEV.=388.72m

LOCATED SOUTHWEST CORNER OF WATER TOWER
N:4809707.062m
E:534958.096m

date	revision	no.

customer

project
THORNDALE DRIVE EXTENSION

title
SCHEMATIC GRADING & OVERALL LAYOUT PLAN

WALTERFEDY
675 Queen Street South, Suite 111
Kitchener, Ontario, Canada N2M 1A1
T 519.576.2150 F 519.576.5489
walterfedy.com

LICENSED PROFESSIONAL ENGINEER
D. A. SCHIPPER
100113544
PROVINCE OF ONTARIO

The contractor shall check and verify all dimensions and report any errors or omissions to the consultant before commencing or proceeding with any work. Do not scale this drawing.

Copyright © 2014 WalterFedy

scale:	1:500
date:	2014.05.14
job no.:	2014-0023-10
CAD file:	2014-0023-10
drawn by:	ACH
checked by:	

sheet no.:
44 of 48

APPENDIX I

MTE STUDY AREA BOREHOLE LOGS (2018)

ID Number: MW 101-18

Project: West Waterloo Westhill District North/South Collector Rd

Project No: 34280-101

Client: The Westhill Landowners Group

Site Location: 651 Erb Street West, Waterloo, ON

Drill Date: 6/22/2018

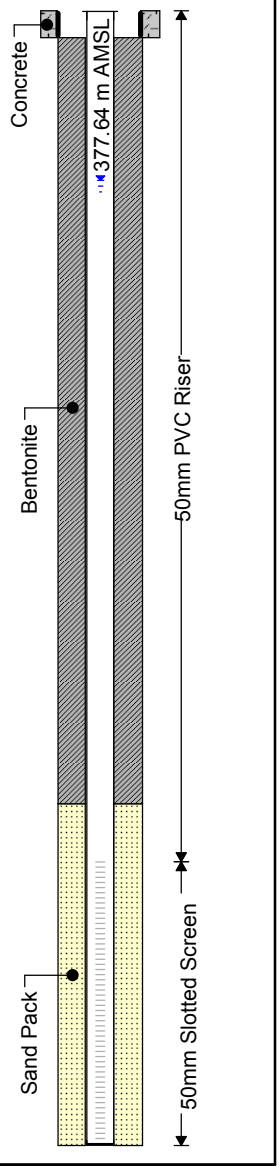
Drilling Contractor: Direct Environmental Drilling

Drill Rig: Geoprobe

Drill Method: Direct Push

Protective Cover: Monument

SUBSURFACE PROFILE			SAMPLE					HEADSPACE	
Depth (ft / m)	Symbol	Soil Description	Elevation (masl) Depth (m)	Number	Type	Recovery (%)	Soil Sample Lab Analysis	VOC ppm 20 40 60 80 / Hydrocarbon ppm 100 200 300 400	Well Completion Details
0 / 0		Ground Surface	378.6						
		FILL light brown topsoil fill. some organics and ontains trace sands with rootlets. damp.	0.0						
			377.9						
2		**SILT** light brown to grey. some clay and stones with trace sand. moist to very moist.	0.6	1	DP	100			
4			377.0						
		SILT TILL light brown to grey. sand and silt till. some stones and clay. very moist.	1.5						
6 / 2				2	DP	100			
8									
10			375.5						
		grey. some clay and trace sand. very moist to wet. red staining.	3.0						
12			374.7						
		SILTY SAND grey. sand seam. wet to saturated. red staining.	3.8	3	DP	100			
14 / 4		**SILT TILL** grey. clay and silt till. some clay and stones with trace sand. very moist to wet. red staining .							
			374.0						
		grey. some stones. wet.	4.6						
16									
18				4	DP	100			
			372.9						
		grey. clay silt till.some sand. wet.	5.6						
20 / 6			372.5						
			6.1						



Field Technician: FAH

Drafted by: JAK

Reviewed by: ALB

MTE

Sheet: 1 of 1

ID Number: MW 102-18

Project: West Waterloo Westhill District North/South Collector Rd

Project No: 34280-101

Client: The Westhill Landowners Group

Site Location: 73/87 Ira Needles Blvd, Waterloo, ON

Drill Date: 6/22/2018

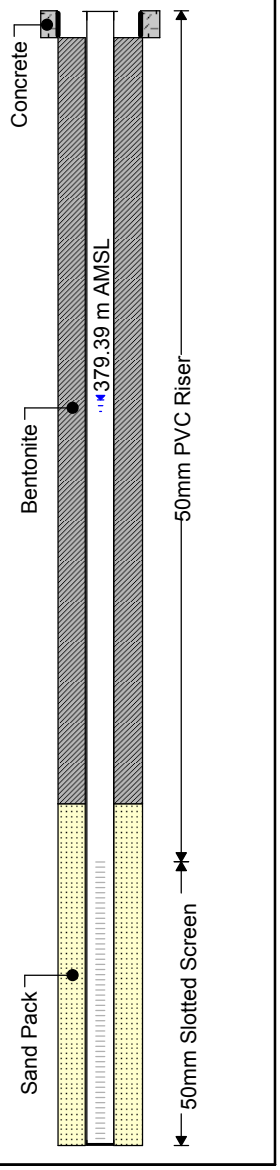
Drilling Contractor: Direct Environmental Drilling

Drill Rig: Geoprobe

Drill Method: Direct Push

Protective Cover: Monument

SUBSURFACE PROFILE			SAMPLE					HEADSPACE	
Depth (ft / m)	Symbol	Soil Description	Elevation (masl) Depth (m)	Number	Type	Recovery (%)	Soil Sample Lab Analysis	VOC ppm (20 40 60 80) / Hydrocarbon ppm (100 200 300 400)	Well Completion Details
0 ft / 0 m		Ground Surface	381.5						
		FILL llght brown topsoil fill.some sand and silt with rootlets and trace organics. Damp.	0.0						
			381.2						
		SILT TILL brown. clay silt Till. trace sand and stones. Moist with red staining.	0.3	1	DP	100			
4			380.0						
		brown transitioning to grey.. clay silt till. trace sand and stone. Very moist.	1.5	2	DP	100			
10 / 2			378.4						
		grey. sandy silt till. trace clay and stones. Wet.	3.0	3	DP	100			
14 / 4			376.9						
		grey. sandy silt till. some clay. trace stones. wet to saturated.	4.6	4	DP	100			
18 / 6			375.4						
20			6.1						



Field Technician: FAH

Drafted by: JAK

Reviewed by: ALB

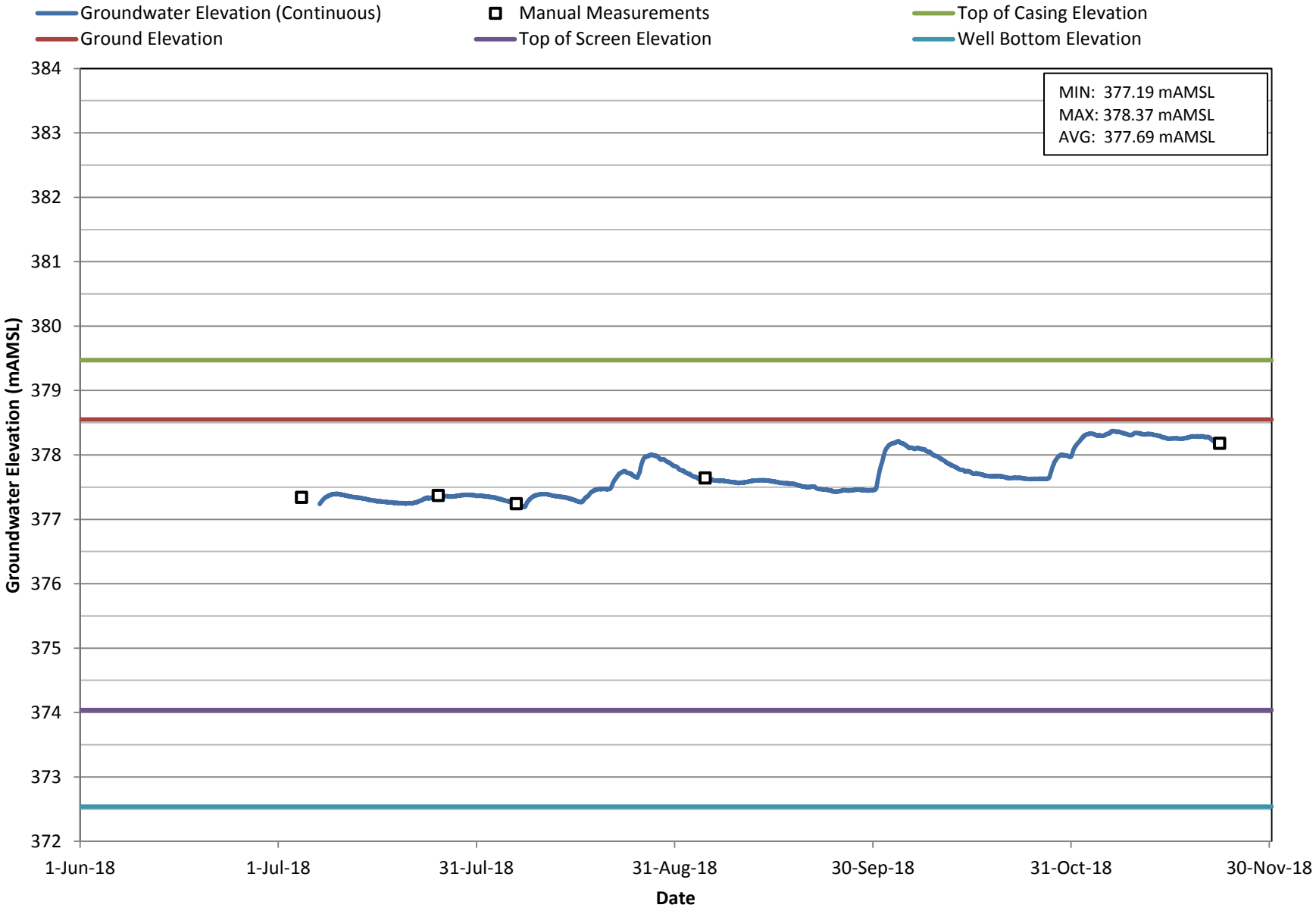
MTE

Sheet: 1 of 1

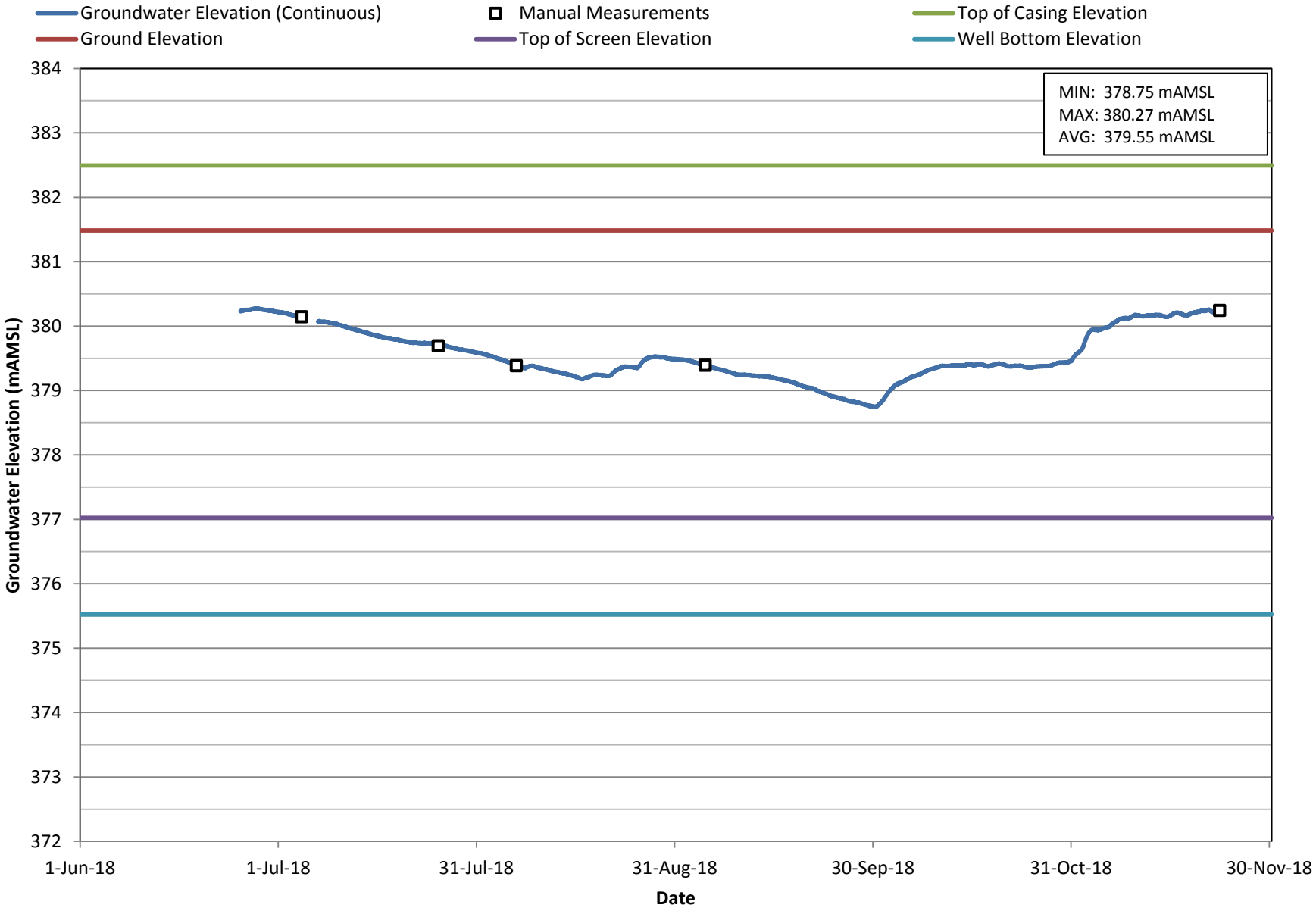
APPENDIX J

HYDROGRAPHS

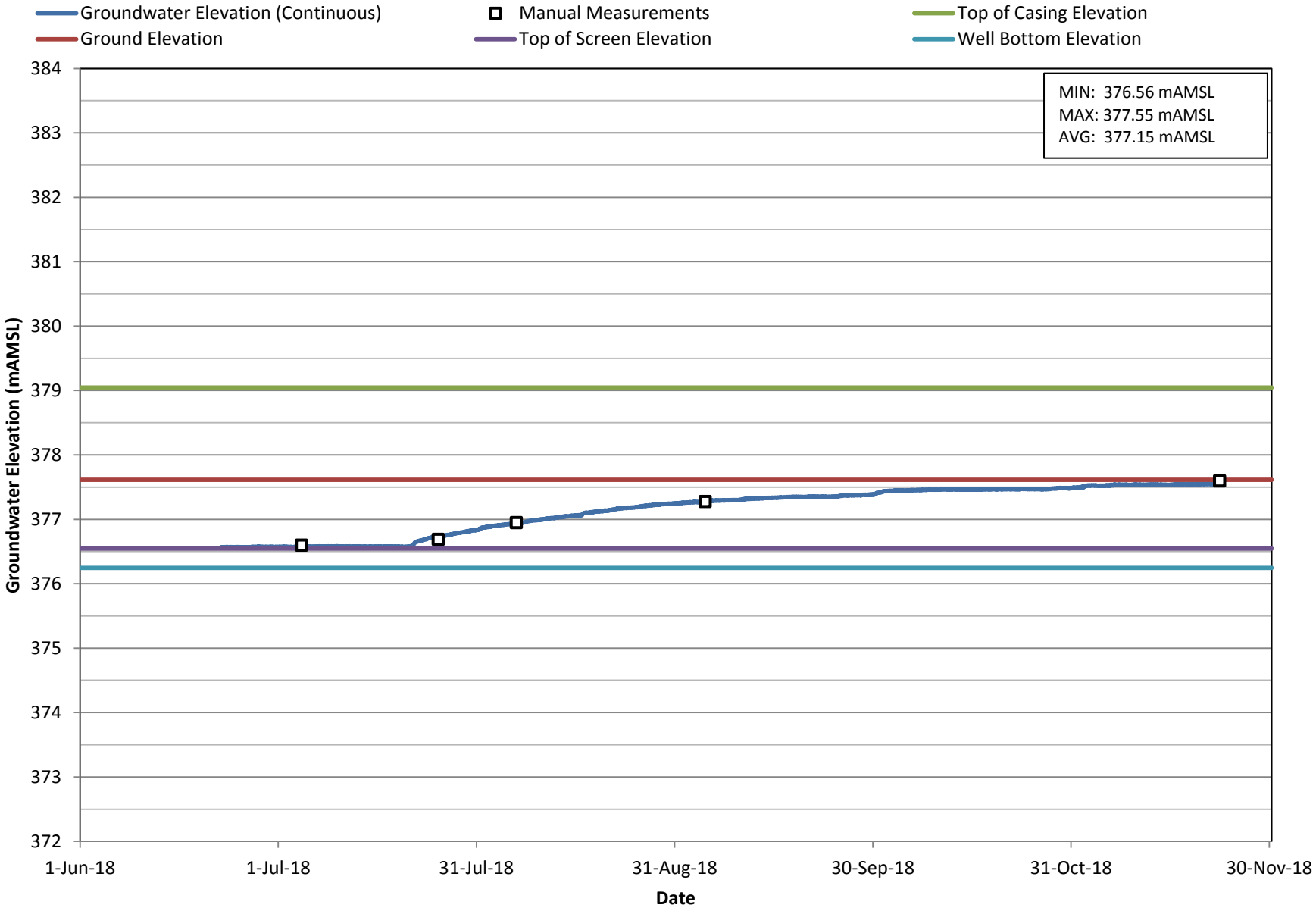
Hydrograph 1: Groundwater Elevations (mAMSL) - MW101-18



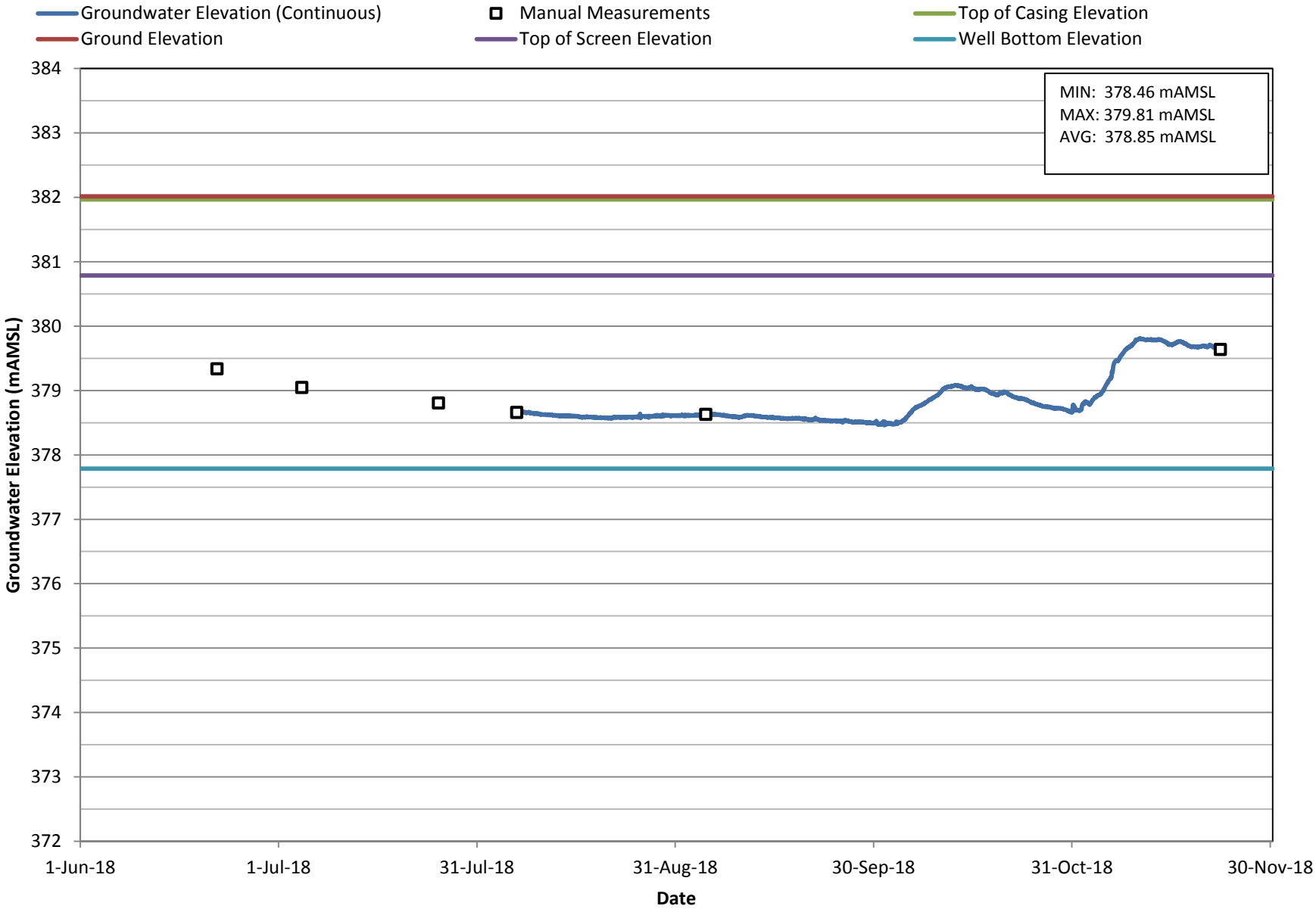
Hydrograph 2: Groundwater Elevations (mAMSL) - MW102-18



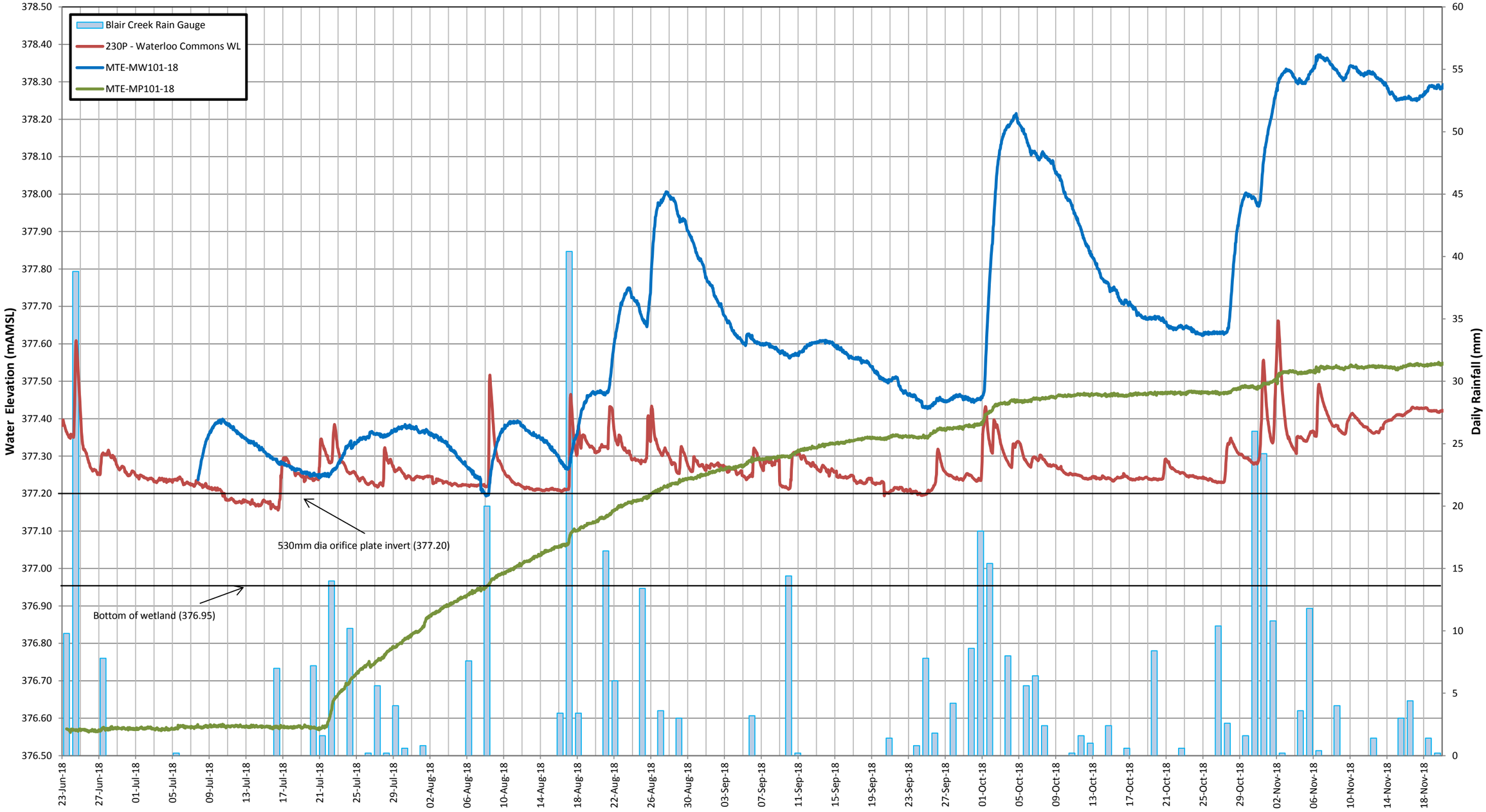
Hydrograph 3: Groundwater Elevations (mAMSL) - MP101-18



Hydrograph 4: Groundwater Elevations (mAMSL) - MW102-16



Hydrograph 5 - Waterloo Commons Wetland Feature Water Elevations (mAMSL)



APPENDIX K

AQUIFER TEST SUMMARY REPORTS

Drawing on experience...building on strength

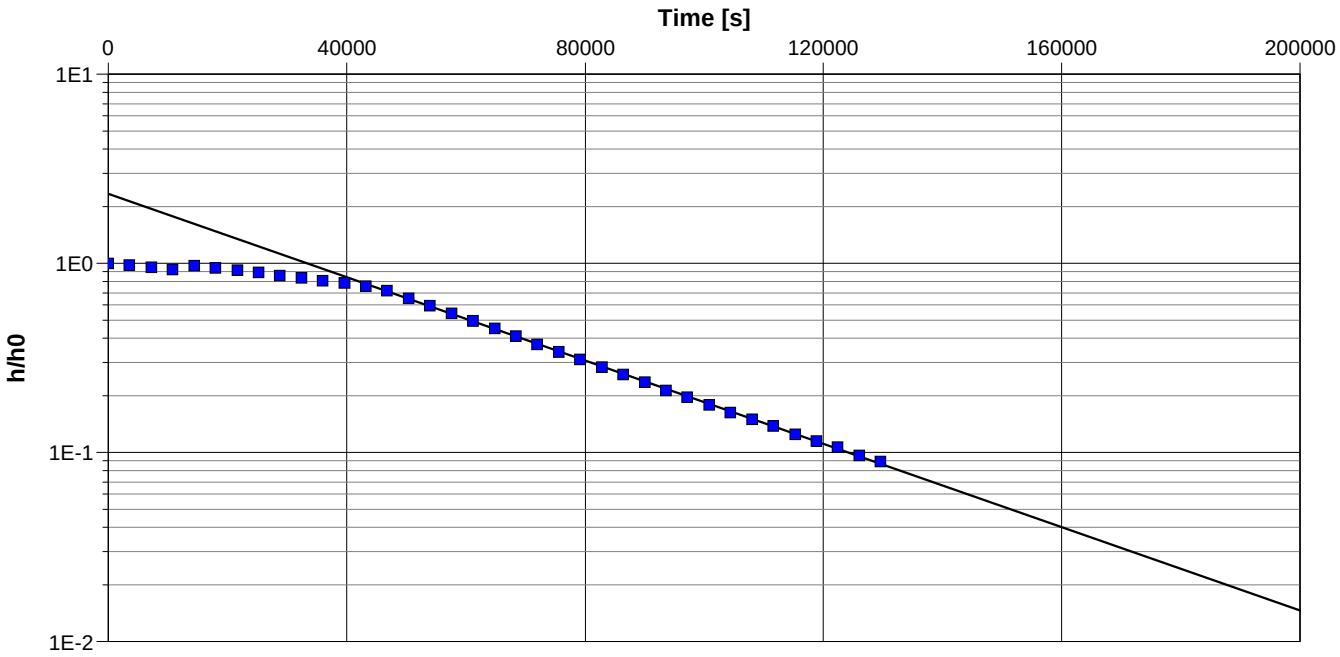
Slug Test Analysis Report

Project: Hydrogeological Assessment - West Waterloo Westhill District

Number: 34280-101

Client: The Westhill Landowners Group

Location: Waterloo. ON	Slug Test: MTE-MW101-18 Recovery Test 1	Test Well: MTE-MW101-18
Test Conducted by: FAH		Test Date: 9/6/2018
Analysis Performed by: FAH	MTE-MW101-18 Recovery Test 1	Analysis Date: 9/6/2018
Aquifer Thickness: 4.79 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MTE-MW101-18	1.69×10^{-8}	

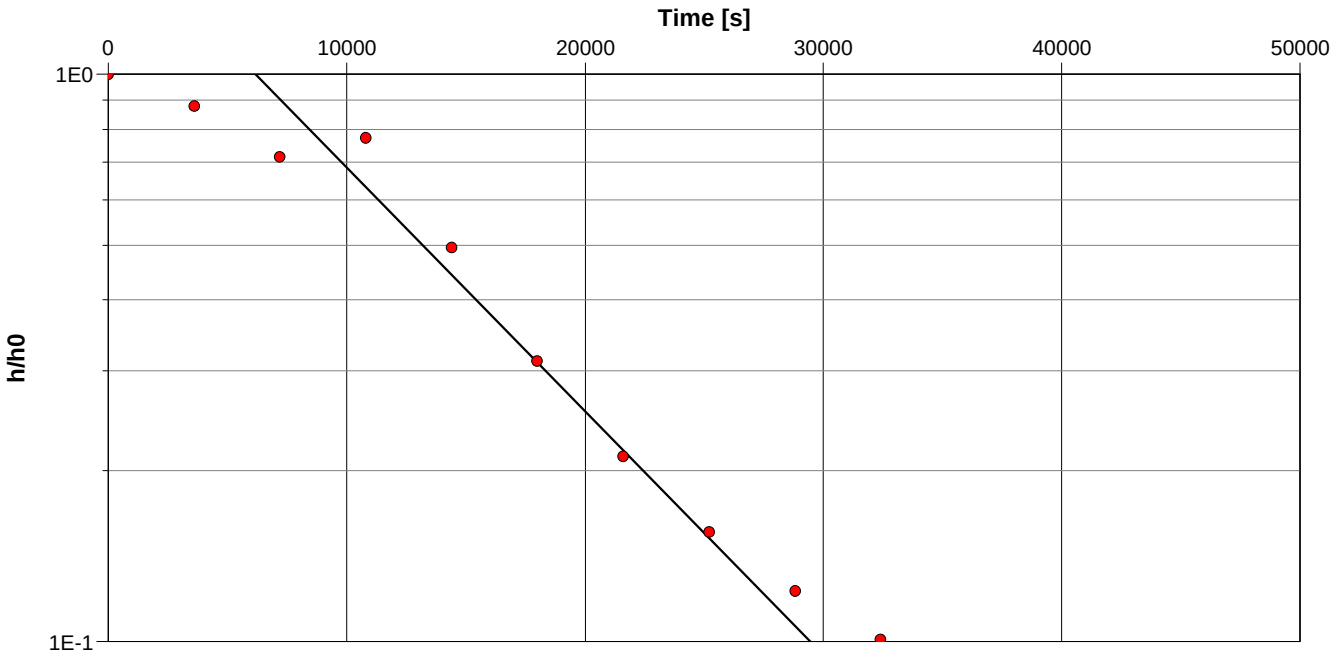
Slug Test Analysis Report

Project: Hydrogeological Assessment - West Waterloo Westhill District

Plan Number: 34280-101

Client: The Westhill Landowners Group

Location: Waterloo. ON	Slug Test: MTE-MW102-18 Recovery Test 1	Test Well: MTE-MW102-18
Test Conducted by:		Test Date: 9/6/2018
Analysis Performed by: FAH	MTE-MW102-18 Recovery Test 1	Analysis Date: 9/6/2018
Aquifer Thickness: 4.54 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MTE-MW102-18	6.59×10^{-8}	

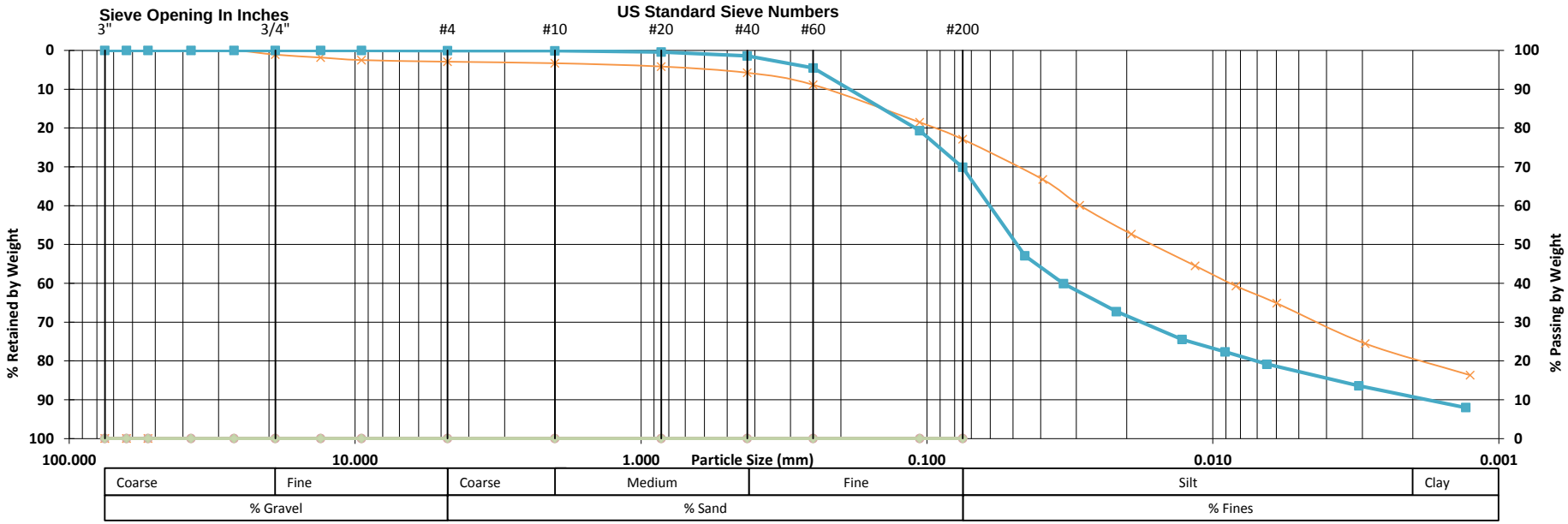
APPENDIX L

PARTICLE GRAIN SIZE DISTRIBUTION

Particle Size Distribution Analysis Test Results

PROJECT NAME: West Waterloo Westhill District North/South Collector Rd
CLIENT: The Westhill Landowners Group
DATE SAMPLED: July 31, 2018
DATE TESTED: Aug. 3-9, 2018
FILE No.: 34280-101
TABLE #: 1

Unified Soil Classification



Symbol	Borehole ID	Sample #	*Sample Depth*	Description
×—×—	MW101-18	N/A	4.57-5.64mbgs	Clayey Sandy SILT, trace Gravel
■—	MW102-18	N/A	4.57-5.33mbgs	Sandy SILT, some Clay

NOTES:

CERTIFIED BY CCIL Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

MTE Consultants Inc.
365 Home Street
Stratford, Ontario N5A 2A5
Phone: 519-271-7952
Fax: 519-271-3545
www.mte85.com

APPENDIX M

LABORATORY CERTIFICATES OF ANALYSIS

MTE CONSULTANTS INC.
ATTN: ANDREW BINGEMAN
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9

Date Received: 05-JUL-18
Report Date: 11-JUL-18 16:55 (MT)
Version: FINAL

Client Phone: 519-743-6500

Certificate of Analysis

Lab Work Order #: L2124640

Project P.O. #: NOT SUBMITTED
Job Reference: 34280-101
C of C Numbers: 17-626142
Legal Site Desc:

Mary-Lynn Pike
Client Services Supervisor

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124640-1 MW101-18 Sampled By: CLIENT on 05-JUL-18 @ 14:10 Matrix: WATER							
Physical Tests							
Colour, Apparent	37.2		2.0	CU		06-JUL-18	R4114336
Conductivity	2340		3.0	umhos/cm		06-JUL-18	R4114791
Hardness (as CaCO3)	834	HTC	10	mg/L		06-JUL-18	
pH	7.71		0.10	pH units		06-JUL-18	R4114791
Total Suspended Solids	19700	DLHC	40	mg/L	10-JUL-18	11-JUL-18	R4122187
Total Dissolved Solids	1640	DLDS	20	mg/L		09-JUL-18	R4119430
Turbidity	>4000		0.10	NTU		06-JUL-18	R4113972
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	363		10	mg/L		09-JUL-18	R4120859
Ammonia, Total (as N)	0.283		0.020	mg/L		06-JUL-18	R4114383
Chloride (Cl)	527	DLDS	2.5	mg/L		09-JUL-18	R4120768
Fluoride (F)	0.12	DLDS	0.10	mg/L		09-JUL-18	R4120768
Nitrate (as N)	<0.10	DLDS	0.10	mg/L		09-JUL-18	R4120768
Nitrite (as N)	<0.050	DLDS	0.050	mg/L		09-JUL-18	R4120768
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L		06-JUL-18	R4114407
Sulfate (SO4)	79.4	DLDS	1.5	mg/L		09-JUL-18	R4120768
Total Metals							
Aluminum (Al)-Total	<0.010		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Antimony (Sb)-Total	0.00029		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Arsenic (As)-Total	0.00048		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Barium (Ba)-Total	0.191		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Boron (B)-Total	0.028		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Cadmium (Cd)-Total	0.000079		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Calcium (Ca)-Total	198		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Cesium (Cs)-Total	0.000019		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Cobalt (Co)-Total	0.00105		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Copper (Cu)-Total	0.0123		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Iron (Fe)-Total	<0.050		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Lead (Pb)-Total	0.00030		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Magnesium (Mg)-Total	82.2		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Manganese (Mn)-Total	0.153		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Molybdenum (Mo)-Total	0.00358		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Nickel (Ni)-Total	0.00760		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Phosphorus (P)-Total	<0.050		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Potassium (K)-Total	6.76		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Rubidium (Rb)-Total	0.00269		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Selenium (Se)-Total	0.000596		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Silicon (Si)-Total	7.88		0.10	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124640-1 MW101-18 Sampled By: CLIENT on 05-JUL-18 @ 14:10 Matrix: WATER							
Total Metals							
Silver (Ag)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Sodium (Na)-Total	156	DLHC	0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Strontium (Sr)-Total	0.477		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Sulfur (S)-Total	30.2		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Thallium (Tl)-Total	0.000029		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Thorium (Th)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Tin (Sn)-Total	0.00092		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Titanium (Ti)-Total	<0.00030		0.00030	mg/L	06-JUL-18	06-JUL-18	R4113997
Tungsten (W)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Uranium (U)-Total	0.00613		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Vanadium (V)-Total	0.00088		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Zinc (Zn)-Total	0.0105		0.0030	mg/L	06-JUL-18	06-JUL-18	R4113997
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	06-JUL-18	06-JUL-18	R4113997
L2124640-2 MW102-18 Sampled By: CLIENT on 05-JUL-18 @ 15:00 Matrix: WATER							
Physical Tests							
Colour, Apparent	33.6		2.0	CU		06-JUL-18	R4114336
Conductivity	755		3.0	umhos/cm		06-JUL-18	R4114791
Hardness (as CaCO3)	395	HTC	10	mg/L		06-JUL-18	
pH	7.89		0.10	pH units		06-JUL-18	R4114791
Total Suspended Solids	4630	DLHC	40	mg/L	10-JUL-18	11-JUL-18	R4122187
Total Dissolved Solids	570	DLDS	20	mg/L		09-JUL-18	R4119430
Turbidity	>4000		0.10	NTU		06-JUL-18	R4113972
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	337		10	mg/L		09-JUL-18	R4120859
Ammonia, Total (as N)	0.094		0.020	mg/L		06-JUL-18	R4114383
Chloride (Cl)	6.50		0.50	mg/L		09-JUL-18	R4120768
Fluoride (F)	0.120		0.020	mg/L		09-JUL-18	R4120768
Nitrate (as N)	<0.020		0.020	mg/L		09-JUL-18	R4120768
Nitrite (as N)	<0.010		0.010	mg/L		09-JUL-18	R4120768
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L		06-JUL-18	R4114407
Sulfate (SO4)	58.1		0.30	mg/L		09-JUL-18	R4120768
Total Metals							
Aluminum (Al)-Total	0.016		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Antimony (Sb)-Total	0.00016		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Arsenic (As)-Total	0.00063		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Barium (Ba)-Total	0.199		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Boron (B)-Total	0.011		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124640-2 MW102-18 Sampled By: CLIENT on 05-JUL-18 @ 15:00 Matrix: WATER							
Total Metals							
Cadmium (Cd)-Total	0.000028		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Calcium (Ca)-Total	102		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Cesium (Cs)-Total	<0.000010		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Cobalt (Co)-Total	0.00046		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Copper (Cu)-Total	0.0044		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Iron (Fe)-Total	<0.050		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Lead (Pb)-Total	0.00024		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Magnesium (Mg)-Total	34.3		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Manganese (Mn)-Total	0.0727		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Molybdenum (Mo)-Total	0.00304		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Nickel (Ni)-Total	0.00145		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Phosphorus (P)-Total	<0.050		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Potassium (K)-Total	1.69		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Rubidium (Rb)-Total	0.00093		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Selenium (Se)-Total	0.000186		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Silicon (Si)-Total	7.32		0.10	mg/L	06-JUL-18	06-JUL-18	R4113997
Silver (Ag)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Sodium (Na)-Total	12.8		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Strontium (Sr)-Total	0.227		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Sulfur (S)-Total	19.4		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Thallium (Tl)-Total	0.000011		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Thorium (Th)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Tin (Sn)-Total	0.00038		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Titanium (Ti)-Total	0.00289		0.00030	mg/L	06-JUL-18	06-JUL-18	R4113997
Tungsten (W)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Uranium (U)-Total	0.00227		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Vanadium (V)-Total	0.00063		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Zinc (Zn)-Total	0.0067		0.0030	mg/L	06-JUL-18	06-JUL-18	R4113997
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Total	MS-B	L2124640-1, -2
Matrix Spike	Boron (B)-Total	MS-B	L2124640-1, -2
Matrix Spike	Calcium (Ca)-Total	MS-B	L2124640-1, -2
Matrix Spike	Iron (Fe)-Total	MS-B	L2124640-1, -2
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2124640-1, -2
Matrix Spike	Manganese (Mn)-Total	MS-B	L2124640-1, -2
Matrix Spike	Phosphorus (P)-Total	MS-B	L2124640-1, -2
Matrix Spike	Potassium (K)-Total	MS-B	L2124640-1, -2
Matrix Spike	Rubidium (Rb)-Total	MS-B	L2124640-1, -2
Matrix Spike	Silicon (Si)-Total	MS-B	L2124640-1, -2
Matrix Spike	Sodium (Na)-Total	MS-B	L2124640-1, -2
Matrix Spike	Strontium (Sr)-Total	MS-B	L2124640-1, -2
Matrix Spike	Sulfur (S)-Total	MS-B	L2124640-1, -2
Matrix Spike	Zinc (Zn)-Total	MS-B	L2124640-1, -2

Sample Parameter Qualifier key listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
HTC	Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-WT	Water	Alkalinity, Total (as CaCO3)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

CL-IC-N-WT Water Chloride by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COLOUR-APPARENT-WT Water Colour APHA 2120

Apparent Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method after sample decanting. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

EC-WT Water Conductivity APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

F-IC-N-WT Water Fluoride in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-WT Water Hardness APHA 2340 B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-T-CCMS-WT Water Total Metals in Water by CRC EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-WT Water Ammonia, Total as N EPA 350.1

Sample is measured colorimetrically. When sample is turbid a distillation step is required, sample is distilled into a solution of boric acid and measured colorimetrically.

NO2-IC-WT Water Nitrite in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT Water Nitrate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Reference Information

PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

PO4-DO-COL-WT	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

SOLIDS-TDS-WT	Water	Total Dissolved Solids	APHA 2540C

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

SOLIDS-TSS-WT	Water	Suspended solids	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

TURBIDITY-WT	Water	Turbidity	APHA 2130 B

Sample result is based on a comparison of the intensity of the light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Sample readings are obtained from a Nephelometer.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

17-626142

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: MTE CONSULTANTS INC.
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9
Contact: ANDREW BINGEMAN

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-WT	**Water**							
Batch R4120859								
WG2817578-3 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			97.2		%		80-120	09-JUL-18
WG2817578-2 LCS								
Alkalinity, Total (as CaCO3)			101.5		%		85-115	09-JUL-18
WG2817578-1 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	09-JUL-18
CL-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Chloride (Cl)			102.1		%		90-110	09-JUL-18
WG2817301-11 MB								
Chloride (Cl)			<0.50		mg/L		0.5	09-JUL-18
COLOUR-APPARENT-WT	**Water**							
Batch R4114336								
WG2815428-2 LCS								
Colour, Apparent			106.7		%		85-115	06-JUL-18
WG2815428-1 MB								
Colour, Apparent			<2.0		CU		2	06-JUL-18
EC-WT	**Water**							
Batch R4114791								
WG2815438-6 LCS								
Conductivity			97.4		%		90-110	06-JUL-18
WG2815438-5 MB								
Conductivity			<3.0		umhos/cm		3	06-JUL-18
F-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Fluoride (F)			102.0		%		90-110	09-JUL-18
WG2817301-11 MB								
Fluoride (F)			<0.020		mg/L		0.02	09-JUL-18
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-2 LCS								
Aluminum (Al)-Total			102.0		%		80-120	06-JUL-18
Antimony (Sb)-Total			100.3		%		80-120	06-JUL-18
Arsenic (As)-Total			99.7		%		80-120	06-JUL-18
Barium (Ba)-Total			102.8		%		80-120	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-2 LCS								
Beryllium (Be)-Total			98.6		%		80-120	06-JUL-18
Bismuth (Bi)-Total			102.0		%		80-120	06-JUL-18
Boron (B)-Total			93.8		%		80-120	06-JUL-18
Cadmium (Cd)-Total			99.5		%		80-120	06-JUL-18
Calcium (Ca)-Total			97.9		%		80-120	06-JUL-18
Chromium (Cr)-Total			96.4		%		80-120	06-JUL-18
Cesium (Cs)-Total			101.9		%		80-120	06-JUL-18
Cobalt (Co)-Total			99.0		%		80-120	06-JUL-18
Copper (Cu)-Total			98.5		%		80-120	06-JUL-18
Iron (Fe)-Total			97.1		%		80-120	06-JUL-18
Lead (Pb)-Total			103.6		%		80-120	06-JUL-18
Magnesium (Mg)-Total			98.4		%		80-120	06-JUL-18
Manganese (Mn)-Total			99.96		%		80-120	06-JUL-18
Molybdenum (Mo)-Total			102.5		%		80-120	06-JUL-18
Nickel (Ni)-Total			99.5		%		80-120	06-JUL-18
Phosphorus (P)-Total			100.0		%		70-130	06-JUL-18
Potassium (K)-Total			97.9		%		80-120	06-JUL-18
Rubidium (Rb)-Total			105.3		%		80-120	06-JUL-18
Selenium (Se)-Total			98.2		%		80-120	06-JUL-18
Silicon (Si)-Total			96.8		%		60-140	06-JUL-18
Silver (Ag)-Total			96.9		%		80-120	06-JUL-18
Sodium (Na)-Total			98.4		%		80-120	06-JUL-18
Strontium (Sr)-Total			102.7		%		80-120	06-JUL-18
Sulfur (S)-Total			92.4		%		80-120	06-JUL-18
Thallium (Tl)-Total			102.4		%		80-120	06-JUL-18
Tellurium (Te)-Total			98.3		%		80-120	06-JUL-18
Thorium (Th)-Total			104.6		%		70-130	06-JUL-18
Tin (Sn)-Total			99.8		%		80-120	06-JUL-18
Titanium (Ti)-Total			95.0		%		80-120	06-JUL-18
Tungsten (W)-Total			101.9		%		80-120	06-JUL-18
Uranium (U)-Total			107.4		%		80-120	06-JUL-18
Vanadium (V)-Total			100.6		%		80-120	06-JUL-18
Zinc (Zn)-Total			93.1		%		80-120	06-JUL-18
Zirconium (Zr)-Total			99.0		%		80-120	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-1 MB								
Aluminum (Al)-Total			<0.0050		mg/L		0.005	06-JUL-18
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Arsenic (As)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Barium (Ba)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Boron (B)-Total			<0.010		mg/L		0.01	06-JUL-18
Cadmium (Cd)-Total			<0.000005C		mg/L		0.000005	06-JUL-18
Calcium (Ca)-Total			<0.050		mg/L		0.05	06-JUL-18
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Copper (Cu)-Total			<0.0010		mg/L		0.001	06-JUL-18
Iron (Fe)-Total			<0.010		mg/L		0.01	06-JUL-18
Lead (Pb)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	06-JUL-18
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Phosphorus (P)-Total			<0.050		mg/L		0.05	06-JUL-18
Potassium (K)-Total			<0.050		mg/L		0.05	06-JUL-18
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	06-JUL-18
Selenium (Se)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Silicon (Si)-Total			<0.10		mg/L		0.1	06-JUL-18
Silver (Ag)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Sodium (Na)-Total			<0.050		mg/L		0.05	06-JUL-18
Strontium (Sr)-Total			<0.0010		mg/L		0.001	06-JUL-18
Sulfur (S)-Total			<0.50		mg/L		0.5	06-JUL-18
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	06-JUL-18
Thorium (Th)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Tin (Sn)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	06-JUL-18
Tungsten (W)-Total			<0.00010		mg/L		0.0001	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-1 MB								
Uranium (U)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Vanadium (V)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Zinc (Zn)-Total			<0.0030		mg/L		0.003	06-JUL-18
Zirconium (Zr)-Total			<0.00030		mg/L		0.0003	06-JUL-18
NH3-WT	**Water**							
Batch R4114383								
WG2815492-10 LCS								
Ammonia, Total (as N)			100.2		%		85-115	06-JUL-18
WG2815492-9 MB								
Ammonia, Total (as N)			<0.020		mg/L		0.02	06-JUL-18
NO2-IC-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Nitrite (as N)			101.8		%		70-130	09-JUL-18
WG2817301-11 MB								
Nitrite (as N)			<0.010		mg/L		0.01	09-JUL-18
NO3-IC-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Nitrate (as N)			101.1		%		70-130	09-JUL-18
WG2817301-11 MB								
Nitrate (as N)			<0.020		mg/L		0.02	09-JUL-18
PH-WT	**Water**							
Batch R4114791								
WG2815438-6 LCS								
pH			7.00		pH units		6.9-7.1	06-JUL-18
PO4-DO-COL-WT	**Water**							
Batch R4114407								
WG2815497-7 DUP		**L2124640-1**						
Orthophosphate-Dissolved (as P)		<0.0030	<0.0030	RPD-NA	mg/L	N/A	30	06-JUL-18
WG2815497-6 LCS								
Orthophosphate-Dissolved (as P)			102.9		%		70-130	06-JUL-18
WG2815497-5 MB								
Orthophosphate-Dissolved (as P)			<0.0030		mg/L		0.003	06-JUL-18
WG2815497-8 MS		**L2124640-1**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-WT	**Water**							
Batch R4114407								
WG2815497-8 MS		**L2124640-1**						
Orthophosphate-Dissolved (as P)			98.2		%		70-130	06-JUL-18
SO4-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Sulfate (SO4)			102.8		%		90-110	09-JUL-18
WG2817301-11 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	09-JUL-18
SOLIDS-TDS-WT	**Water**							
Batch R4119430								
WG2817308-2 LCS								
Total Dissolved Solids			97.7		%		85-115	09-JUL-18
WG2817308-1 MB								
Total Dissolved Solids			<10		mg/L		10	09-JUL-18
SOLIDS-TSS-WT	**Water**							
Batch R4122187								
WG2818030-2 LCS								
Total Suspended Solids			102.9		%		85-115	11-JUL-18
WG2818030-1 MB								
Total Suspended Solids			<2.0		mg/L		2	11-JUL-18
TURBIDITY-WT	**Water**							
Batch R4113972								
WG2815502-2 LCS								
Turbidity			107.0		%		85-115	06-JUL-18
WG2815502-1 MB								
Turbidity			<0.10		NTU		0.1	06-JUL-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2124640-COFC

COC Number: 17 - 626142

Page 2 of 2

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Company:	MTE	Select Report Format: PDF EXCEL EDD (DIGITAL)	Regular [R] Standard TAT if received by 3 pm - business days - no surcharges apply
Contact:	Andrew Bingeman	Quality Control (QC) Report with Report YES NO	PRIORITY (Business Days): 4 day [P4-20%]; 3 day [P3-25%]; 2 day [P2-50%]
Phone:	519 742 6500	Compare Results to Criteria on Report - provide details below if box checked	EMERGENCY: 1 Business day [E-100%]; Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)]
	Company address below will appear on the final report	Select Distribution: EMAIL MAIL FAX	
Street:	520 Bingemans Centre Dr	Email 1 or Fax: abingeman@mte85.com	Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
City/Province:	Kitchener, ON	Email 2:	For tests that can not be performed according to the service level selected, you will be contacted.
Postal Code:	N2B 3X7	Email 3:	
Invoice To	Same as Report To: YES NO	**Invoice Distribution**	**Analysis Request**
	Copy of Invoice with Report: YES NO	Select Invoice Distribution: EMAIL MAIL FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
Company:	MTE	Email 1 or Fax: accounting@mte85.com	
Contact:	Accounting	Email 2:	

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:	34780-101	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):	L2124640 COC	ALS Contact: MM	Sampler:

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals	Gen Chem 1	TSS	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	MW101-18	05-Jul-18	14:10	water	X	X	X			4
	MW102-18	↓	15:00	↓	X	X	X			4

Drinking Water (DW) Samples' (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? NO	Total metals
Are samples for human consumption/ use? NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen		SIF Observations	Yes		No
Ice Packs	Ice Cubes X	Custody seal intact	Yes		No
Cooling Initiated X					

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C: 25 20.1

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
Jeremy Jamieson	05-Jul-18	16:27				MW	July 05/18	16:15

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JULY 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

MTE CONSULTANTS INC.
ATTN: ANDREW BINGEMAN
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9

Date Received: 05-JUL-18
Report Date: 11-JUL-18 16:55 (MT)
Version: FINAL

Client Phone: 519-743-6500

Certificate of Analysis

Lab Work Order #: L2124641

Project P.O. #: NOT SUBMITTED
Job Reference: 34280-101
C of C Numbers: 17-626141
Legal Site Desc:

Mary-Lynn Pike
Client Services Supervisor

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124641-1 SW101 Sampled By: CLIENT on 05-JUL-18 @ 13:45 Matrix: WATER							
Physical Tests							
Colour, Apparent	295		2.0	CU		06-JUL-18	R4114336
Conductivity	2670		3.0	umhos/cm		06-JUL-18	R4114791
Hardness (as CaCO3)	344	HTC	10	mg/L		06-JUL-18	
pH	7.89		0.10	pH units		06-JUL-18	R4114791
Total Suspended Solids	87.1	DLHC	4.0	mg/L	10-JUL-18	11-JUL-18	R4122187
Total Dissolved Solids	1600	DLDS	20	mg/L		09-JUL-18	R4119430
Turbidity	113		0.10	NTU		06-JUL-18	R4113972
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	198		10	mg/L		09-JUL-18	R4120859
Ammonia, Total (as N)	0.020		0.020	mg/L		06-JUL-18	R4114383
Chloride (Cl)	767	DLDS	2.5	mg/L		09-JUL-18	R4120768
Fluoride (F)	0.12	DLDS	0.10	mg/L		09-JUL-18	R4120768
Nitrate (as N)	<0.10	DLDS	0.10	mg/L		09-JUL-18	R4120768
Nitrite (as N)	<0.050	DLDS	0.050	mg/L		09-JUL-18	R4120768
Orthophosphate-Dissolved (as P)	0.0099		0.0030	mg/L		06-JUL-18	R4114407
Sulfate (SO4)	15.2	DLDS	1.5	mg/L		09-JUL-18	R4120768
Total Metals							
Aluminum (Al)-Total	1.73	DLHC	0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Arsenic (As)-Total	0.0051	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Barium (Ba)-Total	0.117	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Boron (B)-Total	<0.10	DLHC	0.10	mg/L	06-JUL-18	06-JUL-18	R4113997
Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Calcium (Ca)-Total	102	DLHC	0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Cesium (Cs)-Total	0.00018	DLHC	0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	06-JUL-18	06-JUL-18	R4113997
Cobalt (Co)-Total	0.0011	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Iron (Fe)-Total	4.86	DLHC	0.10	mg/L	06-JUL-18	06-JUL-18	R4113997
Lead (Pb)-Total	0.00414	DLHC	0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Magnesium (Mg)-Total	21.6	DLHC	0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Manganese (Mn)-Total	0.560	DLHC	0.0050	mg/L	06-JUL-18	06-JUL-18	R4113997
Molybdenum (Mo)-Total	0.00253	DLHC	0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	06-JUL-18	06-JUL-18	R4113997
Phosphorus (P)-Total	0.74	DLHC	0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Potassium (K)-Total	3.90	DLHC	0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Rubidium (Rb)-Total	0.0036	DLHC	0.0020	mg/L	06-JUL-18	06-JUL-18	R4113997
Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Silicon (Si)-Total	7.1	DLHC	1.0	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124641-1 SW101 Sampled By: CLIENT on 05-JUL-18 @ 13:45 Matrix: WATER							
Total Metals							
Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Sodium (Na)-Total	409	DLHC	0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Strontium (Sr)-Total	0.386	DLHC	0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Sulfur (S)-Total	<5.0	DLHC	5.0	mg/L	06-JUL-18	06-JUL-18	R4113997
Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	06-JUL-18	06-JUL-18	R4113997
Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Tin (Sn)-Total	<0.0010	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Titanium (Ti)-Total	<0.060	DLUI	0.060	mg/L	06-JUL-18	06-JUL-18	R4113997
Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Uranium (U)-Total	0.00096	DLHC	0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Vanadium (V)-Total	0.0074	DLHC	0.0050	mg/L	06-JUL-18	06-JUL-18	R4113997
Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	06-JUL-18	06-JUL-18	R4113997
Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	06-JUL-18	06-JUL-18	R4113997
L2124641-2 SW102 Sampled By: CLIENT on 05-JUL-18 @ 13:45 Matrix: WATER							
Physical Tests							
Colour, Apparent	62.4		2.0	CU		06-JUL-18	R4114336
Conductivity	447		3.0	umhos/cm		06-JUL-18	R4114791
Hardness (as CaCO3)	189	HTC	10	mg/L		06-JUL-18	
pH	8.13		0.10	pH units		06-JUL-18	R4114791
Total Suspended Solids	4.8		2.0	mg/L	10-JUL-18	11-JUL-18	R4122187
Total Dissolved Solids	274	DLDS	20	mg/L		09-JUL-18	R4119430
Turbidity	13.3		0.10	NTU		06-JUL-18	R4113972
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	192		10	mg/L		09-JUL-18	R4120859
Ammonia, Total (as N)	0.023		0.020	mg/L		06-JUL-18	R4114383
Chloride (Cl)	30.1		0.50	mg/L		09-JUL-18	R4120768
Fluoride (F)	0.076		0.020	mg/L		09-JUL-18	R4120768
Nitrate (as N)	<0.020		0.020	mg/L		09-JUL-18	R4120768
Nitrite (as N)	<0.010		0.010	mg/L		09-JUL-18	R4120768
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L		06-JUL-18	R4114407
Sulfate (SO4)	2.12		0.30	mg/L		09-JUL-18	R4120768
Total Metals							
Aluminum (Al)-Total	0.035		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997
Antimony (Sb)-Total	0.00012		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Arsenic (As)-Total	0.00230		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Barium (Ba)-Total	0.0188		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Boron (B)-Total	0.030		0.010	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2124641-2 SW102 Sampled By: CLIENT on 05-JUL-18 @ 13:45 Matrix: WATER							
Total Metals							
Cadmium (Cd)-Total	<0.000010		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Calcium (Ca)-Total	54.2		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Cesium (Cs)-Total	<0.000010		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Cobalt (Co)-Total	0.00015		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Copper (Cu)-Total	<0.0010		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Iron (Fe)-Total	0.941		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Lead (Pb)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Magnesium (Mg)-Total	13.0		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Manganese (Mn)-Total	0.0641		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Molybdenum (Mo)-Total	0.000402		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Nickel (Ni)-Total	0.00057		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Phosphorus (P)-Total	0.059		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Potassium (K)-Total	3.93		0.050	mg/L	06-JUL-18	06-JUL-18	R4113997
Rubidium (Rb)-Total	0.00063		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Selenium (Se)-Total	0.000123		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Silicon (Si)-Total	0.60		0.10	mg/L	06-JUL-18	06-JUL-18	R4113997
Silver (Ag)-Total	<0.000050		0.000050	mg/L	06-JUL-18	06-JUL-18	R4113997
Sodium (Na)-Total	17.5		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Strontium (Sr)-Total	0.175		0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Sulfur (S)-Total	0.86		0.50	mg/L	06-JUL-18	06-JUL-18	R4113997
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	06-JUL-18	06-JUL-18	R4113997
Thallium (Tl)-Total	<0.000010		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Thorium (Th)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Tin (Sn)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Titanium (Ti)-Total	<0.0010	DLUI	0.0010	mg/L	06-JUL-18	06-JUL-18	R4113997
Tungsten (W)-Total	<0.00010		0.00010	mg/L	06-JUL-18	06-JUL-18	R4113997
Uranium (U)-Total	0.000482		0.000010	mg/L	06-JUL-18	06-JUL-18	R4113997
Vanadium (V)-Total	<0.00050		0.00050	mg/L	06-JUL-18	06-JUL-18	R4113997
Zinc (Zn)-Total	<0.0030		0.0030	mg/L	06-JUL-18	06-JUL-18	R4113997
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	06-JUL-18	06-JUL-18	R4113997

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Total	MS-B	L2124641-1, -2
Matrix Spike	Boron (B)-Total	MS-B	L2124641-1, -2
Matrix Spike	Calcium (Ca)-Total	MS-B	L2124641-1, -2
Matrix Spike	Iron (Fe)-Total	MS-B	L2124641-1, -2
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2124641-1, -2
Matrix Spike	Manganese (Mn)-Total	MS-B	L2124641-1, -2
Matrix Spike	Phosphorus (P)-Total	MS-B	L2124641-1, -2
Matrix Spike	Potassium (K)-Total	MS-B	L2124641-1, -2
Matrix Spike	Rubidium (Rb)-Total	MS-B	L2124641-1, -2
Matrix Spike	Silicon (Si)-Total	MS-B	L2124641-1, -2
Matrix Spike	Sodium (Na)-Total	MS-B	L2124641-1, -2
Matrix Spike	Strontium (Sr)-Total	MS-B	L2124641-1, -2
Matrix Spike	Sulfur (S)-Total	MS-B	L2124641-1, -2
Matrix Spike	Zinc (Zn)-Total	MS-B	L2124641-1, -2

Sample Parameter Qualifier key listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
HTC	Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-WT	Water	Alkalinity, Total (as CaCO3)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COLOUR-APPARENT-WT	Water	Colour	APHA 2120

Apparent Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method after sample decanting. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-WT	Water	Hardness	APHA 2340 B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-WT	Water	Ammonia, Total as N	EPA 350.1

Sample is measured colorimetrically. When sample is turbid a distillation step is required, sample is distilled into a solution of boric acid and measured colorimetrically.

NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Reference Information

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-WT Water pH APHA 4500 H-Electrode
Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

PO4-DO-COL-WT Water Diss. Orthophosphate in Water by Colour APHA 4500-P PHOSPHORUS
This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-WT Water Sulfate in Water by IC EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

SOLIDS-TDS-WT Water Total Dissolved Solids APHA 2540C
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

SOLIDS-TSS-WT Water Suspended solids APHA 2540 D-Gravimetric
A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

TURBIDITY-WT Water Turbidity APHA 2130 B
Sample result is based on a comparison of the intensity of the light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Sample readings are obtained from a Nephelometer.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

17-626141

GLOSSARY OF REPORT TERMS
Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: MTE CONSULTANTS INC.
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9
Contact: ANDREW BINGEMAN

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-WT	**Water**							
Batch R4120859								
WG2817578-3 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			97.2		%		80-120	09-JUL-18
WG2817578-2 LCS								
Alkalinity, Total (as CaCO3)			101.5		%		85-115	09-JUL-18
WG2817578-1 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	09-JUL-18
CL-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Chloride (Cl)			102.1		%		90-110	09-JUL-18
WG2817301-11 MB								
Chloride (Cl)			<0.50		mg/L		0.5	09-JUL-18
COLOUR-APPARENT-WT	**Water**							
Batch R4114336								
WG2815428-2 LCS								
Colour, Apparent			106.7		%		85-115	06-JUL-18
WG2815428-1 MB								
Colour, Apparent			<2.0		CU		2	06-JUL-18
EC-WT	**Water**							
Batch R4114791								
WG2815438-6 LCS								
Conductivity			97.4		%		90-110	06-JUL-18
WG2815438-5 MB								
Conductivity			<3.0		umhos/cm		3	06-JUL-18
F-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Fluoride (F)			102.0		%		90-110	09-JUL-18
WG2817301-11 MB								
Fluoride (F)			<0.020		mg/L		0.02	09-JUL-18
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-2 LCS								
Aluminum (Al)-Total			102.0		%		80-120	06-JUL-18
Antimony (Sb)-Total			100.3		%		80-120	06-JUL-18
Arsenic (As)-Total			99.7		%		80-120	06-JUL-18
Barium (Ba)-Total			102.8		%		80-120	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-2 LCS								
Beryllium (Be)-Total			98.6		%		80-120	06-JUL-18
Bismuth (Bi)-Total			102.0		%		80-120	06-JUL-18
Boron (B)-Total			93.8		%		80-120	06-JUL-18
Cadmium (Cd)-Total			99.5		%		80-120	06-JUL-18
Calcium (Ca)-Total			97.9		%		80-120	06-JUL-18
Chromium (Cr)-Total			96.4		%		80-120	06-JUL-18
Cesium (Cs)-Total			101.9		%		80-120	06-JUL-18
Cobalt (Co)-Total			99.0		%		80-120	06-JUL-18
Copper (Cu)-Total			98.5		%		80-120	06-JUL-18
Iron (Fe)-Total			97.1		%		80-120	06-JUL-18
Lead (Pb)-Total			103.6		%		80-120	06-JUL-18
Magnesium (Mg)-Total			98.4		%		80-120	06-JUL-18
Manganese (Mn)-Total			99.96		%		80-120	06-JUL-18
Molybdenum (Mo)-Total			102.5		%		80-120	06-JUL-18
Nickel (Ni)-Total			99.5		%		80-120	06-JUL-18
Phosphorus (P)-Total			100.0		%		70-130	06-JUL-18
Potassium (K)-Total			97.9		%		80-120	06-JUL-18
Rubidium (Rb)-Total			105.3		%		80-120	06-JUL-18
Selenium (Se)-Total			98.2		%		80-120	06-JUL-18
Silicon (Si)-Total			96.8		%		60-140	06-JUL-18
Silver (Ag)-Total			96.9		%		80-120	06-JUL-18
Sodium (Na)-Total			98.4		%		80-120	06-JUL-18
Strontium (Sr)-Total			102.7		%		80-120	06-JUL-18
Sulfur (S)-Total			92.4		%		80-120	06-JUL-18
Thallium (Tl)-Total			102.4		%		80-120	06-JUL-18
Tellurium (Te)-Total			98.3		%		80-120	06-JUL-18
Thorium (Th)-Total			104.6		%		70-130	06-JUL-18
Tin (Sn)-Total			99.8		%		80-120	06-JUL-18
Titanium (Ti)-Total			95.0		%		80-120	06-JUL-18
Tungsten (W)-Total			101.9		%		80-120	06-JUL-18
Uranium (U)-Total			107.4		%		80-120	06-JUL-18
Vanadium (V)-Total			100.6		%		80-120	06-JUL-18
Zinc (Zn)-Total			93.1		%		80-120	06-JUL-18
Zirconium (Zr)-Total			99.0		%		80-120	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-1 MB								
Aluminum (Al)-Total			<0.0050		mg/L		0.005	06-JUL-18
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Arsenic (As)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Barium (Ba)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Boron (B)-Total			<0.010		mg/L		0.01	06-JUL-18
Cadmium (Cd)-Total			<0.000005C		mg/L		0.000005	06-JUL-18
Calcium (Ca)-Total			<0.050		mg/L		0.05	06-JUL-18
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Copper (Cu)-Total			<0.0010		mg/L		0.001	06-JUL-18
Iron (Fe)-Total			<0.010		mg/L		0.01	06-JUL-18
Lead (Pb)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	06-JUL-18
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Phosphorus (P)-Total			<0.050		mg/L		0.05	06-JUL-18
Potassium (K)-Total			<0.050		mg/L		0.05	06-JUL-18
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	06-JUL-18
Selenium (Se)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Silicon (Si)-Total			<0.10		mg/L		0.1	06-JUL-18
Silver (Ag)-Total			<0.000050		mg/L		0.00005	06-JUL-18
Sodium (Na)-Total			<0.050		mg/L		0.05	06-JUL-18
Strontium (Sr)-Total			<0.0010		mg/L		0.001	06-JUL-18
Sulfur (S)-Total			<0.50		mg/L		0.5	06-JUL-18
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	06-JUL-18
Thorium (Th)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Tin (Sn)-Total			<0.00010		mg/L		0.0001	06-JUL-18
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	06-JUL-18
Tungsten (W)-Total			<0.00010		mg/L		0.0001	06-JUL-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-WT	**Water**							
Batch R4113997								
WG2815378-1 MB								
Uranium (U)-Total			<0.000010		mg/L		0.00001	06-JUL-18
Vanadium (V)-Total			<0.00050		mg/L		0.0005	06-JUL-18
Zinc (Zn)-Total			<0.0030		mg/L		0.003	06-JUL-18
Zirconium (Zr)-Total			<0.00030		mg/L		0.0003	06-JUL-18
NH3-WT	**Water**							
Batch R4114383								
WG2815492-10 LCS								
Ammonia, Total (as N)			100.2		%		85-115	06-JUL-18
WG2815492-9 MB								
Ammonia, Total (as N)			<0.020		mg/L		0.02	06-JUL-18
NO2-IC-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Nitrite (as N)			101.8		%		70-130	09-JUL-18
WG2817301-11 MB								
Nitrite (as N)			<0.010		mg/L		0.01	09-JUL-18
NO3-IC-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Nitrate (as N)			101.1		%		70-130	09-JUL-18
WG2817301-11 MB								
Nitrate (as N)			<0.020		mg/L		0.02	09-JUL-18
PH-WT	**Water**							
Batch R4114791								
WG2815438-6 LCS								
pH			7.00		pH units		6.9-7.1	06-JUL-18
PO4-DO-COL-WT	**Water**							
Batch R4114407								
WG2815497-6 LCS								
Orthophosphate-Dissolved (as P)			102.9		%		70-130	06-JUL-18
WG2815497-5 MB								
Orthophosphate-Dissolved (as P)			<0.0030		mg/L		0.003	06-JUL-18
SO4-IC-N-WT	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-WT	**Water**							
Batch R4120768								
WG2817301-12 LCS								
Sulfate (SO4)			102.8		%		90-110	09-JUL-18
WG2817301-11 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	09-JUL-18
SOLIDS-TDS-WT	**Water**							
Batch R4119430								
WG2817308-2 LCS								
Total Dissolved Solids			97.7		%		85-115	09-JUL-18
WG2817308-1 MB								
Total Dissolved Solids			<10		mg/L		10	09-JUL-18
SOLIDS-TSS-WT	**Water**							
Batch R4122187								
WG2818030-2 LCS								
Total Suspended Solids			102.9		%		85-115	11-JUL-18
WG2818030-1 MB								
Total Suspended Solids			<2.0		mg/L		2	11-JUL-18
TURBIDITY-WT	**Water**							
Batch R4113972								
WG2815502-2 LCS								
Turbidity			107.0		%		85-115	06-JUL-18
WG2815502-1 MB								
Turbidity			<0.10		NTU		0.1	06-JUL-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2124641-COFC

COC Number: 17 - 626141

Page 1 of 1

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Company:	MTE	Select Report Format: [X] PDF [ ] EXCEL [ ] EDD (DIGITAL)	Regular [R] [X] Standard TAT if received by 3 pm - business days - no surcharges apply
Contact:	Andrew Bingeman	Quality Control (QC) Report with Report [X] YES [ ] NO	PRIORITY (Business Days): 4 day [P4-20%] [ ]; 3 day [P3-25%] [ ]; 2 day [P2-50%] [ ]
Phone:	(519) 743-6500	[ ] Compare Results to Criteria on Report - provide details below if box checked	EMERGENCY: 1 Business day [E-100%] [ ]; Same Day, Weekend or Statutory holiday [E2-200%] (Laboratory opening fees may apply) [ ]
	Company address below will appear on the final report	Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX	
Street:	520 Bingemans Centre Dr.	Email 1 or Fax: abingeman@mte85.com	Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
City/Province:	Kitchener ON	Email 2	For tests that can not be performed according to the service level selected, you will be contacted.
Postal Code:	[redacted]	Email 3	

Invoice To		Invoice Distribution	
	Same as Report To [ ] YES [X] NO	Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX	
	Copy of Invoice with Report [ ] YES [X] NO	Email 1 or Fax: accounting@mte85.com	
Company:	MTE	Email 2	
Contact:	Accounting		

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:	34280-1.01	Major/Minor Code:	Routing Code:
PO / AFE:		Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only):	L2124641 OSC	ALS Contact: MM	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total metals	Gen Chem. 1	TSS	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	SW101	05-Jul-18	13:45	Water	X	X	X			4
	SW102	↓	12:15	↓	X	X	X			4

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? [ ] YES [X] NO	total metals.
Are samples for human consumption/ use? [ ] YES [X] NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	[ ]	SIF Observations	Yes [ ]	No [ ]	
Ice Packs	[ ] Ice Cubes [X]	Custody seal intact	Yes [ ]	No [ ]	
Cooling Initiated	[X]				

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				20.1			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
	05-Jul-18	16:27				W	05/7/18	16:25

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JULY 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

MTE CONSULTANTS INC. (Kitchener)
ATTN: JAKE CARMAN
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9

Date Received: 08-AUG-18
Report Date: 15-AUG-18 12:30 (MT)
Version: FINAL

Client Phone: 519-743-6500

Certificate of Analysis

Lab Work Order #: L2143413

Project P.O. #: NOT SUBMITTED
Job Reference: 34280-101
C of C Numbers: 14-457981
Legal Site Desc:

Mary-Lynn Pike
Client Services Supervisor

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2143413-1 230Q Sampled By: J. CARMAN on 08-AUG-18 @ 10:00 Matrix: WATER							
Physical Tests							
Total Suspended Solids	15.6	DLHC	1.0	mg/L	09-AUG-18	10-AUG-18	R4163154
Anions and Nutrients							
Chloride (Cl)	344		0.50	mg/L		10-AUG-18	R4165753
Nitrate (as N)	0.110		0.020	mg/L		10-AUG-18	R4165753
Phosphorus (P)-Total Dissolved	0.0545		0.0030	mg/L	13-AUG-18	15-AUG-18	R4169433
Phosphorus, Total	0.135		0.0030	mg/L	13-AUG-18	14-AUG-18	R4168437
Total Metals							
Copper (Cu)-Total	0.0025		0.0010	mg/L	09-AUG-18	13-AUG-18	R4162696
Lead (Pb)-Total	0.00069		0.00010	mg/L	09-AUG-18	13-AUG-18	R4162696
Zinc (Zn)-Total	0.0087		0.0030	mg/L	09-AUG-18	13-AUG-18	R4162696
L2143413-2 233Q Sampled By: J. CARMAN on 08-AUG-18 @ 10:00 Matrix: WATER							
Physical Tests							
Total Suspended Solids	273	DLHC	5.0	mg/L	09-AUG-18	10-AUG-18	R4163154
Anions and Nutrients							
Chloride (Cl)	3.11		0.50	mg/L		10-AUG-18	R4165753
Nitrate (as N)	0.066		0.020	mg/L		10-AUG-18	R4165753
Phosphorus (P)-Total Dissolved	0.0766		0.0030	mg/L	13-AUG-18	15-AUG-18	R4169433
Phosphorus, Total	0.815	DLM	0.030	mg/L	13-AUG-18	14-AUG-18	R4168437
Total Metals							
Copper (Cu)-Total	0.036	DLHC	0.010	mg/L	09-AUG-18	13-AUG-18	R4162696
Lead (Pb)-Total	0.0168	DLHC	0.00050	mg/L	09-AUG-18	13-AUG-18	R4162696
Zinc (Zn)-Total	0.109	DLHC	0.030	mg/L	09-AUG-18	13-AUG-18	R4162696
L2143413-3 235Q Sampled By: J. CARMAN on 08-AUG-18 @ 14:00 Matrix: WATER							
Physical Tests							
Total Suspended Solids	15.5	DLHC	1.0	mg/L	09-AUG-18	10-AUG-18	R4163154
Anions and Nutrients							
Chloride (Cl)	293		0.50	mg/L		10-AUG-18	R4165753
Nitrate (as N)	<0.020		0.020	mg/L		10-AUG-18	R4165753
Phosphorus (P)-Total Dissolved	0.0155		0.0030	mg/L	13-AUG-18	15-AUG-18	R4169433
Phosphorus, Total	0.0785		0.0030	mg/L	13-AUG-18	14-AUG-18	R4168437
Total Metals							
Copper (Cu)-Total	0.0021		0.0010	mg/L	09-AUG-18	13-AUG-18	R4162696
Lead (Pb)-Total	0.00088		0.00010	mg/L	09-AUG-18	13-AUG-18	R4162696
Zinc (Zn)-Total	0.0099		0.0030	mg/L	09-AUG-18	13-AUG-18	R4162696

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Chloride (Cl)	MS-B	L2143413-1, -2, -3
Matrix Spike	Phosphorus, Total	MS-B	L2143413-1, -2, -3

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT	Water	Total P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P B E

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

P-TD-COL-WT	Water	Total Dissolved P in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SOLIDS-TSS-LOW-WT	Water	Total Suspended Solids to 0.5 mg/L	APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104–1°C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

14-457981

Reference Information

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: MTE CONSULTANTS INC. (Kitchener)
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9
Contact: JAKE CARMAN

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-IC-N-WT	**Water**							
Batch R4165753								
WG2846885-12 LCS								
Chloride (Cl)			100.3		%		90-110	10-AUG-18
WG2846885-17 LCS								
Chloride (Cl)			100.0		%		90-110	10-AUG-18
WG2846885-11 MB								
Chloride (Cl)			<0.50		mg/L		0.5	10-AUG-18
WG2846885-16 MB								
Chloride (Cl)			<0.50		mg/L		0.5	10-AUG-18
MET-T-CCMS-WT	**Water**							
Batch R4162696								
WG2845091-2 LCS								
Copper (Cu)-Total			99.5		%		80-120	10-AUG-18
Lead (Pb)-Total			104.5		%		80-120	10-AUG-18
Zinc (Zn)-Total			95.0		%		80-120	10-AUG-18
WG2845091-1 MB								
Copper (Cu)-Total			<0.0010		mg/L		0.001	10-AUG-18
Lead (Pb)-Total			<0.000050		mg/L		0.00005	10-AUG-18
Zinc (Zn)-Total			<0.0030		mg/L		0.003	10-AUG-18
NO3-IC-WT	**Water**							
Batch R4165753								
WG2846885-12 LCS								
Nitrate (as N)			100.5		%		70-130	10-AUG-18
WG2846885-17 LCS								
Nitrate (as N)			100.1		%		70-130	10-AUG-18
WG2846885-11 MB								
Nitrate (as N)			<0.020		mg/L		0.02	10-AUG-18
WG2846885-16 MB								
Nitrate (as N)			<0.020		mg/L		0.02	10-AUG-18
P-T-COL-WT	**Water**							
Batch R4168437								
WG2847541-2 LCS								
Phosphorus, Total			94.2		%		80-120	14-AUG-18
WG2847541-1 MB								
Phosphorus, Total			<0.0030		mg/L		0.003	14-AUG-18
P-TD-COL-WT	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-TD-COL-WT	**Water**							
Batch R4169433								
WG2847948-2 LCS								
Phosphorus (P)-Total	Dissolved		95.1		%		80-120	15-AUG-18
WG2847948-1 MB								
Phosphorus (P)-Total	Dissolved		<0.0030		mg/L		0.003	15-AUG-18
SOLIDS-TSS-LOW-WT	**Water**							
Batch R4163154								
WG2844831-2 LCS								
Total Suspended Solids			98.4		%		85-115	10-AUG-18
WG2844831-1 MB								
Total Suspended Solids			<0.50		mg/L		0.5	10-AUG-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2143413-COFC

COC Number: 14 - 457981

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)*	
Company:	MTE Consultants Inc.	Select Report Format:	[x] PDF [ ] EXCEL [ ] EDD (DIGITAL)	R [x]	Regular (Standard TAT if received by 3pm)
Contact:	Jake Carman	Quality Control (QC) Report with Report	[x] Yes [ ] No	P [ ]	Priority (2-4 business days if received by 3pm)
Address:	520 Bingemans Centre Drive, Kitchener, ON N2B 3X9	[x] Criteria on Report - provide details below if box checked		E [ ]	Emergency (1-2 business days if received by 3pm)
Phone:	519-743-6500 ext. 1273	Select Distribution:	[x] EMAIL [ ] MAIL [ ] FAX	E2 [ ]	Same day or weekend emergency if received by 10am - contact ALS for surcharge.
		Email 1 or Fax	jcarman@mte85.com	Specify Date Required for E2,E or P:	
		Email 2			

Invoice To	Same as Report To	[ ] Yes [x] No	Invoice Distribution		
	Copy of Invoice with Report	[ ] Yes [x] No	Select Invoice Distribution:	[x] EMAIL [ ] MAIL [ ] FAX	
Company:	MTE Consultants Inc.		Email 1 or Fax	accounting@mte85.com	
Contact:	Gail Reddatz		Email 2		

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	34280-101	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)	L2143413 COC	ALS Contact:	Sampler: Jake Carman

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TSS LOW	TURBIDITY	Chloride	Nitrates	Total Phosphorus	Total Dissolved Phosphorus	Lead	Copper	Zinc	Number of Containers
	230Q	8-Aug-18	9am	WATER	X	X		X	X	X	X	X	X	
2	233Q	↓			X	X		X	X	X	X	X	X	
3	235Q	↓	2pm	↓	X	X		X	X	X	X	X	X	

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? [ ] Yes [x] No	
Are samples for human drinking water use? [ ] Yes [x] No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen: [ ]	SIF Observations	Yes [ ]	No [ ]
Ice packs [ ] Yes [ ] No	Custody seal intact	Yes [ ]	No [ ]
Cooling Initiated [ ]			

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	
		21.0	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Jake Carman	Date: 8-Aug-18	Time: 3:06	Received by:	Date:	Time:	Received by:	Date: Aug 08/18	Time: 15:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

TAB 3

TECHNICAL MEMORANDUM

MTE FILE NO.: C 34280-101
DATE: December 4, 2018
PREPARED BY: Jake Carman, E.I.T.

Re: Surface Water Monitoring
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

The purpose of this memorandum is to describe the local watercourses and surface water monitoring program (established in 2018) for the drainage area associated with the West Waterloo, Westhill District (WW-WD) North/South Collector Rd (NS-CR). The Surface Water Monitoring study area is located southwest of the intersection of Erb Street and Ira Needles Boulevard, encompassed by Erb Street to the north, Region of Waterloo Landfill to the west, Ira Needles Boulevard to the east and The Boardwalk commercial plaza to the south. The drainage area also contains the Westhill Meadows Golf Course and is bisected by a hydro corridor.

The Waterloo Commons wetland is the ultimate downstream receiver of the overall drainage area, receiving drainage from the Region of Waterloo Landfill Stormwater Management (SWM) Facility, Cressman lands, Hydro Corridor, Westhill Meadows Golf Course and the Waterloo Commons commercial development. Surface runoff draining to the Waterloo Commons wetland feature is attenuated by an orifice-controlled outlet into the Erb Street storm sewer. Waterloo Commons wetland feature receives approximately 34.4ha of local surface drainage (refer to Catchment A on **Figure 1.1: Existing Catchment Areas and Monitoring Locations**) as well as approximately 36.6 ha of controlled drainage from the Region of Waterloo Landfill SWM Facility to the west and approximately 5.4 ha of drainage from Ira Needles Boulevard including Westhill Drive to the east. Additionally, local groundwater movements contribute to the Waterloo Commons wetland feature. The rate of contribution will need to be further observed over time to confirm any suspected trends. Based on summer 2018 monitoring the contributions have been slow and small in volume; likely due to clay/silt characteristics of the underlying soils. For further details about local groundwater characteristics refer to the **Hydrogeological Assessment – West Waterloo, Westhill District (WW-WD), North/South Collector Rd (NS-CR)** (MTE, 2018). The surface water monitoring program will continue past 2018 to provide a larger sample size and further populate the data set of the early monitoring observations.

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2.0 DRAINAGE AREA CHARACTERIZATION, WATERCOURSES AND CATCHMENT AREAS

The overall catchment area collectively drains to the Waterloo Commons SWM/wetland feature. For the purpose of this study, five sub-catchments have been identified for further detail and analysis of local wetland features and depression storage. These catchment areas are illustrated on **Figure 1.1**.

Sub-Catchment 1 is located at the south-west corner of the drainage area, and represents 6.16 ha of hydro corridor lands which drain into the wetland identified as HEPC South. This catchment is currently, and has historically, been used as agricultural lands and is zoned as OS1/Open Space One. The ultimate overflow of this sub-catchment is north towards the Waterloo Commons SWM/wetland feature and Erb Street.

Sub-Catchment 2 is located along the south-east edge of Catchment Area A and represents 5.39 ha of FD/Future Determination zoned land which is currently being used as portions of the Westhill Meadows Golf Course as well as greenfield lands. This catchment drains into two wetland features on the Cressman property identified as Cressman West and the Former Cressman East. The southern portion of the catchment generally drains into the Cressman West wetland with any overflow volumes flowing into the Former Cressman East. The ultimate overflow of this sub-catchment is north-west from the Former Cressman East wetland feature towards the local topographical draw through the Westhill Meadows Golf Course.

Sub-Catchment 3 is located along the northern portion of the west side of Catchment Area A and represents 1.01 ha of OS1/Open Space 1 zoned land which drains into a wetland identified as HEPC North. This land is currently being used as agricultural and greenfield lands. The ultimate overflow for this catchment is east towards the Waterloo Commons wetland.

Sub-Catchment 4 is located at the north-east corner of Catchment Area A and represents the Waterloo Commons commercial development. This development has an area of 2.87 ha and controls runoff utilizing an outlet at the southwest portion of the sub-catchment directing rainfall into a stormwater management control feature which further directs the runoff into the Waterloo Commons wetland. This sub-catchment is zoned as mixed-use neighbourhood commercial (C2-40) and is comprised of a commercial plaza with associated parking.

Sub-Catchment 5 is located along the north edge of Catchment Area A and represents the 0.78 ha uncontrolled portion of Erb Street which drains to the low point in the road and further into the Waterloo Commons wetland. This uncontrolled runoff from this section of road will contain high concentrations of road salt/chlorides during the winter and spring melt seasons. **Table 2.0** summarizes the zoning, size and identification number of each sub-catchment.

Table 2.0 - Westhill Catchment Areas		
Sub-Catchment	Zoning	Area
1	OS1/Open Space One	6.16
2	FD/Future Determination	5.39
3	OS1/Open Space One	1.01
4	C2-40/Mixed-Use Neighbourhood Commercial	2.87
5	Erb Street	0.78
A *	Varies	34.38

*Includes only local surface runoff within the study area. An additional 36.6 ha of drainage area from the Region of Waterloo Landfill SWMP site and 5.4 ha from the Westhill Road/Ira Needles Boulevard area

3.0 MONITORING STATION INSTALLATION, DEVICES & BENCHMARKING

The monitoring stations generally consist of 7 foot long T-bars buried approximately one metre below the surface, an attached perforated PVC pipe to house the pressure transducer, and a staff gauge (one metre high) to provide a local reference for field observations of water level. The pressure transducer is hung inside of the PVC pipe with a locking well cap such that the sensor located at or just above the local ground elevation.

The monitoring program is conducted through the use of HOBO U20 water level data loggers at monitoring locations 231P, 232P, 233P, 234P and 235P. A HOBO MX2001 BLE level logger is used at monitoring location 230P. Location 230P also served as the local barometric data station. Each unit is programmed to log water level and temperature data in one hour increments.

As a result of using these types of loggers, inconsistencies in the raw data may occur due to the following:

- In order to retrieve the data from the loggers, the loggers must be removed from the water and may take some time to acclimatize/re-settle to actual water temperatures and levels once re-installed. These disruptions are particularly noticeable in locations with small volumes of cooler water; any of these occurrences will be clearly labelled on monitoring analysis figures.
- During the periods where the loggers were unattended, it has been observed that loggers are occasionally tampered with and loggers become displaced. If this occurrence is observed, the erroneous data will removed or clearly labelled in plots and the summaries.

Refer to **Table 3.1** for station specific details, including: start dates, watercourse, location descriptions and coordinates.

Table 3.1: West Hill Monitoring Locations

Station Label	Start Date	Description	Location Coordinates (UTM NAD83 Zone 17)
230 P (SW)	Summer 2018	Waterloo Commons WL Near Outlet HW	534514, 4810353
231 P (SW)	Summer 2018	HEPC North Wetland	534450, 4810151
232 P (SW)	Summer 2018	Cressman West WL	534882, 4809940
233 P (SW)	Summer 2018	SWM Retention Area (Former Cressman East WL)	534957, 4810001
234 P (SW)	Summer 2018	HEPC South Wetland	534590, 4809893
235 P (SW)	Summer 2018	Region Landfill SWMP	534370, 4810199

4.0 DATA ANALYSIS

4.1 Water Level Monitoring Analysis

Water level monitoring graphs have been created for summer 2018 showing the depth logged by the pressure transducer as a function of time. Rainfall data from the GRCA Blair Creek weather station was plotted to help establish the relationship between rainfall and the water level at various locations within the drainage area. Monthly precipitation data over the monitoring period from the GRCA Blair Creek weather station is summarized in **Table 4.0**.

TABLE 4.0: Monthly Precipitation Summary

Precipitation - GRCA Blair Creek Weather Station			
2010-2017 Average		2018	
Month	Rain (mm)	Month	Rain (mm)
Jan	37.3	Jan	79
Feb	29.0	Feb	74
Mar	54.3	Mar	42.6
Apr	86.8	Apr	91.6
May	81.6	May	66
Jun	86.8	Jun	82.8
Jul	85.8	Jul	50.8
Aug	72.4	Aug	118
Sep	93.5	Sep	42.4
Oct	98.8	Oct	111.2
Nov	63.4	Nov	96.6
Dec	40.3	Dec	-
Total	**829.8**	**Total**	**855.0**

Location 230P – Waterloo Commons SWM/Wetland

The Waterloo Commons SWM/wetland feature exists immediately south of Erb Street, east of the Waterloo Regional Landfill and west of the driveway access to the commercial block at the corner of Erb Street and Ira Needles Boulevard. The Waterloo Commons SWM/wetland feature is a pond that has seasonally dependant volumes of standing water. There is an associated GRCA classified wetland area surrounding the pond area. This feature has a defined outlet to the storm sewer within Erb Street, though the outlet has been seen to be frequently clogged with mud and organic debris, causing water levels in the wetland to typically be higher than designed. Debris impeding the outlet is removed during pressure transducer download dates, but has been found to re-clog very quickly since the base level of mud and debris in the wetland is higher than the outlet elevation. Water levels did not appear to noticeably change following any of these download/outlet clearing dates throughout summer 2018.

The monitoring station is located immediately upstream of the orifice controlled storm outlet, within the GRCA categorized wetland. The Waterloo Commons SWM/wetland receives surface water inputs from several local watercourses including local surface runoff from the adjacent portions of agricultural/greenfield lands as well as Erb Street and the Region of Waterloo Landfill SWM Pond. The Waterloo Commons SWM/wetland also functions as a stormwater detention basin for volume control in parallel with the upstream SWM forebay/detention basin which is west of the Waterloo Commons commercial block parking lot.

From late June through November water levels varied from 377.16 to approximately 377.66, responding to rainfall events with spikes in elevation and droughts with gradual declines due to evaporation. The storm serviced outlet of this wetland was surveyed in August 2018 with an elevation of 377.20. Water levels rarely drop to the invert elevation, likely a result of the clogging of the outlet orifice with organic matter causing a higher water level. It appears that the water levels within this wetland decrease at a slower rate than other local wetlands, which suggests contributions from the local groundwater flows and underlying soil conditions with low permeability.

Location 231P – HEPC North

The HEPC North location is located immediately east of the City of Waterloo Landfill SWM facility, south of Erb Street and west of the Waterloo Commons SWM/wetland, in a slight depression which is labelled as a wetland feature by the GRCA.

This monitoring station is located in the centre of the GRCA wetland boundaries and during installation and inspections there was never any sign of surface water being retained for any significant period of time during summer months. This is consistent with the monitoring results which do not show and depth response to any rainfall event during the summer of 2018. Small diurnal fluctuations are seen on the HEPC Water Level graph close to the local ground elevation of 379.68 and are a result of data calibration inconsistencies due to the elevation change and relative distance between the barometer and water level logger location. In late fall saturated soils and increased rainfall caused a small volume of water to collect and stay standing within the wetland, visible from the November 2018 data download/station inspection. During the final logger download of 2018 the standing water near the monitoring station was iced over, making the logger inaccessible for download. The logged data will be downloaded and analysed in spring 2019 after the ice melts.

Location 232P – Cressman West

The Cressman West monitoring station is located east of the hydro corridor, south of the Westhill Meadows golf course, north of the Boardwalk on Ira Needles and approximately 260 metres west of Ira Needles Boulevard. This location is classified by the GRCA as a wetland feature.

This monitoring station is located in a local tree-lined depression in an undeveloped field and during inspections there was never any sign of surface water being retained for any observable period of time within the depression. This is consistent with the monitoring results which do not show and depth response to any rainfall event during 2018. Small diurnal fluctuations are seen on the HEPC Water Level graph close to the local ground elevation of 382.28 and are a result of data calibration inconsistencies due to the elevation change and relative distance between the barometer and water level logger location.

Location 233P – SWM Retention Area (Former Cressman East)

The SWM Retention Area monitoring station is located east of the hydro corridor, south of the Westhill Meadows golf course, north of the Boardwalk on Ira Needles and approximately 160 metres west of the Ira Needles Boulevard. This location is classified by the GRCA as a wetland feature. The Former Cressman East wetland feature was approved to be removed by the GRCA in 2016, and will be referred to herein as the 'SWM Retention Area'; the wetland removal permit can be found appended to the Hydrogeological Assessment for West Waterloo, Westhill District North/South Collector Road (MTE, 2018).

This monitoring station is located in a wetland area which held approximately 20 cm of water during the time of installation, which is consistent with an elevation of 380.15. During the dry period between June 30 and July 17 the wetland dried up to a point where it did not have any standing surface water. During subsequent rainfall events on July 17 and 23 the wetland responded by gaining some standing surface water which then infiltrated/evaporated within the following day. During the final logger download of 2018 the standing water near the monitoring station was iced over, making the logger inaccessible for download. The logged data will be downloaded and analysed in spring 2019 after the ice melts.

Location 234P – HEPC South

The HEPC South location is located east of the City of Waterloo Landfill, south of the HECP North wetland and west of hydro corridor, in a depression which is labelled as a wetland feature by the GRCA.

This monitoring station is located in the centre of the GRCA wetland boundaries and during installation and there were not any signs of surface water being retained for any significant period of time. When monitoring results were analysed it became apparent that this depression held 20-25 cm of water following the June 25 rain event and retained this water level until July 8 when a lack of rainfall and high temperatures caused the water to evaporate and infiltrate. During the remainder of the year storm events on August 25 and October 1 caused approximately 5cm and 10cm of ponding to be detained and eventually infiltrated and evaporated. Starting on October 27 a series of rainfall events resulted in the wetland water level rising to approximately 27cm (elevation of 382.28) and retaining this water level until the final download of 2018 in late November. It appears that this wetland seasonally holds standing water, likely between late October and July, drying up during summer months.

Location 235P – Region of Waterloo Landfill SWMP

This monitoring station was installed adjacent to the outlet of the Region of Waterloo Landfill SWMP. During installation the facility water level was at the permanent pool level of approximately 55cm of depth which corresponds with an elevation of 379.40 as stated in the *Stormwater Management Plan Report on North Area of Waterloo Landfill and ANOWL* (CRA, 1989). This pond is likely outletting at a higher rate than designed due to sediment accumulation. When visiting on-site staff from the Region of Waterloo Landfill mentioned that the pond will likely undergo a sediment removal process in the near future.

This monitoring station observed water elevations ranging from 379.17 to 379.70 in response to local climatic conditions. Observed responses to droughts and rainfall events were well within the expected values for a stormwater management facility.

4.2 Wetland Quality Monitoring Analysis

A quality monitoring program was established in 2018 with the goal of observing water quality characteristics provided within each watercourse feature which is within the drainage area boundaries. Three monitoring locations were observed: 230Q, 233Q and 235Q – each location numerically identifies with each respective monitoring station. During samples with insufficient flow outletting from the SWM facility, the samples were taken from surface water near cooling trench outlet.

Water quality criteria measured are as follows:

- Total suspended solids (TSS)
- Chloride
- Nitrate
- Total Phosphorus
- Dissolved Phosphorus
- Copper
- Lead
- Zinc

Observed results demonstrated elevated chloride levels at 230Q and 235Q relative to typical SWM facility and wetland concentrations within Waterloo Region. This is likely due to road salts being directed into each monitoring location during the spring snow melt. Further quality sample analysis will be deferred until a later reporting date so that a larger sample size can be obtained and used to eliminate any potential outlier sample results.

5.0 CONCLUSIONS

From the above analyses, the following trends are observed during summer 2018:

- Waterloo Commons SWM/wetland is utilized for local stormwater management control and the outlet is not functioning as designed, causing surface water elevations to be higher than intended
- Waterloo Commons wetland (230P) water elevation levels varied from 377.16 to 377.66 (0.21 to 0.71m of ponding)
- HEPC North wetland (231P) did not observe any surface water ponding during summer months, and late fall ponding will be analysed and visualized when climatic conditions allow the data loggers to be accessed and downloaded
- Cressman West wetland (232P) did not observe any surface water ponding
- SWM Retention Area (Former Cressman East wetland 233P) water elevation levels varied from 379.92 to 380.24 (0.0 to 0.32m of ponding)
- HEPC South wetland (234P) water elevation levels varied from 382.01 to 382.35 (0.0 to 0.34m of ponding)
- Region of Waterloo Landfill SWMP water elevation levels varied from 379.18 to 379.70 (0.44 to 0.96m of ponding/storage)
- Chloride water sample results demonstrated elevated concentrations in the Waterloo Commons wetland and the Landfill SWMP likely due to long-term exposure to local road salt runoff in the winter and spring.

It is also important to note the limitations that are associated with the 2018 monitoring season so far:

- Relatively small sample size will likely result in higher variance of data results
- Rainfall was approximately 37% lower than average throughout the summer until August which was approximately 38% higher than average

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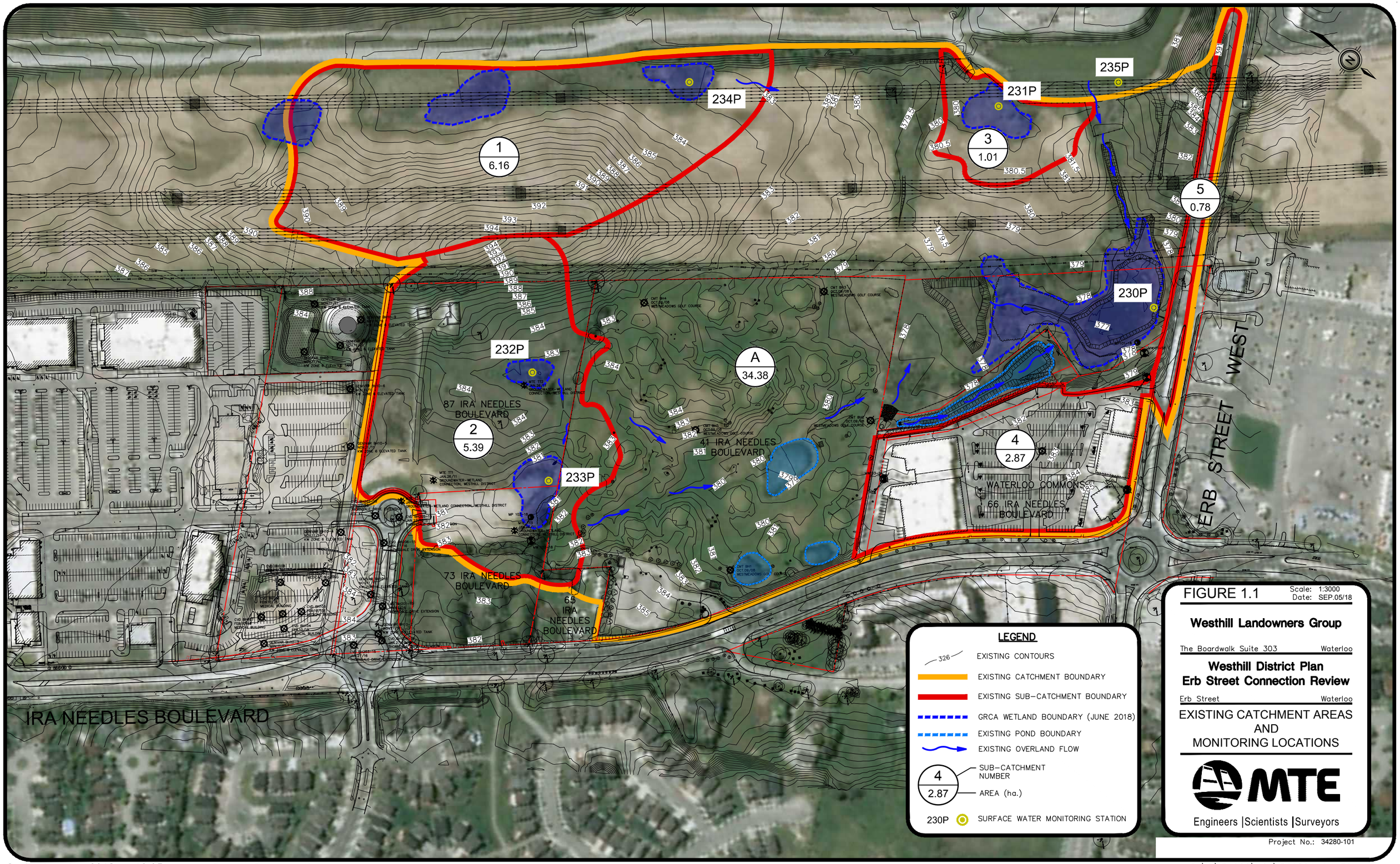


FIGURE 1.1

Scale: 1:3000
Date: SEP.05/18

Westhill Landowners Group

The Boardwalk Suite 303 Waterloo

Westhill District Plan
Erb Street Connection Review

Erb Street Waterloo

EXISTING CATCHMENT AREAS AND MONITORING LOCATIONS

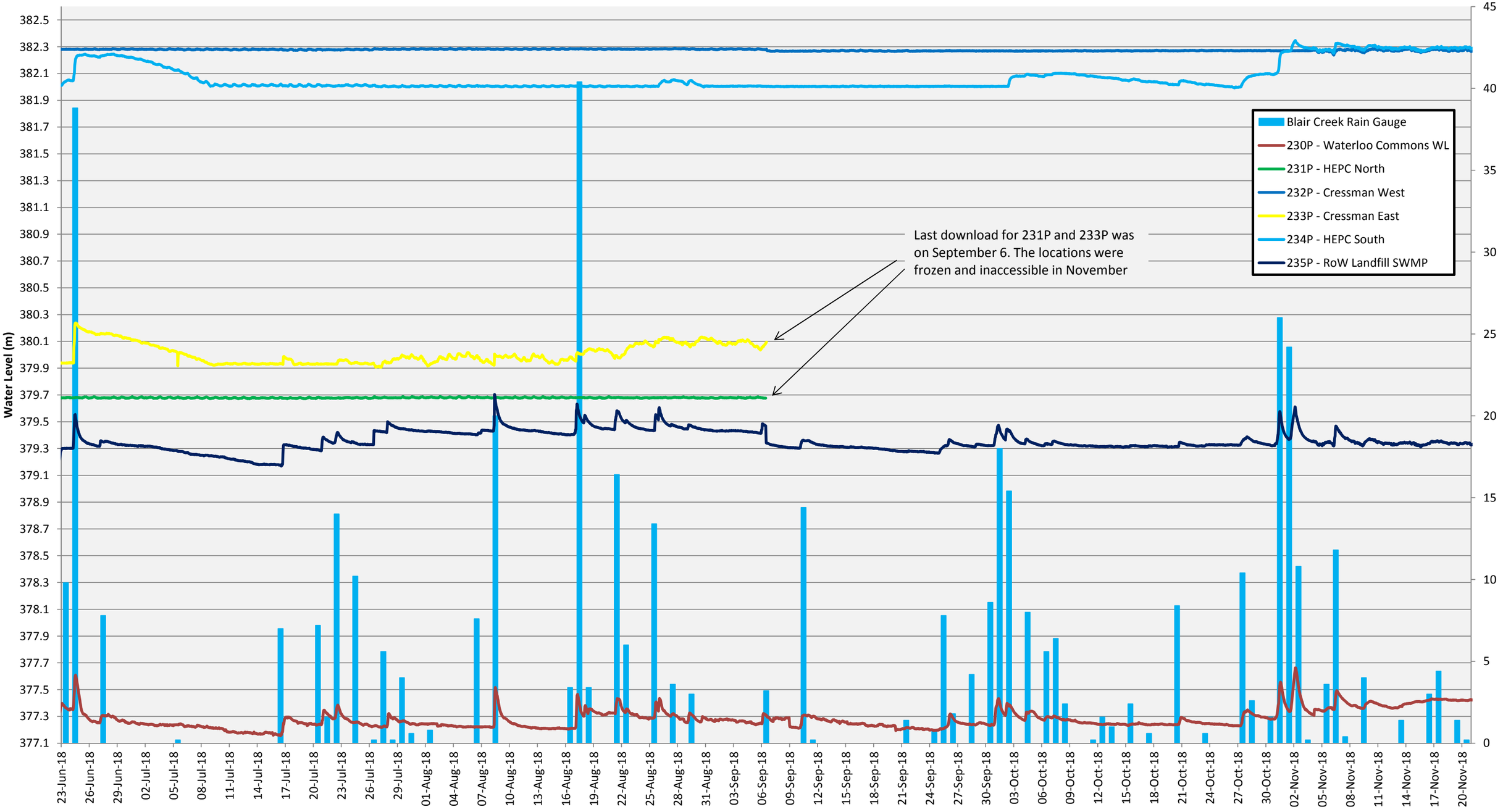
MTE

Engineers | Scientists | Surveyors

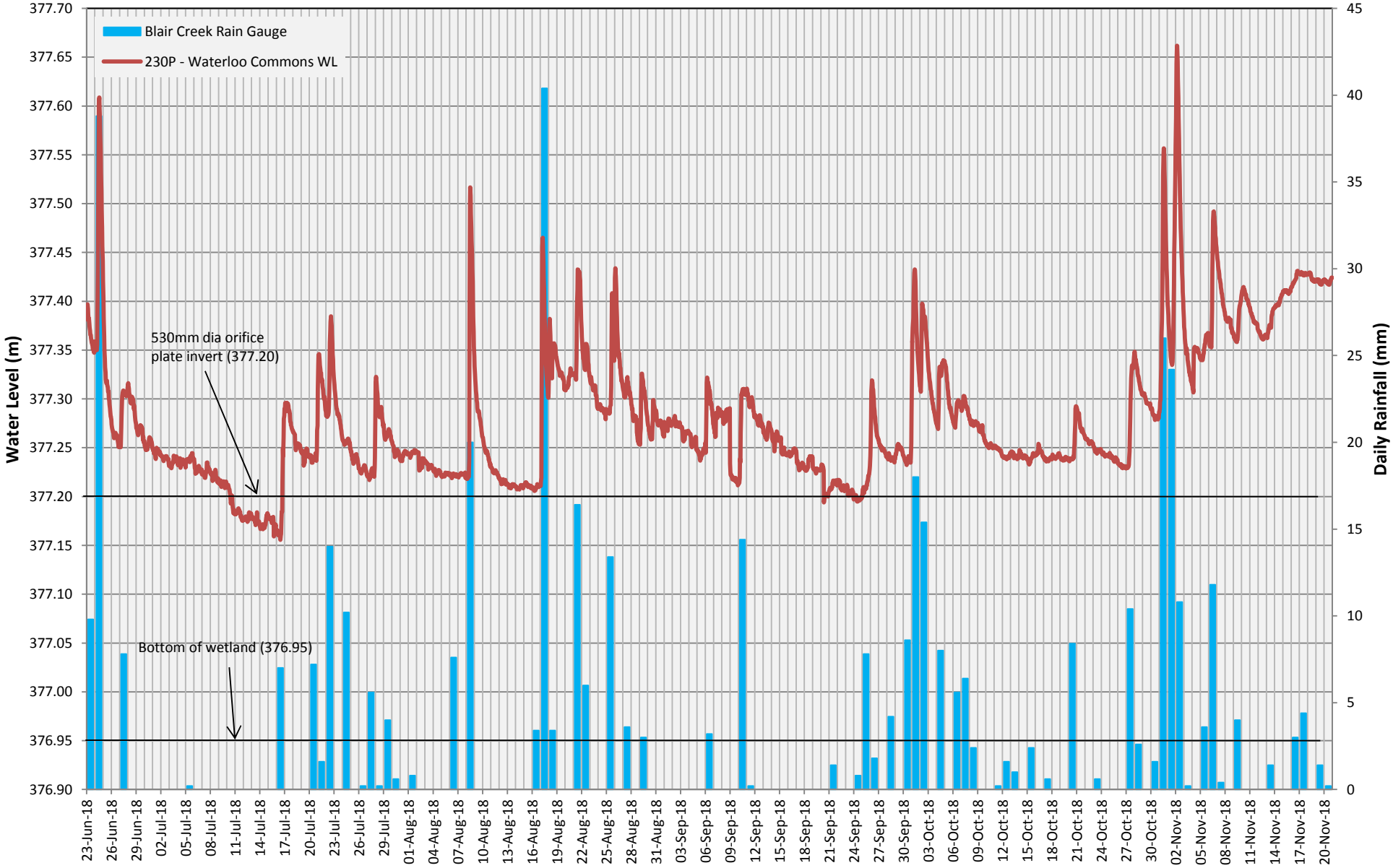
Project No.: 34280-101

Prepared by: JCC

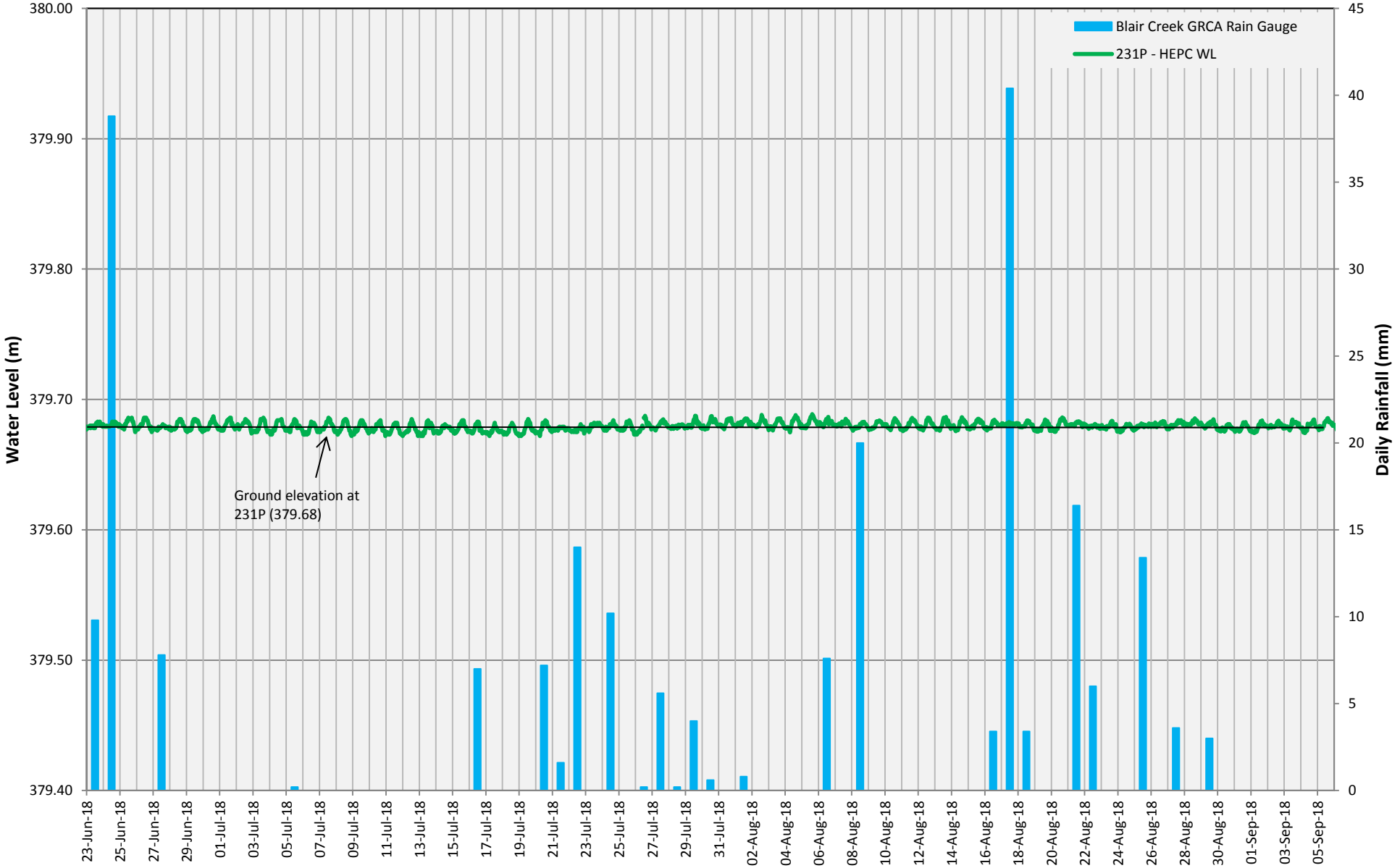
Westhill Monitoring Station Water Levels



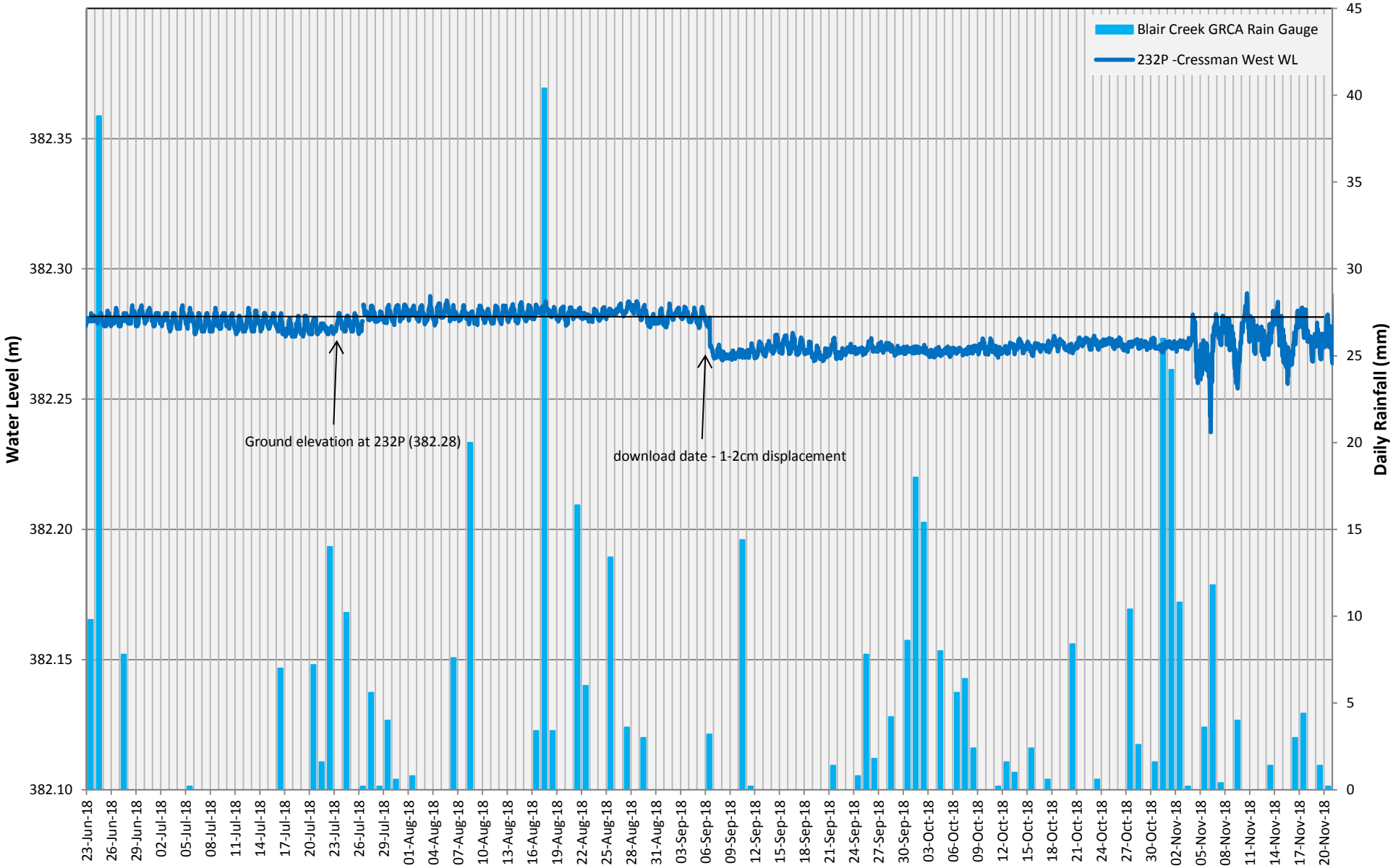
Waterloo Commons WL Water Level



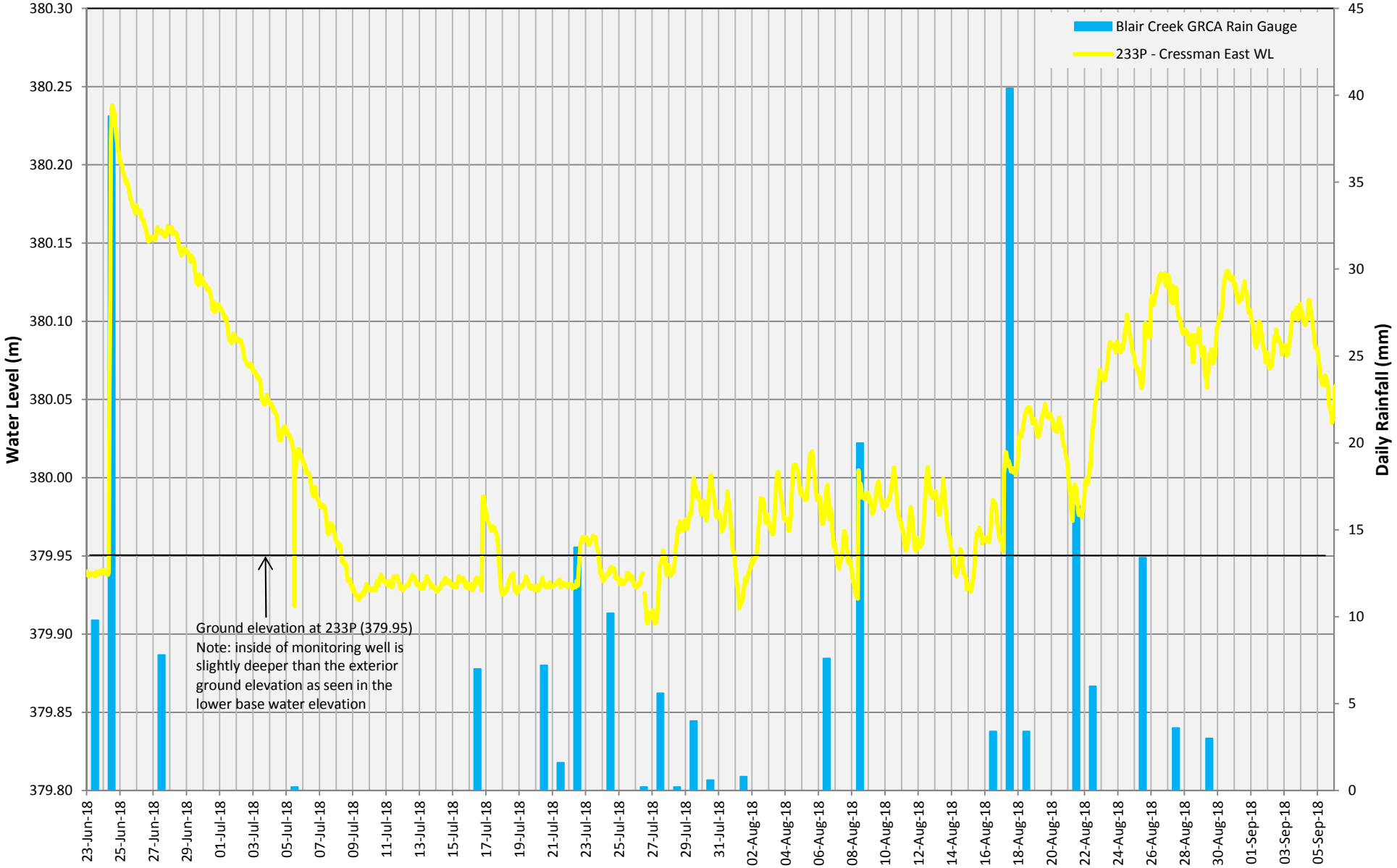
HEPC WL Water Level

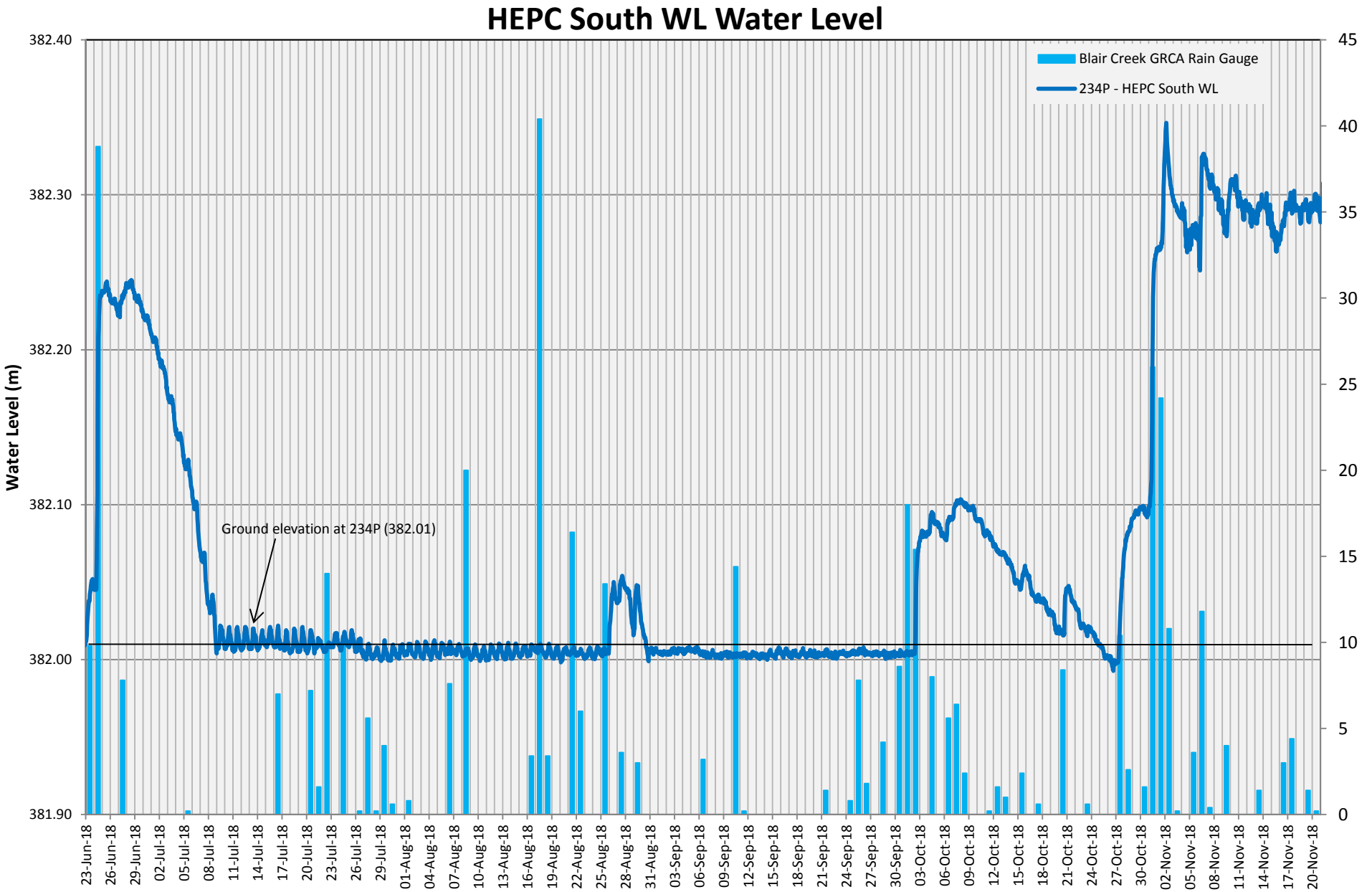


Cressman West WL Water Level

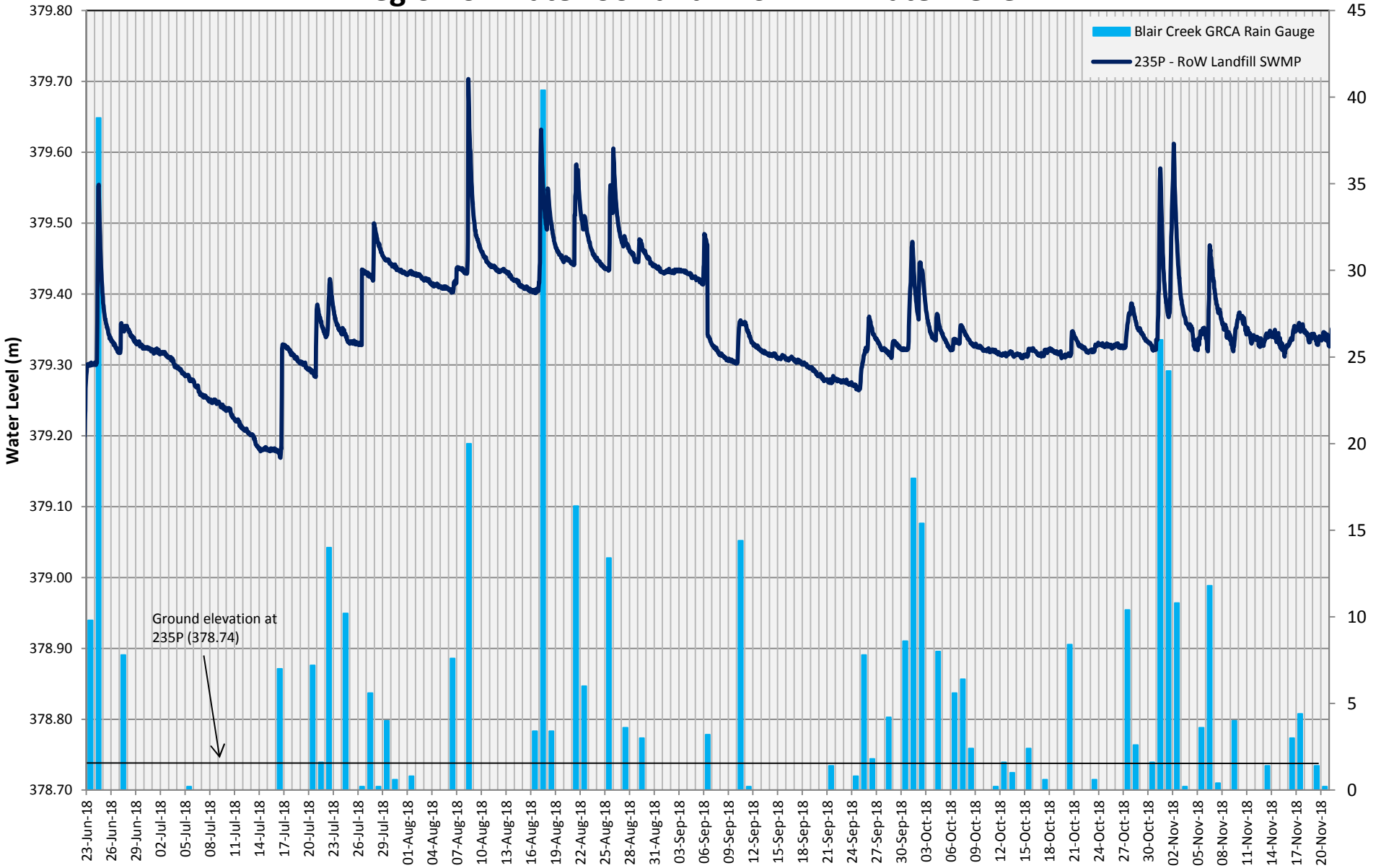


Former Cressman East WL Water Level




HEPC South WL Water Level
Water Level (m)
382.40
382.30
382.20
382.10
382.00
381.90
45
40
35
30
25
20
15
10
5
0
Blair Creek GRCA Rain Gauge
234P - HEPC South WL
Ground elevation at 234P (382.01)
23-Jun-18
26-Jun-18
29-Jun-18
02-Jul-18
05-Jul-18
08-Jul-18
11-Jul-18
14-Jul-18
17-Jul-18
20-Jul-18
23-Jul-18
26-Jul-18
29-Jul-18
01-Aug-18
04-Aug-18
07-Aug-18
10-Aug-18
13-Aug-18
16-Aug-18
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22-Aug-18
25-Aug-18
28-Aug-18
31-Aug-18
03-Sep-18
06-Sep-18
09-Sep-18
12-Sep-18
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18-Sep-18
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24-Sep-18
27-Sep-18
30-Sep-18
03-Oct-18
06-Oct-18
09-Oct-18
12-Oct-18
15-Oct-18
18-Oct-18
21-Oct-18
24-Oct-18
27-Oct-18
30-Oct-18
02-Nov-18
05-Nov-18
08-Nov-18
11-Nov-18
14-Nov-18
17-Nov-18
20-Nov-18

Region of Waterloo Landfill SWMP Water Level



TAB 4

TECHNICAL MEMORANDUM

MTE FILE NO.: C 34280-101
DATE: December 4, 2018
PREPARED BY: Charles Carré, E.I.T.

Re: Technical Design Overview
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained to complete the existing conditions characterization for the proposed road connection from The Boardwalk extension to the proposed connection between Erb Street West and Ira Needles Boulevard, in the City of Waterloo.

This technical memorandum presents the existing site topography and soil characteristics, the technical design overview of the road geometry and pavement design requirements, and the constructability of the proposed works within the study area for the Erb Street connection. This information is to be considered during the identification, assessment, and determination of an appropriate preferred route alternative for the extension of The Boardwalk from Thorndale Drive to the proposed connection between Erb Street West and Ira Needles Boulevard. This technical memo provides background information for the assessment of the north south collector road alternatives.

This document draws upon the existing information found in several previous reports and studies completed by public agencies and private developers relating to projects undertaken within the study area. The intent is to present the technical design overview for the proposed works and describe any potential conflicts that may need to be considered during the establishment and analysis of road alignment alternatives.

2.0 STUDY AREA

The proposed WW-WD, NS-CR is located west of Ira Needles Boulevard, in the southwestern portion of the City of Waterloo. The internal private road (The Boardwalk) begins at the south end of the box store development, near the entrance to Walmart. The road continues northwest, through the development, to its current terminus at the north end of the Boardwalk commercial development, at the existing roundabout extension of the municipally owned Thorndale Drive.

The study area is located in the upper reach of the Subwatershed 314 – Laurel Creek Watershed and is owned by a variety of landowners, including; the Region of Waterloo, the City of Waterloo, the INCC Corporation, Hydro One, Home Hardware, and the Cressman family. The study area generally includes a small portion of the Region of Waterloo's Waterloo Landfill at 925 Erb Street West, a small portion of the

Hydro One corridor (south of Erb Street West), the residences at 87, 73, and 65 Ira Needles Boulevard, the Westhill Meadows Golf course at 41 Ira Needles Boulevard, and the Waterloo Commons commercial development at 653-659 Erb Street West. These properties will be herein referred to as the 'Subject Lands'.

3.0 EXISTING SITE TOPOGRAPHY AND SOIL CHARACTERISTICS

The Subject Lands are categorized as rolling with scattered topographic low areas. The existing topography is undulating with two significant drainage draws; one through the eastern half of the study area (south to north) which crosses the existing Westhill Meadows Golf Course, and a second along the existing hydro corridor which runs along the east side of the landfill. Drainage is predominantly from south to north, from a high of approximately 394.00m in the hydro corridor to a low of approximately 377.00m at the Erb Street Pond, and is captured by other low lying depressions throughout the Subject Lands. These depressions have been collecting surface water runoff over time and have created multiple semi-permanent surface water features. All this runoff eventually makes its way to the Erb Street Pond, which is the study area's lowest elevation point, and is released via a storm sewer under Erb Street West.

At this time, there has not been a survey and geotechnical investigation done for all the properties in question. However, during the development of some of these properties, some information has been gathered about the existing site topography and soil stratigraphy.

In 1996, MTE completed a detailed topographical survey of the property at 41 Ira Needles Boulevard in correlation with the design and construction of the Westhill Meadows Golf Course. Based on a cut/fill analysis made between this original survey and the existing golf course's topography, it is assumed that approximately 14,000m^3 of fill was used to construct the Westhill Meadows Golf Course. Additionally, MTE completed a detailed topographical survey of the Erb Street Pond and nearby adjacent lands by total station in early 2003. All of this background information has been compiled and combined with Regionally generated topographic contours, provided by the Region of Waterloo, to establish the existing conditions of the study area used for this analysis.

In addition to the surveys described above, MTE completed a Scoped Environmental Impact Study (EIS) in 2004 which outlined some information about the soils in the Erb Street Pond and its associated wetland fringe. Furthermore, a geotechnical investigation was conducted by CMT Engineering Inc. in 2008, whereas the advancement of five boreholes was completed on the Westhill Meadows Golf Course.

Surficial soil inspections were also conducted in a number of the vegetation communities for the purpose of examining the soil moisture characteristics in the wetland fringe surrounding the Erb Street Pond. Surficial soils generally consisted of upper layers dominated by silty loams underlain by loam and silty clay. The lands in the vicinity of the existing Erb Street Pond are rolling with scattered topographic low areas. The combination of low topography and layers of less permeable silty clays appears to create conditions in which wetland communities have been established; fed by the collection of surface water. The existing forebay is located in a deeper area in which water levels are sufficient to create almost permanent ponding, with surrounding sloped areas subject to periodic high soil moisture conditions. The lower slopes are sufficiently wet to sustain wetland vegetation, but these areas grade into drier upland conditions.

The table lands above the low lying areas comprise primarily of silt, clay, and silt till deposits, which can be confirmed by the few geotechnical investigations that have been conducted within the study area. Infiltration practice in this area may not be feasible. This can be confirmed by the relatively recent development of the

adjacent Waterloo Commons and Canadian Tire lands, which could not implement any infiltration facilities due to low soil permeability. However, each site in the catchments upstream of the Erb Street Pond should undergo individual geotechnical investigations prior to development to determine the viability of infiltration on a site-by-site basis, and when feasible, utilize roof runoff infiltration facilities.

Based on the site investigations that were previously completed and the assessment of the study area's existing conditions, it is believed that the majority of the development will require the importation of fill, given the structural support required for the construction of roads, parking lots, and buildings throughout. If that is the case, there is a surplus of soil, or "cheap" fill, available for use on the Region's landfill site that could help reduce the amount of soil required to be imported from elsewhere.

It is anticipated that very little soil will need to be exported offsite with the exception of imported topsoil or onsite peat deposits. Borehole CMT-BH01-08 from the 2008 CMT geotechnical investigation of the Westhill Meadows Golf Course encountered a 0.70m thick layer of peat. It is anticipated that there may be some other areas within the Subject Lands where some layers of organics/peat may be encountered, especially near the existing SWM facilities, wetlands, and surface water features. Further investigations into the extent of unsuitable soils will be required during future development stages.

4.0 ROADWAY GEOMETRY AND PAVEMENT DESIGN REQUIREMENTS

The overall design of the proposed roads through the Subject Lands, like any other new road construction within the city, will have to conform to the design standards of the Transportation Association of Canada (TAC), the City of Waterloo, and the Region of Waterloo. As such, the new roads will need to follow the standards described in Table 7.2.5.1 from Section 7.2.5 of the City of Waterloo Development Engineering Manual 2013. An excerpt of the table is provided below.

Excerpt of Table 7.2.5.1				
Geometric Standards for Road Design				
Drawing Number	W-205	W-204	W-203	W-202
Road Classification	Collector	Collector	Collector	Local
Right-of-Way	26m	22m	20m	18m
Pavement Width	15m	13m	11m	9m
Island/Median Width	-	3m	-	-
Maximum Grade	8%	8%	8%	8%
Total Crossfall	195mm	165mm	155mm	135mm
Sidewalk Width	1.5m	1.5m	1.5m	1.5m
S/W offset from P/L	0.3m	0.3m	0.3m	0.3m
S/W cross slope	2%	2%	2%	2%
Boulevard Width	5.3m	3.3m	4.3m	4.3m
Boulevard Cross Slope	3%	3%	3%	3%
Granular 'A'	150mm	150mm	150mm	150mm
Granular 'B'	500mm	500mm	500mm	300mm
HL3 Asphalt	40mm	40mm	40mm	40mm
HL8 Asphalt	50mm	50mm	50mm	50mm
Min. K Values Crest	8	8	8	8
Min. K Values Sag	5	5	5	5

The existing surrounding roads, which have all been designed to the standards described above, have been individually classified based on their right-of-way size and functionality, and are described as follows:

- Ira Needles Boulevard is classified as a 35m Regional Arterial;
- Erb Street West is classified as a 30m Regional Arterial and is believed to be designed following the City's standards for the 35m Arterial road;
- Thorndale Drive is classified as a 22m Minor Collector; and,
- The Boardwalk is considered a private local road. It has a right-of-way approximately 22m wide on average, and is constructed following similar standards for the City's 22m Collector road.

It is assumed that the newly designed roads through the Subject Lands will be minor collector roads, which will need to follow the standards for the City's minor collector roads, based on their respective right-of-way widths. To achieve the requirements from Table 7.2.5.1, parcels of land will need to be dedicated to include the proposed road corridors, which will divide the existing subject properties into multiple new development blocks. Fill importation, as previously discussed, and area grading works within these new development blocks will need to be suitable to allow for adequate drainage and serviceability. As such, easy access to the existing corridors will need to be maintained. Given the surrounding existing grading near the projected connections points to the existing roads; 383.50m± at the north leg of Thorndale/Boardwalk roundabout, 381.50m± at Erb Street West, and 384.00m± at Ira Needles Boulevard, there does not appear to be any major conflicts with the proposed works. With proper grading designs, adequate drainage should be available to convey stormwater runoff and sanitary flow to the existing outlet locations through Erb Street West. Additionally, there should not be any requirements for any excessively steep slopes or road grades in order to match into the surrounding existing grades. The overall constructability of the proposed road connections should be straightforward.

5.0 CONSTRUCTABILITY

As previously discussed, the overall constructability of the extension of The Boardwalk from Thorndale Drive to the proposed connection between Erb Street West and Ira Needles Boulevard should be relatively simple. As long as every landowner and municipal agency involved is on board, easy access to existing corridors (Erb Street West, Ira Needles Boulevard, The Boardwalk/Thorndale Drive) should be maintained.

There is an ongoing Environmental Study Report (ESR) for the road widening of Erb Street West associated with the construction of a proposed roundabout immediately north of the Erb Street Pond. This proposed roundabout is intended to replace the signalized intersection at the Canadian Tire plaza entrance adjacent to the BMO Bank of Montreal and the Shoppers Drug Mart. If this roundabout is constructed as intended, this provides the most logical connection point to Erb Street West for any newly proposed road alignment through the Subject Lands.

There are no anticipated major conflicts with regards to crossing existing infrastructure within either of the three road connection right-of-ways (i.e. Ira Needles Boulevard, Erb Street West, or The Boardwalk/Thorndale roundabout). The only scenario where conflicts may occur is if one of the proposed road alignment alternatives being assessed crosses or encroaches on the gas easement along the eastern property line of the hydro corridor; which contains a 400mm diameter Union Gas transmission main.

6.0 CONCLUSIONS

Based on the assessment of the technical design overview, the following conclusions are provided:

1. Existing site topographical surveys and geotechnical investigations conclude that the existing topography and soils are suitable for the proposed extension of The Boardwalk from Thorndale Drive to the proposed connection between Erb Street West and Ira Needles Boulevard.

2. The majority of the proposed works will require additional fill to be imported to the sites. Some of this fill could potentially be imported from local sources such as the Region of Waterloo's landfill site, which has an excess of suitable soil.

3. There are some small areas of unsuitable soil/material onsite that may need to be exported. Further investigations will need to be conducted to identify the extent of unsuitable material onsite.

4. New roads are to be constructed in accordance with Section 7.2.5 of the City of Waterloo Development Engineering Manual 2013, which also conform to the standards set forth by the Region of Waterloo and the Transportation Association of Canada.

5. The overall constructability of the project should be relatively straightforward based on the existing conditions information available at this time. The proposed connections to the existing road corridors provide adequate and logical links between the surrounding sites. There are no anticipated major conflicts when it comes to municipal services and utilities crossings.

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TAB 5

TECHNICAL MEMORANDUM

MTE FILE NO.: C 34280-101
DATE: December 4, 2018
PREPARED BY: Charles Carré, E.I.T.

Re: Municipal Services and Utilities
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained to complete the existing conditions characterization of municipal services and utilities for the proposed road connection from The Boardwalk extension to the proposed connection between Erb Street West and Ira Needles Boulevard, in the City of Waterloo.

This technical memorandum documents the existing conditions information within the study area for the Erb Street connection. This information is to be considered during the identification, assessment, and determination of an appropriate preferred route alternative for the extension of The Boardwalk from Thorndale Drive to the proposed connection between Erb Street West and Ira Needles Boulevard. This technical memo provides background information for the assessment of the north south collector road alternatives.

This document draws upon the existing information found in several previous reports and studies completed by public agencies and private developers relating to projects undertaken within the study area. The intent is to document the existing municipal services and major utilities within the study area and to describe the potential connection points to these services for the proposed development.

2.0 STUDY AREA

The proposed WW-WD, NS-CR is located west of Ira Needles Boulevard, in the southwestern portion of the City of Waterloo. The internal private road (The Boardwalk) begins at the south end of the box store development, near the entrance to Walmart. The road continues northwest, through the development, to its current terminus at the north end of the Boardwalk commercial development, at the existing roundabout extension of the municipally owned Thorndale Drive.

The study area is located in the upper reach of the Subwatershed 314 – Laurel Creek Watershed and is owned by a variety of landowners, including; the Region of Waterloo, the City of Waterloo, the INCC Corporation, Hydro One, Home Hardware, and the Cressman family. The study area generally includes a small portion of the Region of Waterloo's Waterloo Landfill at 925 Erb Street West, a small portion of the Hydro One corridor (south of Erb Street West), the residences at 87, 73, and 65 Ira Needles Boulevard, the

Westhill Meadows Golf course at 41 Ira Needles Boulevard, and the Waterloo Commons commercial development at 653-659 Erb Street West. These properties will be herein referred to as the 'Subject Lands'. Refer to the appended figures for more details.

3.0 MUNICIPAL SERVICES

During the assessment and scoring of various road connection alternatives, the opportunities for connections to, or extensions of, the existing services will play an important role in determining the benefit, or lack thereof, of certain proposed road alignments. Certain factors, such as constructability and/or cost, will govern which alternative provides a more favourable outcome. The servicing limits for the study area extend approximately from the northern limit of the 101 Ira Needles Boulevard property northward. All servicing; sanitary, storm, and water, for the Boardwalk development is conveyed south through the City of Kitchener. The following sections describe the existing servicing infrastructure, surrounding the Subject Lands, and outlines where potential proposed connections could be made for the proposed road alignments and future developments.

3.1 Water Distribution

The Subject Lands within the study area all reside within the City of Waterloo Pressure Zone 6 (Wat Zone 6). Based on information received from the Region of Waterloo, the current hydraulic grade line (HGL) of Wat Zone 6 is approximately 428m, with a serviceability range of approximately 372m to 392m. However, through ongoing discussions with the Region, it is understood that the HGL will vary depending on fluctuating water levels and demands throughout the distribution network.

Wat Zone 6 receives water from the Zone 6 Reservoir elevated water tank, located at the northwestern end of the Boardwalk development, north of the Landmark Cinemas and adjacent to the hydro corridor. Treated water from the Mannheim Water Treatment Plant is combined with groundwater from a series of wells located near the Mannheim Reservoir. This water is then pumped by the Mannheim Zone 6 Pumping Station, located on Ottawa Street South, in the City of Kitchener. The Mannheim PS is used to fill the Zone 6 Reservoir tank, which is then used to service both the Wat Zone 6 and the City of Kitchener Pressure Zone 6 (Kit Zone 6). Twin 450mm diameter watermains exit the water tank and extend to Ira Needles Boulevard. One watermain runs south along Ira Needles Boulevard and eventually connects to the Mannheim PS system, which serves as the principle water source for Kit Zone 6. The second 450mm diameter watermain, which services the Wat Zone 6, crosses Ira Needles Boulevard near the Medical Centre at The Boardwalk and connects to a local 400mm diameter watermain running north-south on the eastern side of Ira Needles Boulevard. This watermain extends north along Ira Needles Boulevard and traverses along West Hill Drive, eventually intersecting with Erb Street West. It also runs south along Ira Needles Boulevard until it reaches University Avenue West where it traverses easterly.

Further to the watermains described above, there are also other local watermains which surround the Subject Lands. There is a 450mm diameter asbestos cement watermain along north side of Erb Street West which serves as a Wat Zone 6 watermain. This watermain currently services the Waterloo Commons and the Canadian Tire developments; among others outside of the study area. There is also a 600mm concrete pressure pipe watermain along the south side of Erb Street West, which conveys water from the Erb Street Reservoir (and pumping station) to the City of Waterloo Pressure Zone 5.

The existing residential dwellings and commercial building at 41, 65, and 73 Ira Needles Boulevard are currently serviced by private onsite wells.

Lastly, there is a 200mm diameter PVC watermain along the newly extended Thorndale Drive, which terminates at the northern leg of the newly constructed roundabout at the intersection of Thorndale Drive and The Boardwalk.

The most reasonable connections points for a newly proposed watermain, which would be part of the proposed works for the road connections in question, would include the existing 200mm diameter watermain at Thorndale Drive and The Boardwalk and the existing 450mm diameter watermain on the north side of Erb Street West. Refer to **Figure 1.0** for more details regarding the exiting water distribution infrastructure.

3.2 Sanitary Servicing

There are not an abundance of sanitary servicing options for the Subject Lands. There are no municipal sanitary sewers running along either Ira Needles Boulevard or Erb Street West in the traditional sense.

The existing residential dwellings and commercial building at 41, 65, and 73 Ira Needles Boulevard are currently serviced by private onsite septic systems. No sanitary outlet currently exists along Ira Needles Boulevard for these properties.

The only sanitary sewer servicing any of the subject properties is a 300mm diameter sanitary sewer which runs south-north along a servicing easement through the western portion of the Canadian Tire development lands. The upper reach of this service starts at the Westhill Apartments lands (which are excluded from the study area) on the southeastern side of the Ira Needles Boulevard and Erb Street West intersection. A 200mm diameter sanitary sewer then crosses Ira Needles Boulevard and runs along the southern property limit of the Waterloo Commons lands. It connects to a 300mm diameter sanitary sewer near the southwestern corner of the property, is combined with the collection system for the onsite commercial buildings, and flows north along the western property limit towards the plaza entrance at Erb Street West. The manhole in the southwestern corner of the property, where the sanitary sewer transitions from a 200mm diameter sewer to a 300mm diameter sewer, also includes a 300mm diameter stub to the south which provides an outlet connection for the remainder of the Subject Lands south of the Waterloo Commons development. This is assumed to be the most convenient outlet location for the development opportunities associated with the extension of The Boardwalk to the connection between Ira Needles Boulevard and Erb Street West.

The municipal manhole in the Waterloo Commons plaza entrance at Erb Street West also serves as a collection point for a 100mm diameter forcemain along the southern side of Erb Street West. This forcemain services lands to the west of the study area. Additionally, there is an abandoned 100mm diameter forcemain immediately east of the aforementioned manhole, along the southern side of Erb Street West. It is assumed that this abandoned portion of the forcemain originally conveyed sewage east along Erb Street West, into the City of Waterloo, before a connection into this new manhole was made.

The sewage collected in the manhole described above outlets through a 300mm diameter sewer which crosses Erb Street West. The sewage is conveyed within a servicing easement through the Canadian Tire plaza lands and is combined with the onsite collection system for the commercial buildings within the development. Ultimately, this flow is conveyed north to the intersection of Bordeaux Place and Paris

Boulevard and continues north through the Clair Meadows Subdivision. Refer to **Figure 2.0** for more details regarding the existing sanitary infrastructure.

3.3 Storm Servicing

Similarly to the sanitary servicing described in Section 3.2, the ultimate terminus of the storm servicing for the majority of the study area is through the servicing easement along the western portion of the Canadian Tire development lands. However, there are some areas fronting the Subject Lands that are not included in this servicing outlet.

A portion of the southeastern corner of the study area, which includes the Thorndale Drive extension and roundabout right-of-way, and a portion of the Ira Needles Boulevard right-of-way, include municipal storm sewers that do not make their way through the Subject Lands. A series of 300mm diameter and 375mm diameter storm sewers collect runoff from the Thorndale Drive extension and roundabout right-of-way and convey it to the municipal storm sewer along Ira Needles Boulevard. This stormwater is combined with the runoff collected by a series of 300mm, 375mm, 450mm, 525mm, and 750mm diameter storm sewers fronting 65, 73, and 101 Ira Needles Boulevard. The combined runoff is conveyed to the road's local low point, in front of 73 Ira Needles Boulevard, and is directed east across the road through a series of 750mm diameter storm sewers. Ultimately, this stormwater makes its way to the Nature's Watch Community subdivision's stormwater management facility, east of Ira Needles Boulevard.

In a similar fashion, a storm sewer system encompassing 300mm, 375mm, 450mm, 600mm, 750mm, and 975mm diameter sewers collects runoff from the Westhill Drive right-of-way and the Ira Needles Boulevard right-of-way from the intersection with Westhill Drive, northward to the roundabout at Erb Street West. Additionally, this storm sewer system also collects runoff from the Westhill Apartments lands on the southeastern side of the Ira Needles Boulevard and Erb Street West intersection roundabout. The total runoff from these aforementioned areas is combined into a 1050mm diameter storm sewer at the southeastern corner of the Waterloo Commons property. This storm sewer conveys the runoff along the southern property limit to the southwestern corner, where it enters a splitter manhole structure. This splitter manhole is designed to convey the runoff from minor storm events to the Regionally owned SWM forebay along the Waterloo Commons western property line. During major storm events, the runoff bypasses the splitter structure and outlets directly to the Erb Street Pond SWM facility. The history and construction details of this forebay and SWM facility will be discussed further in the subsequent section.

It is understood that the onsite stormwater runoff generated within the majority of the subject properties that make up the study area, of which has not been previously discussed, is all directed towards the Erb Street Pond; whether through interactions with groundwater or surface water features existing on these properties. One such example is an additional stormwater management facility within the study area. This SWM pond, known as Pond 4, is located in the northwestern corner of the hydro corridor – south of Erb Street West, and serves as a retention pond for a majority of the landfill site lands. This pond ultimately outlets through a channel in the hydro corridor and the runoff is combined within the Erb Street Pond.

The existing Erb Street Pond outlet is a 900mm diameter sewer located in the southern embankment of the Erb Street West right-of-way. It is approximately lined up with the plaza entrance adjacent to the BMO Bank of Montreal and the Shoppers Drug Mart. Before the outlet crosses Erb Street West, additional storm runoff is collected by a series of 300mm and 375mm diameter sewers installed along Erb Street West, from the Ira Needles Boulevard roundabout to the low point in the road near the pond's outlet. Additionally, 450mm and 525mm diameter CSP culverts collect runoff from a ditch running west along the northern side of Erb Street

West. Finally, all this runoff is combined and conveyed through the previously discussed servicing easement through the Canadian Tire lands, which also contains the study area's sanitary outlet.

The dedicated 900mm storm sewer does not collect any further stormwater runoff as it travels north through the easement, through the intersection of Bordeaux Place and Paris Boulevard, through the Clair Meadows Subdivision, before outletting directly to Clair Creek - north of the Brandenburg Stormwater Management Facility. Refer to **Figure 3.0** for more details regarding the existing storm infrastructure.

3.4 Stormwater Management

In April 2004, MTE prepared a Final Stormwater Management Report and Scoped Environmental Impact Study (2004 MTE Report) for the Erb Street Pond (formally known as Dutton Lake). This was completed in support of a SWM strategy for the Ira Needles Boulevard Zone #6, which includes the Ira Needles Boulevard right-of-way from Westhill Meadows Golf Course to Erb Street. It was determined that the best stormwater management strategy for Zone #6 and the adjacent properties would be to construct a SWM channel and forebay in conjunction with the existing wetland and pond located adjacent to Erb Street and along the westerly limits of the former Wong Property (now the Waterloo Commons development owned by Rock Developments). This constructed storm outlet and forebay is owned by the Region of Waterloo. The previous stormwater management strategy was prepared and reviewed by the agencies. The strategy facilitated the following:

- As part of the Ira Needles Boulevard construction, the forebay was constructed to service the entire lands upstream of the forebay in their ultimate developed conditions. (The splitter, although also intended for the ultimate developed conditions, was not adequately sized or designed for the current grading constraints and wetpond permanent pool option);
- The outlet control of the pond was sized to service the entire lands;
- The strategy proposed some grading (which provided additional storage) and some additional landscaping around the forebay. It demonstrated that with some excavation of the wetland, grading the SWM facility would provide the quantity and quality controls necessary to service the entire upstream developed conditions; and,
- Ultimately, the entire Erb Street Pond would be owned by the City of Waterloo.

The report was revised in 2011 to provide the agencies with an alternative SWM strategy which was less disruptive to the existing wetland vegetation. MTE chaired meetings with the land owners and the agencies (being the City of Waterloo, the Region of Waterloo, and the Grand River Conservation Authority). The City requested that MTE complete an alternate SWM strategy, whereby the previously proposed re-grading within the wetland be eliminated and constructed works on the SWM facility be kept entirely on the municipally owned lands or easements. At that time, the forebay was, and still is, under the Region of Waterloo ownership and the pond/wetland is under private ownership. Less disruption to the wetland was to be favourable to the GRCA as well. Ultimately, the forebay and proposed works within the wetland was completed per the revised report, dated January 25, 2011. These features are currently, to some degree, in the same conditions as previously designed.

The Subject Lands drain towards the Erb Street Pond and form the uppermost reach of the Laurel Creek Subwatershed 314 (known as Area 1 in the Subwatershed 314 Management Plan, Mark L. Dorfman, Planner Inc., October 1996). The Laurel Creek Subwatershed 314 Management Plan outlined design

parameters for sustainable development. The report recognized the Erb Street Pond as a significant feature for storage of surface water runoff from the area south of Erb Street. Furthermore, the report outlined that the previously existing culvert under Erb Street was to be maintained (or enhanced) as a discharge control.

Prior to Erb Street being reconstructed in 2004, the controlled outlet consisted of a 600mm diameter CSP culvert that crossed Erb Street, with its ends projecting out of the sides of the roadway embankments. Flow was then conveyed downstream via an open ditch to Clair Creek. As part of the Ira Needles Boulevard construction project, portions of Erb Street were reconstructed, which included the replacement of the 600mm diameter CSP culvert with the previously mentioned 900mm diameter concrete storm sewer. It also included the construction of a concrete headwall and outlet structure. This outlet crosses Erb Street West through the servicing easement previously described in Section 3.3.

The 2004 MTE Report described SWM facility upgrades to the Erb Street Pond, targeting the immediate need for a SWM solution for Ira Needles Boulevard Zone #6 and Rock Developments (Waterloo Commons). Future improvements to the pond were conceptually discussed and formed the basis for the comprehensive Erb Street SWM strategy presented in the 2011 revised report.

There are currently issues with the Erb Street Pond outlet, which is very frequently clogged with debris and vegetation, which creates an artificial high water level due to perching of the retained stormwater runoff. This issue will need to be addressed in the ultimate preferred road alignment alternative and preferred SWM strategy. The SWM strategy for the Subject Lands will be an outcome of the study. Four alternatives for the management of stormwater are presented in a subsequent technical memo. All the alternatives include the north south collector road passing through the existing pond's location and the construction of one or multiple new SWM facilities within the study area. Each alternative will be assessed to determine if any or all of the existing ponds will be altered.

4.0 UTILITIES

The proposed road connection alternatives will all have to deal with the usual conflicts associated with the construction of new roads and municipal services, which include crossings with utilities such as underground Bell wires, hydro wires, and local gas lines. These conflicts will be present with any of the proposed road alignment options as these utilities are present along the western side of Ira Needles Boulevard and the southern side of Erb Street West. Additionally, a connection point may be available to the existing 100mm diameter high pressure gas main along the north side of Erb Street West, or the 300mm diameter main along the east side of Ira Needles Boulevard.

There may however be additional concerns with some of the road alignment alternatives that are proposed to cross or encroach on the hydro corridor within the study area. There exists a 400mm gasmain, within a gas easement, running parallel to the hydro corridor along its eastern property line. This is a major Union Gas transmission main which crosses Erb Street West into the Union Gas Station near the southwestern corner of the Canadian Tire development lands. It is understood that Union Gas does not allow any work to be performed atop this transmission main, so agreements will need to be made with them in order to entertain any road alignment option that would cross or encroach on the gas easement. Refer to **Figure 4.0** for more details regarding the existing Union Gas infrastructure.

Additionally, there also exist three major high voltage hydro transmission lines and one local hydro line within the hydro corridor. The multiple transmission line towers require a minimum 15m setback from their

base and may create conflicts with some of the proposed road alignment alternatives. Hydro One has already expressed concerns with having a road run longitudinally within the hydro corridor, but may be in favour of a road crossing it perpendicularly. Special considerations and negotiations with Hydro One will be required to receive approval for any work to be done on their land. Refer to **Figure 5.0** for more details regarding the existing hydro infrastructure.

5.0 CONCLUSIONS

Based on the analysis of the existing conditions of the municipal services and utilities within, and in close proximity to, the study area, the following conclusions are provided:

1. Water servicing for the Subject Lands can be made along the extension of The Boardwalk to the road connection between Ira Needles Boulevard and Erb Street west. Connections can be made to the existing 200mm diameter watermain stub at the Thorndale Drive extension roundabout and at the existing 300mm watermain stub within the Waterloo Commons which ultimately connects to the 450mm diameter watermain along Erb Street West.

2. Sanitary servicing for the Subject Lands can be made along the newly proposed road alignments and connected to the existing 300mm diameter sanitary stub at the southwestern corner of the Waterloo Commons lands. This existing sewer would then convey sewage north through the Clair Meadows Subdivision.

3. Storm servicing for the Subject Lands can be made along the newly proposed road alignments and connected to the existing and/or newly proposed stormwater management facilities within the Subject Lands. Ultimately, the area's storm outlet is found at the north end of the study area, wherein an existing 900mm diameter storm sewer would convey storm runoff north through the Clair Meadows Subdivision to be discharged directly to Clair Creek.

4. Special considerations will need to be made while selecting a preferred route alternative in order to minimize the impacts to existing utilities, such as underground Bell lines, hydro lines, and gas lines, throughout the study area. This is especially true for any alternative that may cross or encroach on the gas easement along the eastern property line of the hydro corridor, which contains a 400mm diameter Union Gas transmission main.

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Fax: 519-743-6513

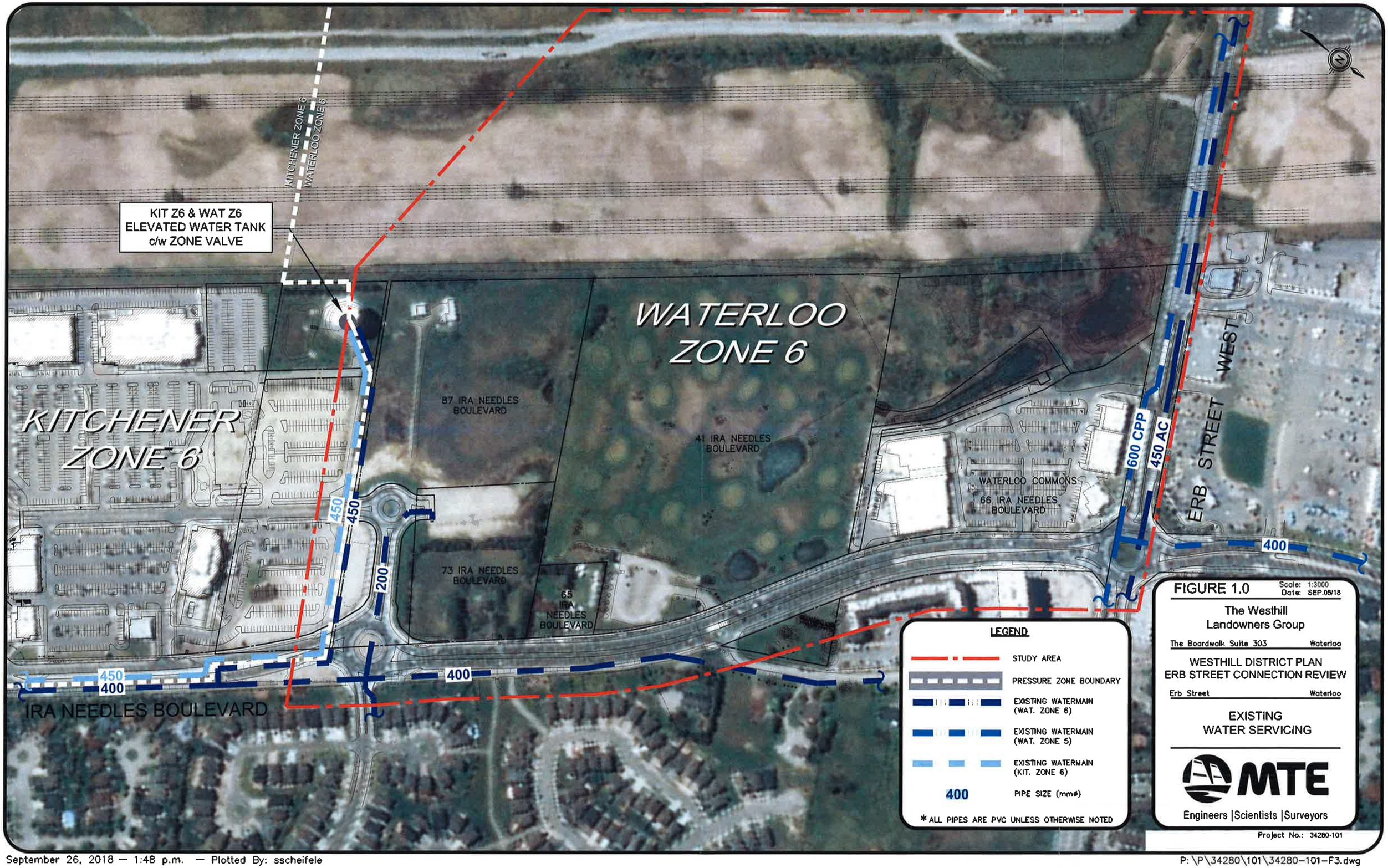


FIGURE 1.0 Scale: 1:3000 Date: SEP.05/18

The Westhill Landowners Group

The Boardwalk Suite 303 Waterloo

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

Erb Street Waterloo

EXISTING WATER SERVICING

MTE

Engineers | Scientists | Surveyors

Project No.: 34280-101

September 26, 2018 — 1:48 p.m. — Plotted By: sscheifele

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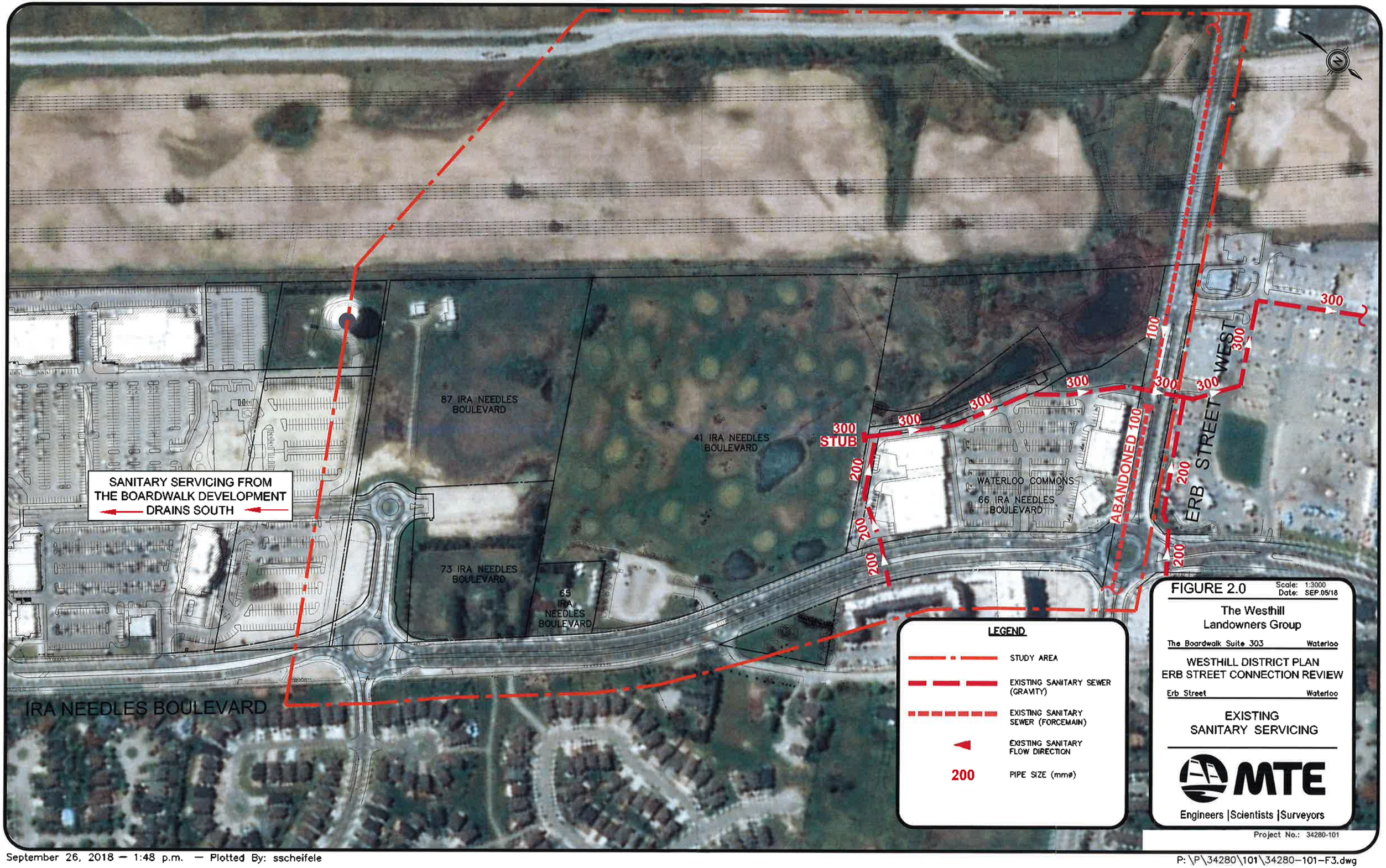


FIGURE 2.0

Scale: 1:3000
Date: SEP.05/18

The Westhill
Landowners Group

The Boardwalk Suite 303 Waterloo

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

Erb Street Waterloo

EXISTING
SANITARY SERVICING

MTE
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September 26, 2018 — 1:48 p.m. — Plotted By: sscheifele

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STORM SERVICING FROM
THE BOARDWALK DEVELOPMENT
DRAINS SOUTH

87 IRA NEEDLES BOULEVARD

41 IRA NEEDLES BOULEVARD

73 IRA NEEDLES BOULEVARD

65 IRA NEEDLES BOULEVARD

WATERLOO COMMONS
66 IRA NEEDLES BOULEVARD

ERB STREET POND

IRA NEEDLES BOULEVARD

ERB STREET WEST

ERB STREET

250 250 300 300 375 375 450 300 450 750 450 375 300 450 525 300 600 750

900 300 750 1050 900 375 900 900 900 300 300 975 450 375 375 375 300 300 975 750 600 300 300 600 450 PLUG 600 PLUG 300 300 375 450 450

LEGEND

- STUDY AREA
- EXISTING STORM SEWER
- EXISTING STORM LEAD (300mmø UNLESS NOTED)
- EXISTING STORM FLOW DIRECTION
- 750 PIPE SIZE (mmø)

FIGURE 3.0

Scale: 1:3000
Date: SEP.05/18

The Westhill
Landowners Group

The Boardwalk Suite 303 Waterloo

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

Erb Street Waterloo

EXISTING
STORM SERVICING

MTE
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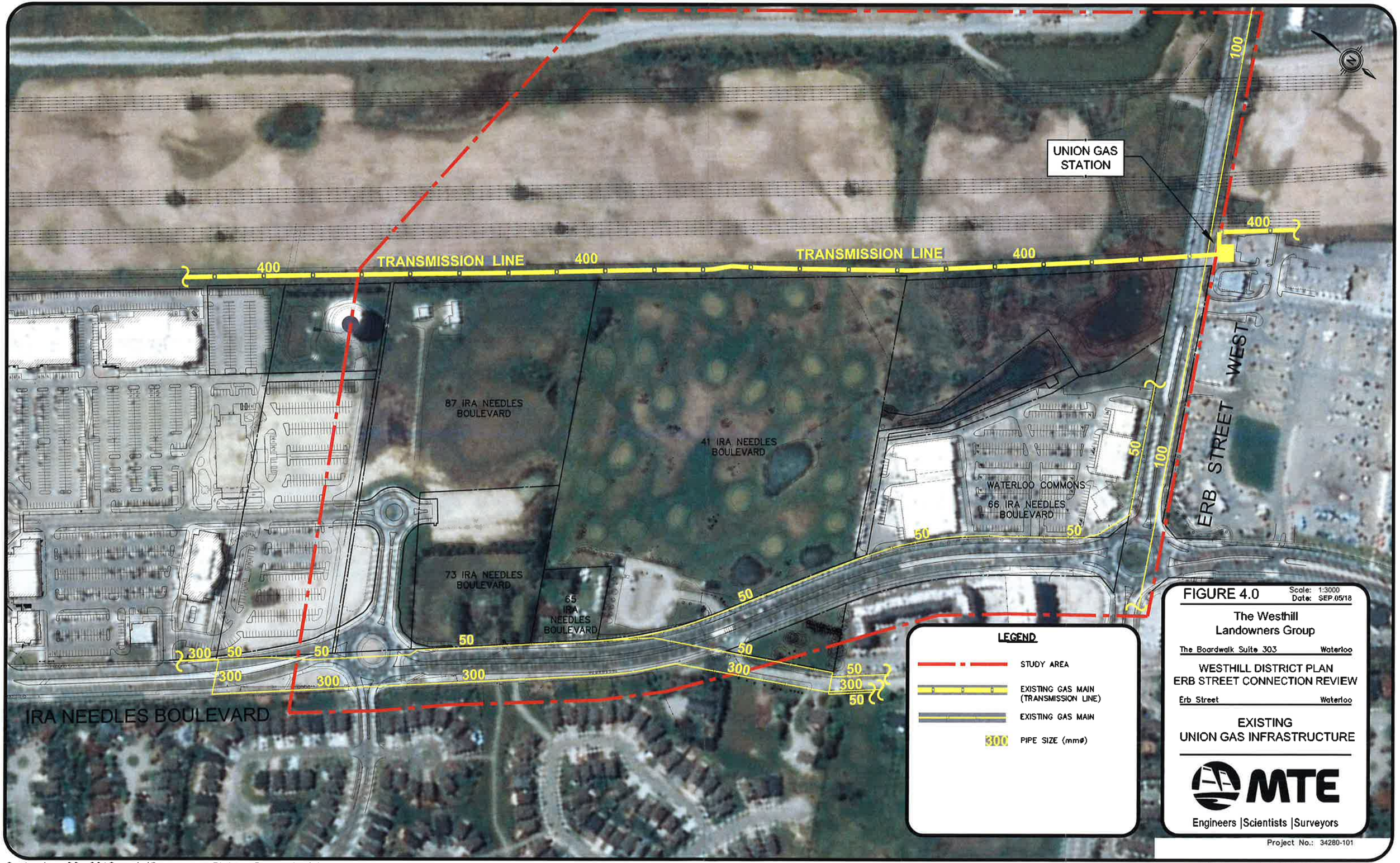


FIGURE 4.0 Scale: 1:3000 Date: SEP.05/18

The Westhill Landowners Group

The Boardwalk Suite 303 Waterloo

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

Erb Street Waterloo

EXISTING
UNION GAS INFRASTRUCTURE

MTE

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Project No.: 34280-101

September 26, 2018 — 1:48 p.m. — Plotted By: sscheifele

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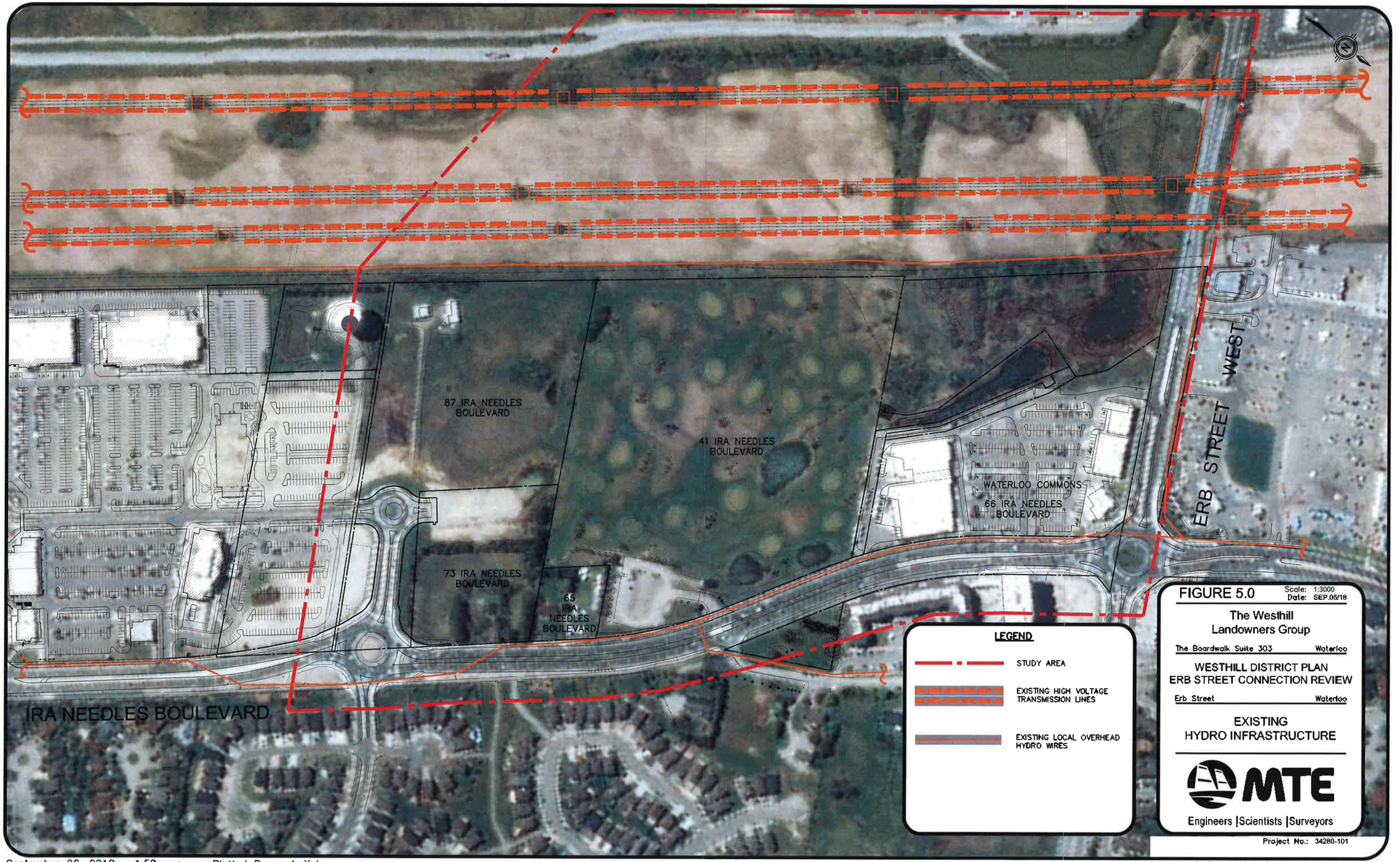


FIGURE 5.0 Scale: 1:3000 Date: SEP.05/18

The Westhill Landowners Group

The Boardwalk Suite 303 Waterloo

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

Erb Street Waterloo

EXISTING HYDRO INFRASTRUCTURE

MTE

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September 26, 2018 — 1:58 p.m. — Plotted By: sscheifele

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TAB 6

TECHNICAL MEMORANDUM

MTE FILE NO.: C 34280-101
DATE: December 4, 2018
PREPARED BY: Jeff Martens, P.Eng.

Re: Stormwater Management Alternatives Considered
West Waterloo, Westhill District (WW-WD)
North/South Collector Rd (NS-CR)

1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained to complete the existing conditions characterization for the proposed road connection from The Boardwalk extension to the proposed connection between Erb Street West and Ira Needles Boulevard, in the City of Waterloo.

This technical memorandum presents the existing site topography and soil characteristics, the technical design overview of the road geometry and pavement design requirements, and the constructability of the proposed works within the study area for the Erb Street connection. This information is to be considered during the identification, assessment, and determination of an appropriate preferred route alternative for the extension of The Boardwalk from Thorndale Drive to the proposed connection between Erb Street West and Ira Needles Boulevard. This technical memo provides background information for the assessment of the north south collector road alternatives.

This document draws upon the existing information found in several previous reports and studies completed by public agencies and private developers relating to projects undertaken within the study area. The intent is to present the technical design overview for the proposed works and describe any potential conflicts that may need to be considered during the establishment and analysis of road alignment alternatives.

2.0 STUDY AREA

The proposed WW-WD, NS-CR is located west of Ira Needles Boulevard, in the southwestern portion of the City of Waterloo. The internal private road (The Boardwalk) begins at the south end of the box store development, near the entrance to Walmart. The road continues northwest, through the development, to its current terminus at the north end of the Boardwalk commercial development, at the existing roundabout extension of the municipally owned Thorndale Drive.

The study area is located in the upper reach of the Subwatershed 314 – Laurel Creek Watershed and is owned by a variety of landowners, including; the Region of Waterloo, the City of Waterloo, the INCC Corporation, Hydro One, Home Hardware, and the Cressman family. The study area generally includes a small portion of the Region of Waterloo's Waterloo Landfill at 925 Erb Street West, a small portion of the Hydro One corridor (south of Erb Street West), the residences at 87, 73, and 65 Ira Needles Boulevard, the Westhill Meadows Golf course at 41 Ira Needles Boulevard, and the Waterloo Commons commercial development at 653-659 Erb Street West. These properties will be herein referred to as the 'Subject Lands'.

The Westhill District is within the Grand River Watershed and is located south and west of Laurel Creek. Drainage is generally from south to north and ultimately outletting into Clair Creek. Drainage from the Cressman Lands flows through the dug pond on the golf course and ultimately to the culvert crossing at Erb Street. A large drainage area from the Region's land fill site and the Ontario Hydro Corridor also flows to the Erb Street culvert. The culvert crossing at Erb Street was largely undersized and as a result the impoundment of storm water upstream on Erb Street has occurred for the last 30 years resulting in wetland vegetation in the stormwater attenuation area.

The existing Erb Street Pond outlet is a 900mm diameter sewer located in the southern embankment of the Erb Street West right-of-way. Ultimately, the existing 900mm diameter storm sewer would convey storm runoff north through the Clair Meadows Subdivision to be discharged directly to Clair Creek.

Please refer to the Westhill District Plan Final Stormwater Management Report prepared by MTE Consultants Inc. prepared August 26, 2010, prepared in support of the previously approved Westhill District Plan.

The existing conditions are illustrates in the MTE - Existing Conditions Drawing - **Figure MS11.0**

Outlined below are the various stormwater management alternatives to be considered through the study process:

Alternative 1 - See Figure MS11.1

Do Nothing N/S Collector Roadway bisects the existing SWM/Wetland

- One Open Space SWMF with two Public SWMF and Roadway
- Storm sewer outlets to existing Erb Street SWMF
- No quality control upstream of wetland
- Flooding occurs over roadway

Alternative 2 – See Figure MS11.2

New development serviced by seven private site SWMF plus three public SWMF.
Allowable flow rates established based on prorating available culvert capacity.

- Dual sewer on Municipal ROW
    - Clean water sewer for treated water from private sites
    - Dirty water sewer for road drainage
- Public SWMF downstream of roadway drainage
- Double routings for large storm events
- Extensive infrastructure with on-site SWMF and public SWMF

MTE Consultants Inc. www.mte85.com
520 Bingemans Centre Drive
Kitchener, Ontario N2B 3X9
Phone: 519-743-6500
Fax: 519-743-6513

Alternative 3 – See Figure MS11.3

New development serviced by six public ownership SWMF, each SWMF having a dedicated storm outlet.

- Developments proceed independently
- Double sewer for Cressman SWMF, Home Hardware SWMF and road drainage.
    - Clean water sewer for treated water from municipal SWMF
    - Dirty water sewer for road drainage

Alternative 4 – See Figure MS11.4

Two public SWMF, and one private SWMF.

- Minimizes infrastructure costs and maintenance
- Minimal number of municipal SWMF

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MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario N2B 3X9
Phone: 519-743-6500
Fax: 519-743-6513
www.mte85.com

MTE FILE No: 34280-101-MS11.0
PRELIMINARY SWM ALTERNATIVE 3
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EXISTING REGION OF WATERLOO LANDFILL POND

HYDRO CORRIDOR

KW ZONE 6 ELEVATED TANK

87 IRA NEEDLES BOULEVARD

41 IRA NEEDLES BOULEVARD

WATERLOO COMMONS

66 IRA NEEDLES BOULEVARD

THE BOARDWALK

THORNDALE DRIVE

73 IRA NEEDLES BOULEVARD

65 IRA NEEDLES BOULEVARD

IRA NEEDLES BOULEVARD

WESTHILL DRIVE

ERB STREET WEST

750mmø 825mmø 900mmø 900mmø 900mmø

LEGEND

- PROPERTY BOUNDARY
- EASEMENT
- EXISTING SPOT ELEVATIONS/CONTOURS
- EXISTING SANITARY SEWER
- EXISTING WATERMAIN
- EXISTING STORM SEWER
- EXISTING EMBANKMENT (SLOPE AS NOTED)
- LIMIT CONSTRAINT LEVEL 1
- STANDING WATER w/ ECOLOGICAL VEGETATION/FUNCTION
- STANDING WATER

MS11.0 Scale: 1:2500 Date: OCT.16/18

The Westhill Landowners Group

101 IRA NEEDLES BOULEVARD WATERLOO, ON

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION REVIEW

ERB STREET WATERLOO, ON

EXISTING CONDITIONS

MTE Engineers | Scientists | Surveyors

Project No.: 34280-101

October 18, 2018 - 12:39 p.m. - Plotted By: mmiddle

34280-101-MS11.1
PRELIMINARY SWM ALTERNATIVE 3
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HYDRO CORRIDOR

EXISTING
REGION OF WATERLOO
LANDFILL POND

KW ZONE 6
ELEVATED TANK

87 IRA NEEDLES
BOULEVARD

41 IRA NEEDLES
BOULEVARD

WATERLOO
COMMONS

66 IRA NEEDLES
BOULEVARD

THE
BOARDWALK

THORNDALE DRIVE

73 IRA NEEDLES
BOULEVARD

65 IRA
NEEDLES
BOULEVARD

IRA NEEDLES BOULEVARD

WESTHILL DRIVE

ERB STREET WEST

750mmø 825mmø
900mmø 900mmø 900mmø

LEGEND

- EXISTING REGIONAL STORM DETENTION STORAGE AREA
- CONCEPTUAL STORM SEWER COLLECTOR ROAD
- (P) (PRIVATE) SWM POND OWNERSHIP
- (C) (CITY) SWM POND OWNERSHIP
- (R) (REGION) SWM POND OWNERSHIP

MS11.1

Scale: 1:2500
Date: OCT.16/18

The Westhill
Landowners Group

101 IRA NEEDLES BOULEVARD WATERLOO, ON

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION
REVIEW

ERB STREET WATERLOO, ON

ALTERNATIVE 1
FIGURE

MTE
Engineers | Scientists | Surveyors

Project No: 34280-101

HYDRO CORRIDOR

EXISTING
REGION OF WATERLOO
LANDFILL POND

KW ZONE 6
ELEVATED TANK

87 IRA NEEDLES
BOULEVARD

41 IRA NEEDLES
BOULEVARD

WATERLOO
COMMONS

56 IRA NEEDLES
BOULEVARD

THE
BOARDWALK

THORNDALE DRIVE

73 IRA NEEDLES
BOULEVARD

65 IRA
NEEDLES
BOULEVARD

ERB STREET

IRA NEEDLES BOULEVARD

WESTHILL DRIVE

750mmø 825mmø
900mmø 900mmø 900mmø

P
C
R

LEGEND

- PROPOSED STORM DETENTION STORAGE AREA
- CONCEPTUAL STORM SEWER(UNTREATED)
- STORM SEWER(TREATED)
- COLLECTOR ROAD
- (P) (PRIVATE) SWM POND OWNERSHIP
- (C) (CITY) SWM POND OWNERSHIP
- (R) (REGION) SWM POND OWNERSHIP

MS11.2

Scale: 1:2500
Date: OCT.16/18

The Westhill
Landowners Group
101 IRA NEEDLES BOULEVARD WATERLOO, ON

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION
REVIEW
ERB STREET WATERLOO, ON

ALTERNATIVE 2
FIGURE

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34280-101-MS11.2
PRELIMINARY SWM ALTERNATIVE 3
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MTE FILE No: 34280-101-MS11.3
PRELIMINARY SWM ALTERNATIVE 3
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HYDRO CORRIDOR

EXISTING
REGION OF WATERLOO
LANDFILL POND

KW ZONE 6
ELEVATED TANK

87 IRA NEEDLES
BOULEVARD

41 IRA NEEDLES
BOULEVARD

66 IRA NEEDLES
BOULEVARD

73 IRA NEEDLES
BOULEVARD

65 IRA
NEEDLES
BOULEVARD

THE
BOARDWALK

THORNDALE DRIVE

ERB STREET WEST

IRA NEEDLES BOULEVARD

WESTHILL DRIVE

WATERLOO
COMMONS

900mmø

750mmø

825mmø

900mmø

900mmø

C

R

LEGEND

- REGIONAL SWM FACILITIES
- CONCEPTUAL STORM SEWER(UNTREATED)
- STORM SEWER(TREATED)
- COLLECTOR ROAD
- (P) (PRIVATE) SWM POND OWNERSHIP
- (C) (CITY) SWM POND OWNERSHIP
- (R) (REGION) SWM POND OWNERSHIP

MS11.3

Scale: 1:2500
Date: OCT.16/16

The Westhill
Landowners Group
101 IRA NEEDLES BOULEVARD WATERLOO, ON

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION
REVIEW
ERB STREET WATERLOO, ON

ALTERNATIVE 3
FIGURE

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Project No.: 34280-101

October 19, 2016 - 12:29 p.m. - Robert Ilic website

34280-101-MS11.4
PRELIMINARY SWM ALTERNATIVE 3

EXISTING
REGION OF WATERLOO
LANDFILL POND

HYDRO CORRIDOR

KW ZONE 6
ELEVATED TANK

87 IRA NEEDLES
BOULEVARD

41 IRA NEEDLES
BOULEVARD

WATERLOO
COMMONS

66 IRA NEEDLES
BOULEVARD

THE
BOARDWALK

THORNDALE DRIVE

73 IRA NEEDLES
BOULEVARD

65 IRA
NEEDLES
BOULEVARD

ERB STREET

IRA NEEDLES BOULEVARD

WESTHILL DRIVE

750mmø
825mmø
900mmø
900mmø
900mmø

LEGEND

- REGIONAL SWM FACILITIES
- CONCEPTUAL STORM SEWER(UNTREATED)
- STORM SEWER(TREATED)
- COLLECTOR ROAD
- (X) REMOVE SWM POND
- (P) (PRIVATE) SWM POND OWNERSHIP
- (C) (CITY) SWM POND OWNERSHIP
- (R) (REGION) SWM POND OWNERSHIP

MS11.4

Scale: 1:2500
Date: OCT.16/18

The Westhill
Landowners Group
101 IRA NEEDLES BOULEVARD WATERLOO, ON

WESTHILL DISTRICT PLAN
ERB STREET CONNECTION
REVIEW
ERB STREET WATERLOO, ON

ALTERNATIVE 4
FIGURE

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