Kitchener Zone 4 Trunk Watermain Preliminary Design Report

GENIVAR Project No. 111-56128-00

November 2013

Preliminary Design Report

1-367 Woodlawn Rd. W., Guelph, Ontario N1H 7K9
Telephone: 519.827.1453 • Fax: 519.827.1483 • www.genivar.com
Contact: James Witherspoon, P.Eng., LEED AP, Director - Municipal Infrastructure • E-mail: Jamie.Witherspoon@genivar.com
Project No.

111-56128-00

Nathan Morris
Region of Waterloo
150 Frederick St 7th Floor
Kitchener Ontario N2G 4J3

Re: Kitchener Zone 4 Trunk Watermain
Preliminary Design Report

Dear Mr. Morris:

GENIVAR Inc. is pleased to submit the Preliminary Design Report for the Kitchener Zone 4 Trunk Watermain, subsequent to the completion of the Environmental Assessment and additional required studies.

We trust this meets with your approval. If you have any questions or comments, please do not hesitate to contact the undersigned at 519.827.1453.

Yours truly,

GENIVAR Inc.

James Witherspoon, P.Eng., LEED AP
Project Manager
Regional Director – Southcentral Ontario

/JW
# Table of Contents

1. **INTRODUCTION** .......................................................................................................................................................... 1
   1.1 Background ........................................................................................................................................................................ 1
   1.2 Preferred Alignment ......................................................................................................................................................... 1

2. **PRELIMINARY DESIGN PROCESS** .............................................................................................................................. 2
   2.1 Trunk Watermain Characteristics ........................................................................................................................................ 2
       2.1.1 Size and Materials ......................................................................................................................................................... 2
       2.1.2 Trunk Watermain Criteria ................................................................................................................................................ 2
       2.1.3 Trunk Watermain Constraints ......................................................................................................................................... 3
   2.2 Hydro One Requirements ...................................................................................................................................................... 3
   2.3 Land Uses ............................................................................................................................................................................... 4
       2.3.1 Natural Areas ................................................................................................................................................................. 4
       2.3.2 Residential Areas ........................................................................................................................................................... 4
       2.3.3 Agricultural Land Planned for Future Development ........................................................................................................ 5
   2.4 Existing Utilities ..................................................................................................................................................................... 5
       2.4.1 Natural Gas Transmission Line ....................................................................................................................................... 5
       2.4.2 Unidentified Utility Crossing ......................................................................................................................................... 5
       2.4.3 Region of Waterloo Water Supply Well Field .................................................................................................................. 5
       2.4.4 Road Roundabout Crossing ...................................................................................................................................... 5
       2.4.5 Road Crossings ................................................................................................................................................................. 6
       2.4.6 Emergency Services ......................................................................................................................................................... 6

3. **ADDITIONAL STUDIES COMPLETED** ............................................................................................................................ 6
   3.1 Geotechnical Evaluation ....................................................................................................................................................... 6
       3.1.1 Groundwater ................................................................................................................................................................. 6
       3.1.2 Corrosion ........................................................................................................................................................................... 6
       3.1.3 Soil Conditions ................................................................................................................................................................. 7
       3.1.4 Elevated Methane Levels ................................................................................................................................................ 7
   3.2 Stage 2 Archeological Assessment .................................................................................................................................... 7
   3.3 Hydraulic Assessment ............................................................................................................................................................ 7
       3.3.1 Transient Analysis ............................................................................................................................................................ 7
       3.3.2 Hydraulic Assessment ....................................................................................................................................................... 8
           3.3.2.1 Size Verification ..................................................................................................................................................... 8
           3.3.2.2 System Flow Control ............................................................................................................................................... 9
       3.3.3 Water Quality Assessment ............................................................................................................................................ 9
       3.3.4 Structures ......................................................................................................................................................................... 9
   3.4 Topographic Information ....................................................................................................................................................... 10

4. **CONSTRUCTION** ............................................................................................................................................................... 10
   4.1 Construction Methods .......................................................................................................................................................... 10
       4.1.2 Pipe Restraints ............................................................................................................................................................... 11
       4.1.3 Construction Site Operation ........................................................................................................................................ 11
   4.2 Approvals .............................................................................................................................................................................. 11
   4.3 Required Easement and Agreements .................................................................................................................................. 13
   4.4 Monitoring ........................................................................................................................................................................... 13
       4.4.1 Methane Levels .............................................................................................................................................................. 13
       4.4.2 Ground Water ................................................................................................................................................................. 13
       4.4.3 Hydro Tower Condition .............................................................................................................................................. 13
       4.4.4 Wildlife ............................................................................................................................................................................ 14
       4.4.5 Archeological Artifacts ................................................................................................................................................. 14
   4.5 Implementation and Scheduling .......................................................................................................................................... 14
       4.5.1 Schedule Driving Forces ............................................................................................................................................... 14
       4.5.2 Coordination with the Future Infrastructure Construction .............................................................................................. 15
4.5.3 Connection to Existing System ................................................................. 15
4.5.4 Implementation Plan and Phasing ............................................................... 15
4.5.5 Testing, Disinfection, and Commissioning ............................................... 15
4.5.6 Reinstatement ......................................................................................... 16
4.5.7 Staging Areas and Stockpiling of Materials .............................................. 16
4.6 Construction Cost Estimate ........................................................................ 17

5. MAINTENANCE AND OPERATION .................................................................. 18

5.1 Monitoring of Pipe Condition ..................................................................... 18
  5.1.1 Visual ........................................................................................................ 18
  5.1.2 Acoustic ..................................................................................................... 18
  5.1.3 Electromagnetic ....................................................................................... 18

5.2 Operation ........................................................................................................ 18

6. CONCLUSIONS AND RECOMMENDATIONS .................................................. 19

List of Tables
Table 3-1: Trunk Watermain Capacity Design Criteria as per the Design Guidelines and Supplemental Specifications for Municipal Services ............................................................... 8
Table 3-2: Potential Conveyance of Water Provided by 750mm diameter Trunk Watermain ............................................................... 8
Table 3-3: Water Retention Time within Trunk Watermain during operation ............................................................... 9
Table 4-1: Timing of Seasonal Events within Study Area ...................................... 14
Table 4-2: Cost Estimate Breakdown .................................................................. 17

List of Figures
Figure 1-1: Preferred Alignment determined by Kitchener Zone 4 Trunk Watermain Class EA ................. 1
Figure 2-1: Schematic of HONI Design Constraint ............................................... 4

Appendices
Appendix A Preliminary Design Drawings
Appendix B Hydro One Correspondence
Appendix C Union Gas Crossing Consent Document
Appendix D Region of Waterloo: Standard Practices for Construction Work near a Well Field
Appendix E Geotechnical Evaluation
Appendix F Stage 2 Archeological Investigation
Appendix G Transient Analysis
1. Introduction

1.1 Background

A Schedule B Municipal Class Environmental Assessment (Class EA) was undertaken by the Region of Waterloo (Region) and Genivar Inc. to determine the preferred route for a watermain from the Zone 4 Pumping Station to the south end of Kitchener Pressure Zone 4. This watermain was recommended by previously completed studies, outlined in Section 1.1 of the Phase 2 Class EA Report, and is required to support and strengthen the water supply of the two zones and convey more water to the south end of Kitchener Pressure Zone 4. This report follows the completed Phase 2 Class EA Report which outlined the purpose of the project, study area, and Preferred Alignment of the Trunk Watermain. The Schedule B Class EA final report satisfies the requirements for Phase 1 & 2 of the Class EA Act and was subject for public and agency review through a notice of Completion, published on March 3rd, 2013. This Preliminary Design report briefly summarizes findings of the Class EA relevant to the detailed design of the Trunk Watermain, presents the preliminary design of the Preferred Alignment, and summarizes additional studies completed after the Class EA report was finalized. This report is a summary of the Class EA document, and as such, the Class EA report and appendices should be referenced while reviewing this report to ensure all information is presented.

1.2 Preferred Alignment

The Preferred Alignment was determined based on social, environmental, economic, and technical considerations, and is drawn in Figure 1-1 within the study area. The Preferred Alignment of the Trunk Watermain is located within an existing Hydro Corridor from the connection to the Region’s Kitchener Zone 4 Pumping Station on Ottawa Street South, in the City of Kitchener to the corridor’s intersection at Fischer Hallman Road. The alignment is then located within the road easement of Fischer Hallman Road to the planned entrance of the Becker Estates development, south of Huron Road. The Preferred Alignment is then located within the planned road right of ways of Tartan Avenue, Rockcliffe Drive, a maintenance trail, Newcastle Drive, and Rockcliffe Drive, to the connection with the Strasburg Road extension.

Figure 1-1: Preferred Alignment determined by Kitchener Zone 4 Trunk Watermain Class EA
2. Preliminary Design Process

This section briefly summarizes the various considerations taken into account when evaluating and ultimately determining the Preferred Alignment for the Trunk Watermain. Preliminary Design drawings are included in Appendix A of this report.

2.1 Trunk Watermain Characteristics

2.1.1 Size and Materials

The Kitchener Zone 4 Analysis report recommended the installation of a 750 mm diameter Trunk Watermain from the Kitchener Zone 4 Pumping Station to the proposed 600 mm diameter watermain on Strasburg Road (planned for construction in 2015) at the intersection of Rockcliffe Drive, via an alignment through an existing Hydro Corridor. The Zone 4 Hydraulic Analysis Report completed by Stantec in July, 2009 indicated that the existing 750mm diameter watermain which supplies the Kitchener Pressure Zone 4 experiences a capacity deficiency of 247L/s during peak demands. This report also indicated that the projected 2031 population would increase the demand on the Kitchener Pressure Zone 4 by 50%. It was determined that an additional 750mm diameter Trunk Watermain would provide the additional supply to remedy the existing deficiency and allow sufficient supply for the planned future population that is dependent on the Kitchener Zone 4 Pressure Zone. Under the Region’s Water Supply and Distribution Optimization Master Plan Study currently underway, a recommendation is being considered to supply portions of the Pressure Zone Cambridge 1 through Pressure Zone 2 West via that Dundee connection. The 750 mm diameter trunk watermain would provide conveyance for this recommendation.

As part of the Class EA process, this size of watermain was verified to carry the required flow (refer to Section 3.3.2), based on estimated future demands, at appropriate velocities, in accordance with the Ministry of the Environment (MOE) Design Guidelines. Transient analysis of the Preferred Alignment completed as part of this report (Refer to Section 3.3) also confirmed that a 750mm will not experience significant transient pressures.

Based on the required size of the Trunk Watermain concrete pressure pipe or ductile iron could be used. It is recommended that AWWA C301 concrete pressure pipe be used, as it is typical practice for a pipe of this size, primarily due to economic considerations. Due to the location of the Preferred Alignment in relation to existing hydro infrastructure there is an elevated need for electrochemical corrosion resistance. Standard engineering practices should be utilized throughout the design process, such as ensuring dissimilar metals are not in contact, and the installation of sacrificial anodes at all fittings and valves.

2.1.2 Trunk Watermain Criteria

The following lists the criteria used to determine the Preferred Alignment for the Trunk Watermain:

- Alignments for new infrastructure should be, wherever possible, located in publicly owned land to minimize the requirement for purchasing or expropriating property;
- Conflicts with existing infrastructure, natural and man-made features, environmentally sensitive areas, species-at-risk identified by the Ministry of Natural Resources (MNR), etc., should be minimized and existing utility corridors used where possible;
- Changes in alignment (bends, elbows, etc.) should be minimized to optimize the hydraulic performance of the service;
- Alignments should provide for ease of access to allow for monitoring and repair as necessary;
- Watermain appurtenances (valves, drain chambers, air releases) should be located where they are easily accessible for routine operations and maintenance;
- Traffic disruptions are minimized on right of ways;
- Utilize conventional construction methods, where practical;
- A two to three metres of cover should be maintained over the Trunk Watermain to avoid conflicts with local utilities;
- Adequate separation from other infrastructure should be provided to prevent damage in the event of a feedermain break;
Future construction should be considered to ensure new alignments do not cause conflicts with current or proposed works (and development municipal infrastructure); and,

Hydraulic limitations should be considered and the adverse impacts minimized, such as water hammer, increased head loss from bends or velocities which are outside of the ministry of the Environment (MOE) guidelines (0.8m/s to 6.0m/s) resulting from small or large demands.

2.1.3 Trunk Watermain Constraints

- A minimum of 1.8 metres cover is required for frost cover;
- The Trunk Watermain will have a minimum interior diameter of 750mm; and,
- In accordance with MOE guidelines, at least 2.5 metres separation will be provided between any sewers and the new Trunk Watermain. Where this is not possible, at least 0.5 metres vertical separation will be provided. At least 1.5 metres separation will be provided between all other services.

2.2 Hydro One Requirements

The primary interest of Hydro One Networks Inc. (HONI) is to maintain the power supply to their customers. The failure of one tower within the hydro corridor could leave thousands of homes and businesses without power. It is critical that the installation and operation of the Trunk Watermain does not impact existing or future Hydro infrastructure. Additionally, it is important that access be maintained during construction to the hydro easement at all times for maintenance and emergency purposes. It will be necessary for the contractor to ensure and maintain access for HONI forces should the need arise.

Based on a preliminary design meeting with HONI held September 28th, 2011, the following design constrains and criteria were identified by the HONI Staff (Correspondence included in Appendix B of this report):

Constraints

- A minimum 15 metre radius should be maintained between the existing tower structures and the watermain installation, as per Figure 2-1;
- In areas where conditions do not allow for the full separation, a steel carrier casing is required. The casing is required to extend approximately 30 metres on each side of the tower footings;
- Watermain bends shall not be located adjacent to towers due to increased risk of rupture at these points;
- Backfill and piping design must allow for regular maintenance work by HONI, including, but not limited to, large cranes and vehicles;
- No stockpiling of materials is permitted where it will restrict the use of the land for HONI for emergency repair or maintenance; and,
- Hydro Tower settlement monitoring program is to be in place throughout the construction of the Trunk Watermain.

Criteria

- Deeper infrastructure installations are preferred, to minimize the risk of washouts; and,
- Watermain infrastructure alignments may vary within the easement to maximize separation distance between the watermain and the transmission towers. Refer to Section 4.1.3 of this report for further discussion of this option.
These constraints and criteria were used in combination with other design criteria to determine the general location of the Trunk Watermain easement through the hydro corridor.

2.3 Land Uses

The Preferred Alignment is approximately 6.8km long and crosses several different types of land uses, including Residential, Natural, and Agricultural land planned for development. There are several different planned developments within the area of the Preferred Alignment. The following outlines the various land uses and associated potential concerns identified within the Class EA Report. Land owner information is identified on the Preliminary Design drawings of Appendix A. The majority of the Alignment is located within municipally owned land; however, in locations were the alignment is located within private lands, a secondary easement would be required within the Hydro Corridor, this if further discussed in Section 4.3.

2.3.1 Natural Areas

Located at the intersection of the Preferred Alignment and Ottawa Street South and the intersection of the Hydro Corridor and Fisher Hallman Road, are Natural Areas that include Regionally Significant Woodlands (Stn. 0+200 to 0+375, C1.1 of Appendix A), Grand River Conservation Authority (GRCA) protected wetlands (Stn. 3+400 to 3+600, C1.7 of Appendix A), recreational trails (Stn. 3+550, C1.7 of Appendix A), and habitats of identified Species-at-Risk (Stn. 3+450 to 6+675, C1.7 of Appendix A). These areas are identified within the preliminary design drawings of Appendix A, and further discussed in Section 4.

2.3.2 Residential Areas

Residential areas abut approximately 1.0km of the Preferred Alignment located north of Bleams Road. In this area, existing houses back onto the hydro corridor, there is a recreational trail (Stn. 0+875 to 1+475, C1.2 and C1.3 of Appendix A) through the hydro corridor, and this section of land has fluctuating ground elevations. Two (2) Regional Supply Wells (K25 and K29) are located to the southwest of the intersection of Isaiah Drive and the Hydro Corridor (Stn. 0+950, C1.2 of Appendix A); these wells supply ground water to the Manheim Water Treatment Plant. Within this area is a pathogen security zone, designed to protect the quality and safety of the groundwater supply, this is further discussed in Section 4. As part of the
reinstatement process there are several Planned Trails through the hydro corridor identified in the City of Kitchener Trails Master Plan Document which should be consulted during detailed design and be included in the construction of the Trunk Watermain. This is further discussed in Section 4.5.2.

2.3.3 Agricultural Land Planned for Future Development

The section of the alignment between Bleams Road and Fischer Hallman Road is currently used as agricultural land; however, in the future, this area will become part of the Rosenberg Community Development (based on the Rosenberg Secondary Plan, 2011). This development is currently within the Master Plan stage, with construction slated to start within the next 10 years. The plans for this development identify the Hydro Corridor as a natural space, containing no buildings or parking lots, with occasional road crossings the proposed road locations are indicated in the preliminary design drawings. Through discussion with the City of Kitchener, it was identified that a trunk storm pipe would be crossing the hydro corridor, however the location was not confirmed at the time. As the proposed watermain is a pressure pipe, there will be flexibility to alter the vertical alignment as necessary to avoid this sewer. This will be a critical design component and should be flagged for the detailed design review.

The Preferred Alignment is also located within lands planned for construction between Fischer Hallman Road and Strasburg Road. There are two (2) developments located in this area; to the East is the Becker Estates Development, and to the West are several stages of the Huron Woods development, both are identified in drawings C1.10 to C1.14 of Appendix A.

2.4 Existing Utilities

The following section outlines various existing utilities and emergency services which are crossed by the Preferred Alignment of the Kitchener Zone 4 Trunk Watermain

2.4.1 Natural Gas Transmission Line

The Preferred Alignment crosses a 300mm diameter Union Gas transmission utility at two locations, identified within the appended preliminary design drawings. One crossing is within the southern shoulder of Bleams Road (Stn1+717, C1.3 of Appendix A). This transmission line was installed in 2013 by Union Gas. There is also an existing natural gas transmission line located to the west of, and traveling parallel to, Fischer Hallman Road (Stn. 3+000, C1.6 of Appendix A). Through communications with Union Gas, it was identified that a crossing agreement would be required with Union Gas (included in Appendix C).

The following are some of the restrictions that would be placed on construction activities:

- Field locates are required before any construction begins;
- The contractor must not excavate mechanically within 1.0m of the pipeline until the contractor has exposed the pipeline by hand, and;
- Third party observation is required whenever substantial excavation takes place within 1.5m of a gas line.

2.4.2 Unidentified Utility Crossing

Survey and GIS information used during the Class EA process identified a utility easement crossing Fischer Hallman Road, and the Preferred Alignment (Stn. 4+325, C1.8 of Appendix A). Consultation with local utility companies was unable to verify the presence or determine the type of utility. Prior to the completion of the detailed design, this utility easement should be further investigated.

2.4.3 Region of Waterloo Water Supply Well Field

The Class EA identified the location of two Region of Waterloo Water supply wells (K25 and K29) to the south of the crossing of Isaiah Drive (Stn.0+950, C1.2 of Appendix A). The drawings indicate a 200m diameter pathogen protection zone surrounding the wells. Within this area, there are specific restrictions on activities to protect the quality of the water source. Applicable restrictions are included in Appendix D.

2.4.4 Road Roundabout Crossing

Within the Project Site, there are two recently constructed roundabouts located at intersection of Fischer Hallman Road with Seabrook Drive (Stn. 4+215, C1.8 of Appendix A) and Huron Road (Stn. 4+750, C1.9 of Appendix A). During construction, not only the required traffic control requirements for these
roundabouts should be considered, but the reinstatement or avoidance of the recently constructed infrastructure should be considered.

2.4.5 Road Crossings

The Preferred Alignment of the Kitchener Zone 4 Trunk Watermain crosses eight existing roadways and several proposed/planned roadways. Typically there will be local utilities (water, sanitary, storm, cable, and communications) within each of these road crossings which the Trunk Watermain will generally be located below. At the crossing of Ottawa Street South (Stn. 0+025, C1.1 of Appendix A) and Bleams Road (Stn.1+700, C1.3 of Appendix A) there are larger water utilities present within the road right of way which require additional consideration within the completion of the detailed design.

2.4.6 Emergency Services

The City of Kitchener Fire Station 5 is located approximately 200 m west of the intersection of Huron Road and Fischer Hallman Road. The construction work should maintain access to this location and also provide the required movement of emergency vehicles through the site.

3. Additional Studies Completed

Following the public review and finalization of the Preferred Alignment, additional studies were completed to evaluate Geotechnical, Archeological, and Hydrological factors. This section summarizes the findings of the reports which are included in Appendix E through G.

3.1 Geotechnical Evaluation

Preliminary geotechnical information was required to evaluate the potential of the existing soil or ground water conditions to impact the construction or operation of the Trunk Watermain within the Preferred Alignment. The completion of this evaluation is standard engineering practice, to provide a general understanding of the soil conditions. This information was incorporated into the development of design recommendations.

Existing Geotechnical information was obtained from previous studies completed within the study area, including the Fisher Hallman Road and the Huron Woods development. An additional Geotechnical Evaluation was completed by LVM in June, 2013 (Appendix E) to augment existing data. The investigation included the installation of 8 new boreholes within the hydro corridor from Isaiah Drive to Fischer Hallman Road, in addition to summarizing existing information completed by LVM during previous studies in the same area. Borehole location and information is also included on the Preliminary Design drawings provided in Appendix A.

3.1.1 Groundwater

Based on the results for the geotechnical investigation, it was observed that some dewatering may be required during the construction of the Trunk Watermain. The intersection of Fischer Hallman Road with the hydro corridor (Stn. 3+525, C1.7 of Appendix A), and the sections of the Preferred Alignment located within the maintenance trail of the Huron Woods development (Stn. 6+600 to 6+800, C1.13 of Appendix A), were identified to be the locations which could potentially require dewatering during construction. More detailed geotechnical work is required to be completed prior to the finalization of the detailed design to determine a more accurate estimate of the required dewatering. There is potential that a Permit to Take Water from the MOE will be required for this work due to the presence of water in this location. Through a more detailed geotechnical evaluation, measurements of the amount of water present in this area will allow the detailed design team to determine if a Permit to Take Water is required.

3.1.2 Corrosion

Soil samples were analyzed to determine if the properties of the soil along the alignment could lead to the eventual corrosion of the Trunk Watermain. Three (3) samples were collected, at the crossing of the hydro corridor with Ottawa Street South, Bleams Road, and Fischer Hallman Road. The results of the soil tests indicated that there is a negligible concentration of sulphates within the soil. It is anticipated that there would be no significant impacts of chemical corrosion to the Trunk Watermain; however, it will be the responsibility of the detailed design engineer to verify this. It is also important to note that the detail
design engineer should investigate the issue of electrochemical corrosion identified in Section 2.1.1 of this report.

### 3.1.3 Soil Conditions

Soil within the study area was found to consist of interlayered silt and silt till deposits towards the north and south ends of the Alignment, with sand and gravel deposits throughout the middle. The predominate soils encountered are classified as Type 3 soils, and therefore, temporary side slopes must be cut at a maximum of 1 horizontal to 1 vertical. If the soil is saturated, the side slopes should not exceed a ratio of 3 horizontal to 1 vertical.

It was determined that the existing soil is not suitable to be used as bedding underneath the Trunk Watermain. It is recommended that a ‘Class B’ pipe bedding compacted to 100% Standard Proctor Maximum Dry Density be used for the installation of the proposed Trunk Watermain. In the event that the excavated material is saturated or contains organics, it is recommended that this material not be utilized for backfill.

The Class EA recommended that the use of trenchless pipe installation be considered at the crossing of Isaiah Drive. Based on the information evaluated in this report, it was determined that this type of installation would be geotechnically feasible, however, in this area the depth of fill was identified to be between 5 to 6.3 meters. It is important to ensure during the detailed design development that the pipe is structurally supported to minimize the impacts of post construction settlement.

### 3.1.4 Elevated Methane Levels

The geotechnical investigation identified elevated methane levels during the installation of three boreholes in the Isaiah Drive area (Section 3.6 of Appendix E). The levels were found to be 0-40% the lower explosion limit (LEL), while a level of 20% LEL could be potentially hazardous. Methane gas is lighter than air and typically vents vertically into the atmosphere, however, if allowed to accumulate near an ignition source, there is an explosion risk. It is recommended that monitoring of methane levels be included in the construction work plan in this area.

### 3.2 Stage 2 Archeological Assessment

A Stage 2 Archeological Assessment (Appendix F) was completed to further evaluate areas identified through the Stage 1 Archeological Assessment to have archeological potential, as required by the EA process. Within the Stage 1 Assessment, the areas which had not been disturbed by development were identified to have the potential to contain Pre-contact and Euro-Canadian archeological sites. The purpose of the Stage 2 Assessment was to determine if these areas contain archeological artifacts. This was accomplished by digging test pit at 5m intervals within these areas. This assessment of the study area did not find any signs of archeological potential within the study area. This report was approved by the Ministry of Culture and no future archeological assessment is required for the preferred alignment.

### 3.3 Hydraulic Assessment

#### 3.3.1 Transient Analysis

The purpose of transient analysis, included in Appendix G, was to evaluate how the water distribution system would react in response to an event such as a watermain break or loss of power at one, or all, of the pumping stations. This type of design evaluation is typical engineering practice. During typical operation of the distribution system, flow or pressure are changed gradually by operators to avoid damage caused by water hammer or negative pressure within the system. In the event of a watermain break or power loss, the water distribution system would experience a rapid change in pressure or flow which has the potential to further damage the distribution system. It is important to model and evaluate the potential result of these events to ensure the safety of the water distribution system.

The transient initiating events modeled in this analysis consisted of a power failure at the Kitchener Zone 4 Plant Pumping Station (local power failure) and power failure at all the pumping stations and supply points (global power failure) in the Kitchener Zone 4 water network. This analysis was conducted under conditions of peak and minimum hour demands. Additionally, a secondary emergency scenario consisting of closure of the existing 750mm outlet from the Mannheim Pumping Station was simulated. The profile of the proposed Trunk Watermain generally drops lower with distance from the Mannheim...
Pumping Station. A dropping elevation is preferred from a transient perspective since most of the pipeline will be under positive pressure even under vacuum conditions in the upper reaches.

The results of the transient analysis indicated that there are no significant down surge pressures in the proposed watermain from local or global power failures. The results also indicated that the proposed 750mm pipeline will not experience significant transient pressures due mainly to its profile and high suction side hydraulic grade line. It was recommended that the gravity bypass line with check valve to prevent backflow at the Mannheim pumping station be operational at all times as it is essential in protecting the proposed pipeline. It was also recommended that 50mm combination air valves be used for this size of pipeline.

3.3.2 Hydraulic Assessment

3.3.2.1 Size Verification

The Zone 4 Hydraulic Analysis Report identified that the current 750mm diameter connection from the Kitchener Zone 4 Pumping Station to Kitchener Pressure Zone 4 is deficient by approximately 247L/s during peak hour conditions. The intent of this project was to design the Trunk Watermain with the capacity to service the 2031 population projection, as reported in the Kitchener Zone 2 and 4 Boundary Optimization Study (Stantec, 2009). The Kitchener Zone 2 and 4 Boundary Optimization Study also projected the ultimate population (the maximum population the area will ever reach) of the service area to be 39,600 persons.

The Kitchener Zone 2 and 4 Optimization Study used a conservative water demand estimation of 300 L/cap/day, and peaking hour factor of 2 to determine the demand within the newly developed section of Kitchener Pressure Zone 2 West. Based on these conservative values, the Kitchener Zone 2 and 4 Optimization Study determined that the capacity of the current Kitchener Pressure Zone 4 750mm diameter feedermain from the Mannheim Pressure Zone 4 Pumping Station is deficient of approximately 247 L/s during current peak hour conditions.

The modeling results from the Kitchener Zone 4 Hydraulic Analysis (Stantec, 2009) identify that the installation of the 750 mm diameter Trunk Watermain from the Kitchener Zone 4 Pumping Station to south of Huron Road reduces current stress on the Ottawa Street feedermain by conveying 470 L/s during peak hour demands.

Table 3-1: Trunk Watermain Capacity Design Criteria as per the Design Guidelines and Supplemental Specifications for Municipal Services

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Velocity</td>
<td>0.8 m/s</td>
</tr>
<tr>
<td>Maximum Velocity</td>
<td>1.5 m/s</td>
</tr>
<tr>
<td>Head Loss</td>
<td>1.5 m/km or less</td>
</tr>
<tr>
<td>Minimum Pressure</td>
<td>275 kPa (Peak hourly demand)</td>
</tr>
<tr>
<td>Maximum Pressure</td>
<td>700 kPa (Min hourly demand)</td>
</tr>
</tbody>
</table>

The design of the Trunk Watermain was completed using the values identified in Table 3-1, from the Region of Waterloo and Area Municipal Design Guidelines and Supplemental Specifications for Municipal Services.

Table 3-2: Potential Conveyance of Water Provided by 750mm diameter Trunk Watermain

<table>
<thead>
<tr>
<th>Velocity (m/s)</th>
<th>Flow rate (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>397.6</td>
</tr>
<tr>
<td>1.0</td>
<td>441.8</td>
</tr>
<tr>
<td>1.1</td>
<td>486.0</td>
</tr>
<tr>
<td>1.2</td>
<td>530.1</td>
</tr>
<tr>
<td>1.3</td>
<td>574.3</td>
</tr>
<tr>
<td>1.4</td>
<td>618.5</td>
</tr>
<tr>
<td>1.5</td>
<td>662.7</td>
</tr>
</tbody>
</table>
Table 3-2 identifies that the 750 mm diameter Trunk Watermain is capable of transmitting 400L/s to 660L/s while maintaining the acceptable velocities of water through a distribution system. For this project, the required capacity is 470L/s to meet the estimated 2031 peak demand which will result in a velocity of 1.06m/s.

### 3.3.2.2 System Flow Control

With the addition of the Trunk Watermain to the Kitchener Zone 4 pressure system an evaluation was completed to ensure that the flow would be maintained through the existing 750 mm service line connected to the Kitchener Zone 4 Pumping Station. It was determined that the installation of the 750mm Trunk Watermain would not act as a bypass for flow through the existing 750mm service line. The installation of hydraulic flow control valves should be considered to allow for regulation of the flow between the two water mains.

Since the Trunk Watermain is connected within Kitchener Pressure Zone 4, the installation of the pressure reducing valve is not required for the operation of the Trunk Watermain. The installation of a pressure relief valve near the connection of the Trunk Watermain with Strasburg road may be included within the detailed design.

Additional appurtenances that could be included in the detailed design for increased monitoring or control are primarily pressure transducers tied to SCADA for monitoring, datalogging and possible control of the flow control valves at the connection to the system. Valve position indicating transmitters could be considered for inline relief valves and other features to allow for notification of a pressure relief event. Due to the lack of connections on this system, the number of additional appurtenances would be minimal.

### 3.3.3 Water Quality Assessment

The length of time water is retained within the Trunk Watermain is an important factor in maintaining the quality and safety of the drinking water. The length of time drinking water can be stored within the distribution system is dependent on the rate of chlorine degradation within the system. This is a function of chlorination type, concentration, and pipe condition. The typical design criterion is a retention time of less than 2 days within the pipe.

#### Table 3-3: Water Retention Time within Trunk Watermain during operation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Flow Rate</th>
<th>Time in pipe</th>
<th>Velocity</th>
<th>Headloss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L/s</td>
<td>m3/s</td>
<td>seconds</td>
<td>hours</td>
</tr>
<tr>
<td>Estimated 2031 population demand</td>
<td>470</td>
<td>0.47</td>
<td>6391</td>
<td>1.78</td>
</tr>
<tr>
<td>Current system deficiency</td>
<td>275</td>
<td>0.28</td>
<td>10924</td>
<td>3.03</td>
</tr>
<tr>
<td>Minimum Flow Rate</td>
<td>17.4</td>
<td>0.017</td>
<td>172800</td>
<td>48</td>
</tr>
</tbody>
</table>

Table 3-3 identifies that at the design flow rate of the Trunk Watermain, at the current estimated demand and the 30 year population demand, the retention time within the Kitchener Zone 4 Trunk Watermain is much less than the maximum of 2 days. Table 3-3 also identifies that the lowest flow rate possible to maintain the minimum water age is 17.4L/s, which is far less than the current estimated demand on the Trunk Watermain. Therefore, it is not anticipated that any significant deterioration of the water quality and chlorine residual will occur. In the event of issues with chlorine residual decay upon implementation, the correction would be an operational optimization to flush the line daily or weekly by forcing the flow to Kitchener Pressure Zone 4 through this pipe rather than through other sources.

### 3.3.4 Structures

The preliminary design drawings indicate the locations of air relief and drain valve chambers along the alignment. The air relief valves are located at high points within the Trunk Watermain; their purpose is to allow air trapped within the watermain to be removed to optimize performance. The drain valves are located at low points within the pipe cross-section; these valves would be used to drain water from the Trunk Watermain for maintenance events. The location of the valves were initially identified based on the elevation of the Trunk Watermain; however, minor adjustments were made in an attempt to locate the valves in areas which were easy to access.
3.4 Topographic Information

Several surveys were completed throughout the course of the Class EA process and compiled to create a complete map of the existing site conditions. Existing mapping provided by the Region of Fischer Hallman Road was used to supplement survey data. Topographic information of the proposed Huron Woods and Becker Estates developments were received from the developers. There fairly complete topographic information compiled for the Preferred Alignment. Additional topographic information, however, may be required if there are changes to the alignment, or additional construction is completed within the study area prior to the completion of the detailed design.

4. Construction
4.1 Construction Methods

The installation of the Kitchener Zone 4 Trunk Watermain will likely require a combination of various construction methods, including open-cut construction and the application of trenchless technologies to cross the elevation change at Isaiah Drive or any area requiring construction outside of the construction windows identified by the Ministry of Natural Resources (MNR) (Refer to Table 4-1).

Open-Cut

It is anticipated that open-cut construction will be used for the majority of the installation of the Trunk Watermain within the Preferred Alignment. The use of open-cut trench construction is generally limited to excavations less than ten (10) metres in depth due to equipment restrictions and safety concerns. As the depth of the trench increases past depths determined to be safe based on soil conditions, the excavation is required to be temporarily supported either using trench boxes or sheeting to prevent collapse of the trench walls. Trench boxes or sheeting should also be utilized to limit the width of an excavation where spatial constraints prohibit a wide trench, such as roadways or within close proximity to adjacent utilities.

Trenchless Construction

At the crossing of Isaiah Drive (Stn. 0+875, C1.2 of Appendix A) it was identified that other construction methods should be considered to transverse the large elevation changes found within this area. Based on the length (275 meters) and the size of the Trunk Watermain, the feasible trenchless construction methods in this area include Hand Tunnelling and Micro Tunneling. The trenchless alternative would, in some areas of the Isaiah Drive crossing, be 16 meters below the surface. Auger Jack and Boring methods could be used to facilitate the installation of the Trunk Watermain under roadways or Species at Risk Areas, which would be shorter distances.

Micro Tunneling

Micro Tunneling uses a remotely controlled boring machine to create tunnels up to 1.5m in diameter. The completed Geotechnical Investigation (Refer to Appendix E), identified that the soils within the area of the Isaiah Drive crossing consist of silt and sand. It is important that the soil conditions are uniform when using Micro Tunneling, since a variation of materials can make the remote boring machine diverge from its course. It is anticipated that Micro Tunneling is a viable option to create the required tunnel within the Isaiah Drive crossing area.

Hand Tunneling

Hand Tunneling is typically used when technical or site limitations exclude the use of tunneling equipment at the site. This method requires manned access to the tunnel for workers to create the tunnel using shovels. Hydraulic jacks and casings are used to provide tunnel support and safety for the digging crew. Due to the identified methane in the area of the proposed bore, this option may require additional Health and Safety efforts to secure worker safety, which may result in additional costs that make this method less attractive to the contractor.

Auger Bore and Jack (ABJ) Tunnelling

ABJ can be used to install steel casing pipes up to 2.1m in diameter in lengths of up to 100 to 150 metres. ABJ is also capable of installing pipelines in shale bedrock or in soil overburden. In soil overburden, ABJ is typically limited to tunnel alignments in stable soils located at or above the local groundwater table. There is potential for this type of construction method to be utilized for installation of the Trunk Watermain.
at road crossings, such as Ottawa Street South or to cross a Species at Risk habitat, outside of the identified construction window outlined in Section 4.5.

The majority of the Trunk Watermain can be installed with the open cut construction. It is recommended that Hand Tunneling, Micro Tunneling and Jack and Boring be further evaluated by the detailed design consultant for the installation of the Trunk Watermain within the Isaiah Drive crossing area, and any other areas where trenchless installation may be required (such as Species-at-Risk habitats or road crossings depending on traffic and utility conflicts). During the detailed design of the Trunk Watermain a far more detailed geotechnical investigation would be required to properly specify the type of construction of the Trunk Watermain.

4.1.2 Pipe Restraints

Mechanical joint restraints or concrete thrust blocks should be installed to restrain movement of the watermain. Restraint should be provided by thrust blocks positioned at all plugs, caps, tees, line valves, hydrants and bends deflecting 22 ½ degrees or more. On all mains greater than 300 mm diameter, and in areas where there is “disturbed” soil, particularly reconstruction projects or congested works, mechanical joint restraints should be installed.

4.1.3 Construction Site Operation

The preliminary design drawings in Appendix A identify a 15 meter wide construction easement along the Preferred Alignment. The dimensions of this easement are meant to identify the estimated bounds of the trenching operation to install the 750 diameter watermain. In order to facilitate the construction of the Trunk Watermain, access will be required to stage sections of watermain and transport materials to the area of construction. It is recommended that an access lane be constructed and maintained along the opposite side of the hydro corridor to allow the movement of materials along the construction site. It is important that access be maintain for HONI to complete maintenance on the power lines. The drawings included in Appendix A identify potential areas for staging and stockpiling.

4.2 Approvals

Final approval of the design will be required from municipal authorities, HONI, and other regulatory agencies prior to commencing construction. During the detailed design phase of the project, consultation with these approval authorities will ensure that their requirements are adequately addressed within the design drawings and restrictions are included in the contract specifications. Through the completion of the Municipal Class EA, correspondence with the following groups has been completed to identify requirements the Trunk Watermain must comply with.

Ministry of the Environment

Environmental Compliance Approval from the MOE will be required for the construction of the Kitchener Zone 4 Trunk Watermain, in addition to revisions of the Drinking Water License for the Regional water distribution system in accordance with the Environmental Protection Act (1990) and the Ontario Water Resources Act (1990). As indicated in Section 3, depending on the amount of dewatering required during the construction of the Trunk Watermain, a Permit to Take Water may also be required from the MOE.

Grand River Conservation Authority

The GRCA will have to be consulted during the detailed design stage of the Trunk Watermain to coordinate the issuance of permits for each regulated wetland and tributary crossing (Stn.3+525, C1.7 of Appendix A) in accordance with the Conservation Authorities Act (1990).

Ministry of Natural Resources

The Class EA project team had meetings with the MNR regarding identified endangered species within the Study Area. After conducting a Natural Heritage Survey of the Study Area, the Jefferson-X Salamander, a Species-at-Risk, and a Butternut tree had the potential to be located within close proximity of the Preferred Alignment. It was also identified that sections of the Study Area (particularly hayfields) have the potential to be a habitat for the Bobolink and Barn Swallow (two bird species recently classified as a threatened species); however, none were identified during the site visits. Appendix A indicates the areas of concern identified by the MNR.
Through consultation, the MNR has identified the following windows of time which construction should be completed to minimize impact to the identified Species-at-Risk (dates are also outlined in Section 4.5):

- Jefferson Salamander Habitat; between December 1 and March 7th;
- Bobolink and Barn Shallow (Hayfields); between August 1st and March 14th; and,
- Woodlands, located south of Ottawa Street South; between October 15th and March 14th.

These windows have been established to minimize the impact of the construction of the Trunk Watermain on the local Species-at-Risk. All areas disturbed by the activities are to be restored to their original condition prior to the end of the applicable timing window.

Further consultation with the MNR will be required to coordinate approvals within the Species-at-Risk Habitat to ensure that the proper mitigation strategies are implemented to avoid further impacts to these features, in accordance with the *Endangered Species Act* (2007). It is the responsibility of the proponent to assess the condition of, and inventory the existing butternut trees within the study area.

**Ministry of Culture**

As part of the preliminary design, a Stage 2 Archaeological Assessment was completed in areas identified by the Stage 1 Archaeological Assessment. Ministry of Culture approval is required prior to construction of the proposed work in accordance with the *Ontario Heritage Act* (1990). The Stage 2 Archeological Assessment was approved by the Ministry of Culture on July 16th, 2013 (included in Appendix F), therefore no further approvals from the Ministry of Culture are required for this project.

**Hydro One Networks Inc.**

HONI will need to be consulted during the detailed design of the Trunk Watermain to develop an occupancy permit or agreement between the Region of Waterloo and HONI, since a large portion of the Preferred Alignment is within an existing Hydro Corridor. The majority of the Corridor is not owned by HONI (land owners are identified within Appendix A), but an easement is used by HONI to limit land owner’s use of the Corridor space. Approvals from HONI will be based on the coherence of the design to the previously identified HONI design criteria (Refer to Section 2.2). The Region’s Legal department would be required to determine land owner specific easement agreements in addition to an agreement with HONI.

**Kitchener-Wilmot Hydro Commission**

The Kitchener-Wilmot Hydro Commission has a proposed utility easement through the existing Hydro Corridor to the east of Fischer Hallman Road (Stn. 3+475, C1.7 of Appendix A). Approvals or the development of an occupancy permit or agreement will be required for the crossing of this easement within the Hydro Corridor at the intersection of the Hydro Corridor and Fischer Hallman Road.

**Union Gas**

A crossing of a 300mm diameter Union Gas Transmission Pipeline is required to the south of Bleams Road, and also west of Fischer Hallman Road along the Preferred Alignment. A Crossing Agreement with Union Gas, included in Appendix C, will be required to complete construction in this area.

**Utilities**

For some areas of the alignment, various existing utilities (e.g. phone, cable, etc.) will have to be relocated in order to accommodate the Trunk Watermain. Preliminary plan and profile drawings of the preferred Trunk Watermain alignment should be circulated to utility companies and any utility conflicts should be addressed during the detailed design phase. The majority of the impacted utilities have been included in discussion of the Trunk Watermain throughout the Municipal Class EA process, Refer to the Class EA Report for a record of consultation.

**Transportation Approvals**

Transportation approvals from the City of Kitchener and Region of Waterloo roads department will be required for all road closures during the construction of the Trunk Watermain. These approvals will be required to be submitted to the government owner of the roadway. Generally the approvals include the installation of detour signage, notification of emergency services in addition to the assurance to the owner that the planned construction will not permanently impact the condition of the road way. The anticipated
traffic disruptions should be investigated and mitigated during the detailed design of the Trunk Watermain.

Refer to the Final Phase 2 Class EA Report for a full summary of all correspondence. The correspondence with HONI was duplicated in Appendix B of this report, due to its importance to a majority of the Preferred Alignment which is located within Hydro corridor.

4.3 Required Easement and Agreements

A criterion of the EA process, identified in Section 2.1.2, was to maximize the length of the Trunk Watermain alignment within existing municipally owned land. This limits the required easements, permits to enter and acquisitions potentially required to complete the construction of the Trunk Watermain. Although the EA and Preliminary Design of the Trunk Watermain attempted to limit the amount of private land impacted by this project, it was not feasible to locate the Trunk Watermain exclusively within municipally owned land.

Property owner information is included within the preliminary design drawings of Appendix A, the majority of the alignment is located within a road right of way land owned by the City of Kitchener. There are some sections of the preferred alignment, however, which would be located within privately owned land within the hydro corridor; the largest section being the alignment between Bleams Road and Fischer Hallman Road. Within this area a permanent easement agreement would be required between the property owner and the Region, in addition to a secondary easement agreement under the existing HONI easement. Section 2.3.3 identifies that this land is planned to be developed into the Rosenberg Development. The Rosenberg Secondary Plan indicated the land within the Hydro Corridor as open spaces owned by the City of Kitchener. In the event that the construction of the Trunk Watermain corresponds with the development of this area, there may be no easements required within privately owned land.

During the detailed design of the Trunk Watermain, it should be noted that if the existing hydro corridor does not provide sufficient space for the installation of the pipe temporary construction easements on adjacent properties, or permit to enter agreements should be explored to facilitate the proper movement of materials on the construction site.

4.4 Monitoring

4.4.1 Methane Levels

Section 3.1.4 identifies the potential for elevated methane levels when constructing near the Isaiah Drive crossing. There is potential for this substance to cause health and safety concerns if not monitored and treated properly. During construction methane levels should be recorded regularly. The construction work plan should include safety procedures to deal with methane at the site. Proper ventilation is important to maintain, as the highest risk of explosion comes when methane gas is allowed to accumulate.

4.4.2 Ground Water

As part of the detailed design phase of the Trunk Watermain, a ground water monitoring program should be established based on the results of a detailed geotechnical evaluation. It is also important to monitor the ground water levels at the Regional water supply wells (K25 and K29) located to the southwest of Isaiah Drive. The location of the wells is identified in Section 2.3.2. It should also be noted that there is a Pathogen Prohibition Zone surrounding the two supply wells. This zone is in place to protect the quality and safety of the water supply by these wells. Appendix D identifies requirements from the Region when working within close proximity to a well field.

4.4.3 Hydro Tower Condition

As per the HONI requirements for construction within their Hydro Line easement, the work plan for the construction of the Kitchener Zone 4 Trunk Watermain will be required to include the monitoring of the condition of HONI utilities throughout the project. This monitoring should include preconstruction assessments of all infrastructure, in addition to the continuous monitoring of tower settlement. It is critical that the construction within the hydro corridor does not impact the condition or operation of the HONI infrastructure.
4.4.4 Wildlife

As previously indicated, the Preferred Alignment crosses some areas which have been identified to be a habitat, or the potential to be habitat, for Species-at-Risk as identified by the MNR. When work is being completed in these areas, the MNR has recommended the following:

- Construction Workers remain vigilant and alert to the presence of snakes and turtles within the construction zone, and advance equipment at a slow pace to permit any animals to leave the area in order to avoid trampling;
- A qualified person inspects the construction zone for the presence of animal's burrows prior to starting excavation activities, and contacts the MNR Guelph District Office at once if they demonstrate characteristics of the American Badger burrows; and,
- Should Species-at-Risk (plant or animal) be detected during the project, the project proponent will contact MNR Guelph District Office at once for further direction. Snakes and turtles should not be handled prior to phoning the MNR Office.

4.4.5 Archeological Artifacts

Although the study area has been identified to have no areas of archeological potential, there is still the potential for the construction activities to uncover something of archeological worth. In the event this occurs, a licenced archeological professional is to be engaged to complete a field study on the site. In the event that human remains are encountered, the police are to be contacted immediately.

4.5 Implementation and Scheduling

It is expected that construction will proceed in phases, commencing in 2016, determined by both seasonal limitation on work (dry season for wetland crossings, peak-use periods of park use, Species-at-Risk construction windows, etc.) in addition to the possibility of performing the work in tandem with other infrastructure upgrades, as detailed in Section 4.5.2.

Table 4-1: Timing of Seasonal Events within Study Area

<table>
<thead>
<tr>
<th>Seasonal Limitations of Work</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>Location along Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated Water table</td>
<td>Minimize Impact</td>
<td>3+450 to 3+700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal Water flow</td>
<td>No Construction</td>
<td>3+450 to 3+700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breeding Season</td>
<td>No Construction</td>
<td>Undeveloped areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nesting Season</td>
<td>No Construction</td>
<td>Undeveloped areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing Season</td>
<td>Minimize Impacts</td>
<td>2+100 to 3+450</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational Use</td>
<td>Minimize Impacts</td>
<td>0+000 to 1+100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential Species-At-Risk Habitat</td>
<td>No Construction</td>
<td>0+200 to 0+375</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jefferson Salamander Habitat</td>
<td>No Construction</td>
<td>3+450 to 3+700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential Habitats (Hay Fields)</td>
<td>No Construction</td>
<td>2+100 to 3+450</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.5.1 Schedule Driving Forces

Stages 4 and 5 of the Huron Woods Development, in addition to the Becker Estates Development, are to be serviced by the planned Strasburg Trunk Sanitary Sewer. Part of the Strasburg Trunk Sanitary Sewer is to be constructed with the planned Strasburg Road extension. It would be ideal for a section of the Strasburg Trunk Sanitary Sewer to be constructed in partnership with the Kitchener Zone 4 Trunk
Watermain to the south of the Huron Woods development. At the time of this report, both of the Becker Estates and Stages 4 and 5 of the Huron Woods development are waiting on the installation of the Strasburg Trunk Sanitary Sewer.

If the timing of the Trunk Sanitary Sewer construction, and therefore the identified developments, does not coordinate with the installation of the Kitchener Zone 4 Trunk Watermain, there would be substantial additional cost. If the Trunk Watermain is required to be installed prior to the Trunk Sanitary Sewer, and Becker Estates, there would a large additional cost to provide the required grading of the existing property. In the event that the new Kitchener Trunk Watermain is required to be installed after the completion of the developments, reinstatement of new construction would prove to be a costly task, in addition to the disruption to the local residents in the area.

4.5.2 Coordination with the Future Infrastructure Construction

Optimally, the work should be performed in conjunction with other upgrades to minimize overall construction impacts. The only planned work which would present an opportunity to be phased with the installation of the Kitchener Zone 4 Trunk Watermain, is the widening of Fischer Hallman Road by the Region of Waterloo Transportation Division. Through discussion with the project team for the Fischer Hallman Road widening, it would be preferred if the Trunk Watermain were to be installed two (2) years prior to the commencement of the widening project. This would allow the disturbed ground from the Trunk Watermain installation to settle, limiting the impact to the final quality of the Fischer Hallman Road widening project in 2019. The development of the Rosenberg Development should be considered when developing a construction staging strategy, however the timeline of this project has not been identified. The Kitchener Trails Master Plan has identified various trails through the Hydro Corridor which could be completed in conjunction with the installation of the Kitchener Zone 4 Truck Watermain.

4.5.3 Connection to Existing System

The Trunk Watermain is to be connected to the existing 750 mm diameter capped pipe from the northeast side of the Kitchener Zone 4 Pumping Station. This connection point is detailed in Drawings C1.1 of Appendix A.

4.5.4 Implementation Plan and Phasing

Due to the extent of the construction, identified windows of construction, and yearly budgets available, the project may be required to be phased over several contracts. Since this is a new works project, there will be no additional demand on the distribution system during the construction of the Kitchener Zone 4 Trunk Watermain. Preferably, for cost and operational purposes, the majority of the alignment would be completed under a single contract.

Due to the planned construction of the Huron Woods Development, at the connection with Strasburg Road, this section of the Trunk Watermain may be required to be constructed first, to limit the impact to local residents and avoid costly reinstatement of newly constructed roadways. It was determined that a portion of the 750mm diameter Trunk Watermain within Rockcliffe Road (Stn. 6+675 to 7+100, C1.14 of Appendix A) will be included within the contract to construct the Strasburg Road Extension. This will allow the Trunk Watermain to be constructed in this area at the same time as the Strasburg Road and the next stage of the Huron Woods development. Stage 5 of the Huron Woods development is anticipated to be constructed in 2014. It would be advantageous to incorporate the installation of the Trunk Watermain into the construction of this section of development.

4.5.5 Testing, Disinfection, and Commissioning

If the Trunk Watermain is constructed in phases it will be necessary to create a testing and interim operation plan for the various sections of the Trunk Watermain once they are constructed. Typically, once a watermain is installed, it is pressure tested and disinfected prior to commissioning. It is recommended that the Trunk Watermain be installed with a connection to the existing distribution system, allowing the pipe to be charged with water from the system for testing and disinfection purposes. Once the pipe has been tested and disinfected, it would be ideal to keep the watermain full of water and regularly flushed to maintain residual chlorine levels.

Depending on the method used to contract out the installation of the Trunk Watermain there may be conflicts between warranties of different contractors. This should be evaluated when developing the phased installation plan.
For the disinfection of long, large diameter watermains the slug method is recommended since it has the potential for reducing the volume of water and amount of chemicals needed, compared to other AWWA disinfection methods, such as the continuous method. The slug disinfection method involves the slow movement of a highly chlorinated slug of water through the watermain. The required contact time between the slug and the watermain is a minimum 3 hours, which is much less than the 24 hours of contact required for the continuous disinfection method. While the slug is in contact with valves or appurtenances the equipment is required to be fully operated to ensure full disinfection of the system. Disinfection of the Trunk Watermain should only be completed by trained and experienced staff.

The Disinfection and Commissioning plan must be approved by the Region of Waterloo's Water Services Operations Department before it is implemented.

4.5.6 Reinstatement

The construction of the Trunk Watermain would, in most situations, cause only temporary disruptions to the existing land use within the Study Area. Once the Trunk Watermain construction is complete the previous land use will be reinstated or, in some cases, improved with new trails or landscaping. In locations which were previously forested with large trees that were removed for construction, and are unable to be reinstated to exactly the same condition, it is recommended that no large trees are planted within close proximity to the Trunk Watermain to maintain access to equipment for maintenance. Additionally, the presence of large trees, and their corresponding root systems, within close proximity to the Trunk Watermain could lead to serious damage to the pipe structure and would limit access.

4.5.7 Staging Areas and Stockpiling of Materials

It is important to remove excess material from within the Hydro Corridor during construction to allow HONI continuous access to their utility lines. It is recommended that the team identify agricultural lands within close proximity to the Preferred Alignment for storage of equipment, fill and materials during construction. Potential staging area locations have been identified in the drawings of Appendix A.
4.6 Construction Cost Estimate

The base capital cost estimate for the construction of the Kitchener Zone 4 Trunk Watermain is estimated at $10.1 million, plus an additional 35% for engineering design and contingency to address unforeseen issues during construction, making the total cost for the Kitchener Zone 4 Trunk Watermain project $14.0 million. This number does not include the Legal and Approval Fees or the provision of Trenchless construction, these estimated cost are also outlined in Table 4-2 below.

Table 4-2: Cost Estimate Breakdown

<table>
<thead>
<tr>
<th>Section</th>
<th>Description of Work</th>
<th>Estimate Calculations</th>
<th>Quantity</th>
<th>Units</th>
<th>Unit Rate</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 1 Requirements – 10% of Construction Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 1,006,300.00</td>
</tr>
<tr>
<td>Open Cut Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Erosion Control</td>
<td>1 Lump $40,000.00</td>
<td>$ 40,000.00</td>
<td>1</td>
<td>Lump</td>
<td>$40,000.00</td>
<td></td>
</tr>
<tr>
<td>2 Connection to Pumping Station/Existing Pipe</td>
<td>2 Lump $25,000.00</td>
<td>$ 50,000.00</td>
<td>2</td>
<td>Lump</td>
<td>$25,000.00</td>
<td></td>
</tr>
<tr>
<td>3 750 mm diameter Trunk Watermain</td>
<td>6,400 m $1,125.00</td>
<td>$ 7,200,000.00</td>
<td>6,400</td>
<td>m</td>
<td>$1,125.00</td>
<td></td>
</tr>
<tr>
<td>4 Sleeved Undercrossing</td>
<td>240 m $4,000.00</td>
<td>$ 960,000.00</td>
<td>240</td>
<td>m</td>
<td>$4,000.00</td>
<td></td>
</tr>
<tr>
<td>5 Traffic Control</td>
<td>1 Lump $175,000.00</td>
<td>$ 175,000.00</td>
<td>1</td>
<td>Lump</td>
<td>$175,000.00</td>
<td></td>
</tr>
<tr>
<td>6 Reinstatement of Roadways (7m wide)</td>
<td>12,635 m² $100.00</td>
<td>$ 1,263,500.00</td>
<td>12,635</td>
<td>m²</td>
<td>$100.00</td>
<td></td>
</tr>
<tr>
<td>7 Reinstatement (7m wide)</td>
<td>21,665 m² $6.00</td>
<td>$ 130,000.00</td>
<td>21,665</td>
<td>m²</td>
<td>$6.00</td>
<td></td>
</tr>
<tr>
<td>9 Isolation and Control Valves</td>
<td>22 Each $2,000.00</td>
<td>$ 44,000.00</td>
<td>22</td>
<td>Each</td>
<td>$2,000.00</td>
<td></td>
</tr>
<tr>
<td>10 Structural Supports</td>
<td>21 Each $500.00</td>
<td>$ 10,500.00</td>
<td>21</td>
<td>Each</td>
<td>$500.00</td>
<td></td>
</tr>
<tr>
<td>11 Chambers</td>
<td>22 Each $8,000.00</td>
<td>$ 176,000.00</td>
<td>22</td>
<td>Each</td>
<td>$8,000.00</td>
<td></td>
</tr>
<tr>
<td>12 Landscaping and Trails</td>
<td>1,400 m² $10.00</td>
<td>$ 14,000.00</td>
<td>1,400</td>
<td>m²</td>
<td>$10.00</td>
<td></td>
</tr>
<tr>
<td>Trenchless Construction-Option</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 10,063,000.00</td>
</tr>
<tr>
<td>13 Ottawa Street</td>
<td>40 m $2,500.00</td>
<td>$ 100,000.00</td>
<td>40</td>
<td>m</td>
<td>$2,500.00</td>
<td></td>
</tr>
<tr>
<td>14 Isaiah Drive</td>
<td>200 m $6,000.00</td>
<td>$ 1,200,000.00</td>
<td>200</td>
<td>m</td>
<td>$6,000.00</td>
<td></td>
</tr>
<tr>
<td>15 Species at Risk Habitat</td>
<td>250 m $2,500.00</td>
<td>$ 625,000.00</td>
<td>250</td>
<td>m</td>
<td>$2,500.00</td>
<td></td>
</tr>
<tr>
<td>Detailed Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Open Cut Construction &amp; Division 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 11,069,300.00</td>
</tr>
<tr>
<td>17 Legal Fees (obtain required easements)</td>
<td>Each $10,000.00</td>
<td>$ 61,600.00</td>
<td></td>
<td>Each</td>
<td>$10,000.00</td>
<td></td>
</tr>
<tr>
<td>18 Regulatory Approval Costs</td>
<td>8 Each $1,000.00</td>
<td>$ 4,900.00</td>
<td></td>
<td>Each</td>
<td>$1,000.00</td>
<td></td>
</tr>
<tr>
<td>19 Contingency and Engineering</td>
<td>25 % $2,768,000.00</td>
<td>$ 2,768,000.00</td>
<td></td>
<td>%</td>
<td>$2,768.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 13,919,750.00</td>
</tr>
</tbody>
</table>
5. Maintenance and Operation

5.1 Monitoring of Pipe Condition

A thorough pipe condition monitoring program should be in place to ensure the proper operation of the Trunk Watermain. A small leak from the pipe could, in the best case scenario, lead to the loss of billion liters of treated drinking water each year, in the worst case, the leak could result in the washout of the local soils and damage infrastructure and private property. In the case of the Kitchener Zone 4 Trunk Watermain, the location within the hydro corridor elevates the risk of damage due to a pipe leak. If a tower is damaged due to a washout, the impacts to the electrical grid would be substantial.

There are several methods available to evaluate the conditions of pipelines. A report from the USEPA titled “Condition Assessment Technologies of Water Transmission and Distribution Systems” outlines various techniques which could be used to monitor the condition of the Trunk Watermain, applicable methods are summarized in this section.

5.1.1 Visual

A visual inspection could include:

The excavation of the pipe to inspect the exterior - Ideally the continued monitoring of the trunk watermain condition would not include regular excavation of the pipeline. It is not practical to spend the resources excavation and then reinstating the area. If, however, it is suspected that leak exists, excavation would be required to confirm and repair the damage.

Camera inspection of pipe interior – This inspection method provided a visual of the pipe interior, it would be possible to determine the condition of the pipe material, and accurately determine areas of concern. This method along would not be able to locate small leaks or measure the thickness of the pipe material.

5.1.2 Acoustic

There are several products which use sound waves to assess the condition of a pipe, varying from one time inspections to semi-permanent transmitters with a lifespan of up to 10 years. Acoustic inspections are able to determine the existence of, and accurately locate, leaks within the pipeline. This method does not provide information regarding the condition or thickness of the pipe material.

5.1.3 Electromagnetic

This inspection method is typically a one-time inspection consisting of a magnet moving through the pipeline while in operation. Sensors monitor the changes in the magnetic field resulting from varying pipe wall thicknesses, or material pitting. This method can be used to determine the thickness of the pipe material.

It is recommended that a combination of the identified methods be utilized in a staggered schedule to provide a comprehensive knowledge of the pipe condition. A monitoring program should commence once the Trunk Watermain have reached about 75% of its useful lifespan (about 15 years from installation). The program could include annual inspections, rotating though the identified inspection methods.

5.2 Operation

The operation of the Trunk Watermain would be similar to that of the existing 750 mm diameter service main from the Zone 4 Pumping Station. A pressure transducer connected to a SCADA system should be installed at the connection to Strasburg Road to monitor and record the pressure at the end of the Trunk Watermain. The monitoring of this pressure level would give the operator of the distribution system valuable information regarding the demand on the system. An insertion meter could also be installed and connected to the existing SCADA system to measure the inline flow at the same point, further strengthening the base of information available to the system operators.
6. Conclusions and Recommendations

The completion of the Class B Environmental Assessment and subsequent completion of the Preliminary Design of the Kitchener Zone 4 Trunk Watermain has resulted in the identification of an alignment which has the least negative impact on the local environment. The Preferred Alignment has the following Design Characteristics:

- Comprised of 750mm diameter Concrete Pressure Pipe and located within an existing Hydro Corridor from the connection to the Kitchener Zone 4 Pumping Station to the intersection of Fischer Hallman Road. The alignment is then located within the road easement of Fischer Hallman Road, the planned road right of ways of Tartan Avenue, Rockcliffe Drive, a maintenance trail, Newcastle Drive, and Rockcliffe Drive, to the connection with the Strasburg Road extension.

- Restrictions placed on the construction of the Trunk Watermain include those from HONI (Section 2.2), identified MNR construction windows within areas which have the potential to be habitats for Species-at-Risk (Section 4.5), identified GRCA areas of interest and seasonal water flows (Section 4.5), and Region of Waterloo restrictions to protect ground water sources (Section 2.4).

- The estimated cost to construct the Kitchener Zone 4 trunk Watermain is $14.0 million, with limited additional maintenance cost compared to a watermain of the same size.

- It is recommended that the Trunk Watermain be phased with the completion of planned works within the preferred alignment, such as the widening of the Fischer Hallman Road, Huron Development, and Becker Estates Development.
Appendix A

Preliminary Design Drawings
KITCHENER ZONE 4 TRUNK WATERMAIN:
PRELIMINARY DESIGN
IN THE CITY OF KITCHENER
Appendix B

Hydro One Correspondence
Date: October 11, 2011

Location: 483 Bay St. – Hydro One Office

Project Title: Kitchener Zone 4 Trunk Watermain EA and Pre-design

Subject: Hydro One Corridor Review Meeting

Date of Meeting: Sept 28, 2011

Written by: Jamie Witherspoon

Present: COMPANY NAME

Tony Ierullo: Hydro One Networks – Engineering Review
Jim Oriotis: Hydro One Networks – Sr. Real Estate Coordinator
Jenny Mui: Transmission Lines Sustainment, System Investment
Nathan Morris: Region of Waterloo
Kevin Dolishny: Region of Waterloo
Jamie Witherspoon: GENIVAR

Signature: COMPANY NAME

ierullo@HydroOne.com
jim.oriotis@HydroOne.com
Jenny.mui@HydroOne.com
nmorris@regionofwaterloo.ca
kdolishny@regionofwaterloo.ca
Jamie.Witherspoon@genivar.com

---

1. Approval of Agenda

1.1 There was no formal agenda for the meeting.

2. New Business

2.1 Proposed Works

- Region of Waterloo is proceeding with a Schedule B Class EA to install a 750mm watermain longitudinally along the existing Hydro Corridor from Ottawa St. to the future extension of Strasburg Road. The total distance is approximately 5.5 km.
- There are two locations where the watermain will not likely be in the corridor as follows:
  - South of Fischer Hallman Rd. due to natural environmental conflict.
  - North of Huron Road due to corridor congestion with Hydro connections to the adjacent transformer station.
2.2 Ownership Discussion

- Hydro One Networks Inc. (HONI) believes that the majority of the land is private easements.
- If the Land is Provincially owned (Bill 58 Land), it is under the management of Infrastructure Ontario (IO) and that would be a trigger for the IO Class EA process that would need to be completed concurrently with the Municipal EA.
- GENIVAR to investigate land ownership and agricultural use of lands relative to current and future ownership.

2.3 Land Use

- HONI easements provide for their primacy of use for the corridor. Any secondary use such as a watermain must meet the primary requirements.
- Preference is that construction outside of the corridor where practical. GENIVAR indicated that the alternative alignments outside of the corridor are not economically or technically feasible in the preliminary assessment.
2.4 **Limitations on New Infrastructure**

- Longitudinal installation of watermains adjacent to the transmission lines are the highest risk installation.
- A minimum 15 metre radius should be maintained between the top of the footing and the watermain installation (see attached sketch).
- Deeper infrastructure installations are preferred as the risk of wash-out is minimized.
- A steel carrier casing may be required in areas where conditions do not allow for the full separation from the footings. The steel casing would need to extend approximately 30 metres on each side of the footing.
- Watermain bends shall not be located adjacent to towers due to increased risk of rupture at these points.
- HONI will utilize the lands for maintenance activities that can include large cranes and vehicles. All backfill and piping design to allow for this access without restriction.
- During construction, no stockpiling of materials shall be permitted where they would restrict the use of the land by HONI for emergency repair or maintenance.
- The watermain may move within the watermain easement to ensure maximum separation at the transmission towers.

2.5 **Process Moving Forward**

- GENIVAR to provide revised alignment drawings to HONI for general compliance review. Drawings to include cross-section at each transmission tower.
- If the drawings are acceptable, HONI would issue a general compliance review for the EA that would be subject to a final review process for detailed design and access approval.
- Monitoring would be required during construction including settlement monitoring on the towers for any work adjacent to or under (i.e. tunneling)
2.6 **Critical Next Steps**
- Revision of drawings to reflect HONI comments
- Review process – estimated 4-6 weeks
- Continued communication with HONI regarding the project and EA.

3. **Other Business**
- None Mentioned.

4. **Next Meeting**
- To be determined.
Appendix C

Union Gas Crossing Consent Document
March 1, 2012
Region of Waterloo

Attention:

Subject: Proposed Crossing of Union Gas Limited’s, Owen Sound High Pressure Line as specified in Appendix A, for the Kitchener Zone 4 Trunk Watermain

We acknowledge your request for Union Gas Limited (“Union”) to consent to the Crossing(s), on behalf of itself, and Vector Pipelines.

Union constructs and operates natural gas transmission, distribution and storage pipeline facilities. Natural gas is viewed as the cleanest-burning fossil fuel and is an economical source of energy for those persons dependant on it for residential, industrial and commercial uses. Union’s activities are regulated by the Ontario Energy Board who must determine, among other things, that our projects serve the public interest (note: Vector Pipelines is regulated by the National Energy Board). Union must therefore protect its pipelines to ensure an uninterrupted supply of heat and energy in the public interest. Additionally, Union is a regulated utility subject to a fixed rate of return and must avoid unnecessary costs of operating its pipelines.

Union Gas acts as the pipeline operator for its own pipelines, as well as pipelines for the St. Clair Pipelines ’96 and Vector Pipelines Ltd., companies. The Union Gas and Vector Pipelines may be contained within an easement registered against the title to the subject lands. Details of the easement agreement are available at the registry office or through our Lands Department c/o Coordinator Permits Administration.

In consideration of Union consenting to the Crossing, we ask that you agree to the following conditions precedent:

1. That you will comply with the general conditions for consent in Schedule A, attached hereto;

2. That you and your contractor will install the Crossing strictly in the manner described in Schedule B, attached hereto;

3. That the Crossing will be designed and constructed strictly in accordance with your drawing (as specified in Schedule C) and approved by Union attached as Schedule C, hereto.
Please have three copies of this letter dated and executed by your authorized signing officer(s) and return it to the writer within 30 days of the date hereof. We will return one fully executed agreement to you whereupon it shall form an agreement between us for the Crossing. Installation of the Crossing can then proceed after giving a minimum of two business days' advance notice to our office. See attached Appendix A for contact numbers.

Yours very truly,

Nicole Fernandes
District Engineering EIT – Waterloo/Brantford
Union Gas Limited

Read and agreed to at _________________________________ this ______ day of _________________________________, 2012.

Applicant
Witness: (Name of Company/person(s))

by: ______________________________
by: ______________________________
Name/Title

"I/we have authority to bind the corporation."

Copies to: Lands (file)
Appendix A

Transmission Line

NPS-12 STL HP (Owen Sound Transmission Line)

Contact List for Waterloo/Brantford Transmission Lines

Planning & Dispatch Waterloo – 1-866-793-1636 (Ext 7378) to arrange 3rd party observation

Rick Bigelow (Utility Service Manager – Waterloo) – Office 519-885-7405
Cell 519-221-9678

Nicole Fernandes (District Engineering EIT – Waterloo/Brantford) – Office 519-885-7580
Cell 519-635-4314

Emergency (24 hour) – 1-877-969-0999

STIPULATIONS for Crossing All Union Gas Pipelines:

1. The Contractor must not excavate mechanically within 1.0 m laterally of a pipeline until the Contractor has exposed the pipeline by hand, and positively identified the pipeline. Mechanical excavation closer to the pipeline may be permitted, as directed by the Union Gas inspector; however, under no circumstances will mechanical excavation be permitted within 300 mm of the pipeline at a minimum of 45 degrees.
2. It is the contractors’ responsibility to determine depth of existing lines to maintain this separation.
3. The contractor is responsible to daylight each line before crossing.
4. The contractor is responsible to contact appropriate personnel at least 48 hours in advance to arrange for 3rd party inspection.
5. Third party observation is required whenever substantial excavation takes place within 1.50 metres of these lines.
6. As always, field locates are required before any construction begins. These may be obtained by calling Ontario One Call at 1-800-400-2255
SCHEDULE A

General Conditions for Crossing Consent

1. In this agreement:
   (a) the term "Applicant" refers to the person(s) who will own, operate and maintain the Facility;
   (b) the term "Contractor" means the person(s) who constructs and installs the Facility;
   (c) the term "Facility" refers to the works of the Applicant as described in the covering letter-agreement to this Schedule;
   (d) the term "Crossing" refers to the crossing of Union's pipeline(s) by the Facility at the location described in the covering letter-agreement to this Schedule.

2. Union consents to the Crossing to the extent that it has the right to do so and the Applicant shall be responsible for obtaining all other applicable approvals, permits, orders and permissions required to construct and install the Facility.

3. Applicant agrees to comply with all applicable rules, orders, regulations, codes and guidelines of any competent government body or organization affecting the design, installation, construction and operation of the Facility.

4. Applicant agrees to indemnify and save Union harmless against any claims, demands, actions, suits, proceedings, damages, injuries (including injuries resulting in death) that may arise as a result of the construction, installation and operation of the Facility.

5. In connection with Clause 4, above, Applicant, at its own expense shall carry and keep in full force and effect:
   (a) Commercial Liability insurance with an inclusive limit for personal injury and property damage of Five Million Dollars ($5,000,000.00), and such limits may be made up of a combination of Primary and Excess Liability policy and;
   (b) If applicant owns vehicles Automobile Liability Insurance ("Owned" and "Non-Owned") with an inclusive limit for bodily injury (including passengers) and property damage of One Million Dollars ($1,000,000.00).

Applicant shall submit certificates or other evidence of such insurance to Union prior to any work commencing for the Crossing.
6. Applicant agrees to personally perform the installation and construction of the Facility or else to closely supervise its installation and construction by a duly qualified contractor(s) and to ensure that said contractor(s) complies with all terms and conditions of this agreement.

7. The Applicant shall pay forthwith upon presentation of an invoice by Union, all reasonable costs incurred by Union for:
   (a) Review, approval and inspection of the Crossing;
   (b) Reinforcing, modifying or relocating Union's pipeline(s) to accommodate the installation of Applicant's Crossing or the maintenance and repair of its Facility;
   (c) Any reasonable incremental costs incurred by Union in the inspection, operation, maintenance, replacement and repair of its pipeline(s) which are caused by the Crossing.

8. The terms and conditions of this consent shall apply to the construction and installation of the Crossing and any future maintenance work that may be required.

9. This consent is for the Facility shown in Schedule C only and any additional works or facilities proposed by the Applicant shall be the subject of a separate agreement.

10. Applicant hereby agrees and acknowledges that its rights in the Crossing are subordinate to the easement(s) of Union that have been registered or obtained prior to this date and Applicant shall cooperate with all reasonable requests made by Union related to the operation, maintenance and repair of Union's pipeline(s) within the easement(s).

11. In the case of default by the Applicant to carry out any of the provisions of this agreement or if the condition of Applicant's Facility has deteriorated and adversely affects to the operation of Union's pipeline(s), Union may give written notice thereof. If the Applicant fails to take all reasonable steps to remedy the default or the deterioration of the Facility within fifteen (15) days after receipt of the written notice by Union, Union may take such steps as are necessary to remedy the default or deterioration and Applicant shall be liable for and shall pay forthwith all reasonable costs incurred by Union in this regard.

12. All notices required to be given hereunder shall be delivered by registered mail or facsimile to the addresses shown on the covering letter-agreement and shall be deemed to be received on the fifth (5th) day following mailing thereof or upon confirmation of facsimile transmission.

13. This agreement shall be governed in accordance with the laws of Ontario.

14. Neither party to this agreement shall assign or transfer their rights and obligations hereunder to a third party without first obtaining the written
consent of the other party.

15. The rights and obligations of the parties hereto shall terminate upon the earlier of:

(a) two (2) years from the date hereof if the Applicant has not completed the construction and installation of the Facility and restoration of the lands affected by the Crossing; or,

(b) upon the proper abandonment or removal of the Facility and restoration of the lands to a condition acceptable to Union and the owner of the property where the Crossing is situate.

16. This agreement and Schedules A, B and C constitute the entire agreement between Union and the Applicant and any change or alteration hereof shall be made in writing between the parties.

17. If any part of this agreement shall become null and void by virtue of law or governmental regulation, it shall be severed from the agreement, but the remaining terms and conditions shall remain in full force and effect.
SCHEDULE B

Excavation

1. The following conditions shall apply whenever any construction activities shall require the need for the operation of equipment or excavation near the Union pipeline(s).

   (a) To protect exposed Union Pipeline from damage during the proposed work, Union's on-site inspector may require the Applicant to install certain safety precautions before beginning construction.

   (b) To avoid possible damage to the Union Pipeline while excavating, it shall be supported adequately, as directed by Union's on-site inspector.

   (c) To avoid possible damage to Union Pipeline, heavy equipment shall be restricted to crossing within the travelled portion of the easement unless other crossing locations are approved by Union's on-site inspector.

   (d) Applicant shall provide at least two (2) business days’ advance notice prior to commencing any excavation near the Union pipeline(s).

General Conditions for Crossings of the Pipeline by Highways, Private Roads, Railways and Utilities

2. The following general conditions shall apply to Crossings of the Union Pipeline by a highway, private road, railway or utility.

   (a) In the case of a crossing of the Union Pipeline by a highway, private road, railway or utility the Crossing shall, except as otherwise provided herein, conform to the respective specifications and requirements of the current Canadian Standards Association Z662 for Gas Pipeline Systems and if the facility will result in the Union Pipeline not conforming, the Crossing may be made only if the Union Pipeline is reconstructed to conform to such requirements, the cost of which shall be borne and paid for by the Applicant.

   (b) The Applicant shall pay all costs to ensure the Union Pipeline shall, in all cases, be of sufficient strength to withstand all stresses and strains resulting from the Crossing.

   (c) The Crossing shall be constructed so as to cross the Union Pipeline at an angle as close as practicable to ninety (90) degrees, but not less than
forty-five (45) degrees.

3. At any crossing of the Union Pipeline, except crossings by overhead telephone, telegraph or power lines, the Union Pipeline and the Facility shall be identified by suitable markers.

4. A buried utility shall cross under the Union Pipeline unless otherwise approved by Union. A clearance of not less than 1.0m shall be maintained at the point of crossing between the utility and Union Pipeline and all other underground structures. In all circumstances, minimum clearances as stipulated in the current edition of Canadian Standards Association code CAN/CSA-Z662 "Gas Pipeline Systems" shall be complied with.

(a) Underground utility crossings shall also be subject to the following design constraints:

(i) Utilities must be installed at a level grade across the entire width of the Union Pipeline easement with the exception of gravity dependent structures. In such cases, the minimum clearances specified in between the utility and Union Pipeline(s) crossed must be maintained.

(ii) In the case of any Applicant's buried pipelines, no joints may be made over or under any Union Pipeline(s).

(iii) If Applicant's pipeline(s) will operate under pressure, it (they) shall be pre-tested to at least the required pressure test pressure prior to its installation across the Union Pipeline easement.

(iv) In the case of buried power cables, the Applicant shall install a 75mm thick concrete slab, or suitable equivalent (i.e. patio paving stones) placed 300mm above the utility service installation, the full width of the Union Pipeline Easement. There shall be a minimum separation of 300mm between the top of the concrete slab and the bottom of the Union Pipeline(s). This separation shall be maintained over the entire width of the Union Pipeline easement(s). The concrete slab should be unreinforced red dye concrete. The utility shall be permanently identified with "caution" tape on top of the concrete slab.

(v) In the case of buried cables, no joints, splices or other connections shall be made within the Union Pipeline easement.

(vi) The method of installation of all utilities crossing Union Pipeline(s) below ground level must be specified in the Applicant's submission to Union.

5. A highway or private road shall be constructed so that the travelled surface thereof shall be not less than 1.2m above the top of the Union Pipeline or the casing pipe, where required. The bottom of the ditches shall be not less than 1.0m or the minimum distance required by the local M.T.O. office above the top of the Union Pipeline or casing pipe.
Cathodic Protection Requirements

10. Applicant agrees to install, at its cost, all cathodic protection facilities deemed necessary by Union to protect the Union Pipeline(s) or otherwise, reimburse Union for the costs of such facilities and installation.
SCHEDULE C

Plan Showing Approved Crossing

A drawing of each crossing shall be prepared in accordance with sub-sections A, B and D below. The drawing shall show the location and dimensions of the crossing and the clearance between the lowest catenary and the surface of the ground within the pipeline right-of-way or its projected limits.

Standard Drawing Requirements

Note: ALL VIEWS TO BE COMBINED IN ONE DRAWING.

A. **PLAN VIEW**

Scale

- in metric - scale of 1:500 or at a scale which clearly defines all details of the crossing.

Dimensions

- distance along the Union Pipeline easement to the crossing from a definable legal limit; ie. lot line, river, road allowance limit, etc.
- width of the Union Pipeline easement to one-tenth (0.0) of a metre.
- location of the Union Pipeline(s) within the easement to one-tenth (0.0) of a meter at right angles to the pipeline easement.
- angle of the crossing (measured to the Union Pipeline easement)
- show the width of the utility easement(s) to one tenth (0.0) of a metre.
- width of streets in vicinity of crossing.

Note: Parallel Utility easements shall not encroach on the Union Pipeline easement without the written consent of Union.

Identify

- legal description of the crossing location; ie. lot, section, concession, township, town, village, etc.
- all additional Union Pipeline appurtenances; ie’ concrete slabs, weights, pipeline markers, etc.
- north arrow
- scale
B. **SECTION VIEW**

The section view is to be along the proposed utility that crosses the Union Pipeline.

**Scale**
- in metric, vertical 1:100, horizontal 1:200 or to a scale that clearly identifies all details of the crossing.

**Dimensions**
- depth of the Union Pipeline(s) to one-tenth (0.0) of a metre
- Vertical distance of the proposed utility below grade to one-tenth (0.0) of a metre
- clearance to the Union Pipeline
- diameter of each Union Pipeline to be crossed
- easement or right-of-way limits

**Identify**
- if elevations are assumed, then reference the point of the assumed datum
- distance of the pipeline(s) to the Union Pipeline easement limits
- ground surface profile for 20m on either side of crossing
- scale

C. **PROFILE VIEW**

The profile view is to be along the Union Pipeline and is only required if the encroachment is on the Union Pipeline easement for a definable distance; ie. parallel encroachments such as roads and any grading of the easement, etc.

**Scale**
- in metric, vertical 1:100, horizontal 1:200 or to a scale that clearly identifies all details of the crossing

**Dimensions**
- depth of the Union Pipeline(s) to one-tenth (0.0) of a metre
- depth of the proposed utility to one-tenth (0.0) of a metre
• clearance to the Union Pipeline
• diameter of each Union Pipeline to be crossed
• easement or right-of-way limits

Identify
• if elevations are assumed, then reference the point of the assumed datum
• distance of the pipeline(s) to the Union Pipeline easement limits to one-tenth (0.0) of a meter
• ground surface profile for 20m on either side of crossing
• scale
• existing Union Pipeline markers

D. LOCATION PLAN VIEW

Scale
• in metric, scale of 1:12000 or to a scale that clearly identifies the location

Dimensions
• distance to the nearest town of major geographic feature to 0.1 of a kilometre

Identify
• township, town, village, city, county, regional municipality, etc.
• lot, concession, street, highway, road, etc.
• north arrow

TITLE BLOCK

Identify
• name of the Applicant and the name of the engineering company who compiled the drawing (where applicable)
• drawing number and the date of the drawing
• revision dates (if applicable)
• signature of the applicant and the engineering company
- legal description of the crossing location
- description of the utility
- date of the survey

ADDITIONAL INFORMATION

Identify

- all specifications of the utility, ie. diameter, wall thickness, material to be conveyed, minimum yield strength, operating pressure, field test pressure, mill test pressure, materials comprising the utility, protective devices to be installed and the proper method of installation.

- show a note referencing compliance with the applicable CSA standards, Union Gas Limited's Specifications for Pipeline Crossings and the National Energy Board Pipeline Crossing Regulations.

- date of the proposed crossing
1. **Purpose**

   This procedure will ensure proper measures are taken to reduce the risk of microbial or chemical contamination, or groundwater interference, from construction activity near Regional water supply wells. This Procedure should be used for any work planned within 200 m of any Regional supply well. Construction work includes subsurface excavation, paving, dewatering, pile-driving, borehole drilling, stockpiling of construction-related supplies, utilization of heavy equipment, and related activities.

2. **Background**

   This Procedure is to be communicated to Region of Waterloo groups that may be involved in construction projects near (within 200 m of) municipal production wells: Transportation, Design and Construction, Waste Management, Facilities and intermunicipal working groups (e.g.: BMP working group). The Hydrogeology and Source Water (HSW) section of Water Services is the primary contact regarding this Procedure.

   The Region’s Regional Official Plan (section 8) imposes conditions on certain activities within the 100 m security area around any production well. Within sensitive areas around municipal production wells, Water Services may require or request additional management practices or monitoring related to the construction activity, to ensure protection of municipal water supplies. The construction project is financially responsible for any additional work of this nature.

   Water Services will work with groups undertaking construction activities near municipal production wells to evaluate potential construction-related risks to municipal water supplies, identify if any Standard Operating Procedures (SOPs) apply, and propose mitigation measures.

   This Procedure is used in addition to SOP 296885 “Construction Activity In Proximity To A Gudi-EF Well” and SOP 788003 “Spill in a Wellhead Protection Area”.

3. **Notification Requirements**

   3.1 **WORK PLAN:** When construction work is planned within 200 m of a wellfield, the work plan should be provided to the Manager of Hydrogeology and Source Water as early as possible. The HSW Manager will provide feedback on the workplan, will identify if any other HSW Procedures apply to the project, and will notify the Operations division of: the upcoming work, approximate time frame, and appropriate monitoring and contingency actions.
3.2 START/STOP of WORK: The Water Services Operations division (SCADA DESK 571-6208) must be notified a day in advance of any intrusive work within **100 m** of a wellfield- including well drilling/plugging/rehabilitation, dewatering, excavation of soil or rock, vibration, etc. This is so Water Operations can monitor for unusual conditions at the wellfield (turbidity or other unusual conditions).

4. **PROHIBITIONS**

Unless approved by the Manager HSW and subject to a monitoring and contingency action plan, the following construction-related activities should not be within 100m of a well field:

1. Placement of portable toilets
2. Storage of chemical, materials, or waste
3. Fuel storage or generators
4. Refueling of vehicles or equipment
5. Placement of excess soil stockpiles

5. **RECOMMENDED PRACTICES**

The following practices are recommended near a well field:

1. Secondary containment for fuel, generators, and equipment or vehicles which contain fuel or chemicals (i.e. spill pad, equipment “diaper”; etc).
2. a spill contingency plan should be in place
3. a storm water/excess water management plan should be in place
4. in addition to spill reporting provisions as required by the Environmental Protection Act, forthwith report any signs of contaminated soil or water encountered to the Water Services contact person specified in the spill contingency plan.

6. **REQUIREMENTS FOR INFRASTRUCTURE**

The following practices are recommended or may be required within **100 m** of a Regional water supply well

1. New individual wastewater treatment systems, private supply wells, pipelines, sewers, stormwater management ponds (or other ponds) and the direct infiltration of stormwater will not be permitted.
2. New impermeable surfaces of any kind will be restricted or minimized to the greatest extent feasible
3. Replacement of storm or sanitary sewers should use enhanced construction techniques to achieve near-zero exfiltration leakage criteria.

7. **Contacts**

- Eric Hodgins, Manager, Hydrogeology and Source Water or designate
  519 575-4426 (office hours)

- Water Services Scada Desk (24 hours)
  Leave message for supervisor on call
  519 571-6208
Appendix E

Geotechnical Evaluation
Regional Municipality of Waterloo

Southern Kitchener Trunk Watermain
Fischer Hallman Road to Ottawa Street South
Kitchener, Ontario

Geotechnical Investigation Report

Date: June 21, 2013
Ref. N°: 160-P-0002897-0-01-100-GE-R-0001-01
Regional Municipality of Waterloo

Southern Kitchener Trunk Watermain
Fischer Hallman Road to Ottawa Street South
Kitchener, Ontario

Geotechnical Investigation Report

Prepared by:
Karen Thrans, Dipl.-Ing.
Project Manager

Reviewed by:
Team Leader, Engineering Group
**Property and Confidentiality**

*This engineering document is the property of LVM Inc. and, as such, is protected under Copyright Law. It can only be used for the purposes mentioned herein. Any reproduction or adaptation, whether partial or total, is strictly prohibited without having obtained LVM inc.'s and its client's prior written authorization to do so.*

Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM inc.'s subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager.*

**Regional Municipality of Waterloo**

150 Frederick Street, 7th Floor
Kitchener, Ontario N2G 4J3
Attention: Mr. Nathan Morris

<table>
<thead>
<tr>
<th>REVISION AND PUBLICATION REGISTER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revision No.</strong></td>
</tr>
<tr>
<td>00</td>
</tr>
<tr>
<td>01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 electronic copy</td>
</tr>
<tr>
<td>1 electronic copy, 3 hard copies</td>
</tr>
<tr>
<td>1 original</td>
</tr>
</tbody>
</table>

jw

160-P-0002897-0-01-100-GR-0001-01

* SOUTHERN KITCHENER TRUNK WATERMAIN, FISCHER HALLMAN ROAD TO OTTAWA STREET SOUTH, KITCHENER
INTRODUCTION

LVM inc. (LVM) has been retained by the Regional Municipality of Waterloo to carry out a geotechnical investigation for the proposed trunk watermain along the existing hydro corridor located between Fischer Hallman Road and Ottawa Street South in Kitchener, Ontario, at the location shown on the appended Location Plan, Drawing 1. This work was authorized by Mr. Nathan Morris of the Regional Municipality of Waterloo under Purchase Order PO-167858.

This report summarizes the subsurface soil and groundwater conditions encountered at the site and provides geotechnical recommendations pertaining to the construction of the new trunk watermain using both open cut and trenchless technologies.
1 GENERAL INFORMATION

The proposed trunk watermain is to be installed along an approximately 3.5 km long section of the existing hydro corridor located between Fischer Hallman Road in the east and Ottawa Street South in the west, in Kitchener, Ontario. The design and alignment of the new trunk watermain are currently preliminary and conceptual; however, it is understood that open cut as well as trenchless technologies will be used to install the new trunk watermain.

The original scope of work for the geotechnical investigation included a total of ten boreholes. However, due to access constraints along the east section of the new watermain (between Fischer Hallman Road and Bleams Road) the borehole number was reduced to a total of eight. Existing subsurface soil and groundwater information from previous projects completed by LVM along the hydro corridor have been used to supplement the current borehole program.

The existing hydro corridor crosses agriculturally used lands in the east and residential and forested lands in the west. The ground surface along the subject section of the hydro corridor comprises undulating hills and grades vary substantially between the borehole locations with elevations at the borehole locations ranging between 348.5 and 376.5 m. Overall grades typically slope up from Fischer Hallman Road towards the northwest to Ottawa Street South.

2 INVESTIGATION PROCEDURE

2.1 DESKTOP REVIEW

LVM has previously completed geotechnical and hydrogeological investigations for various projects located within the vicinity of the proposed trunk watermain. The following reports have been reviewed to supplement the existing subsurface soil and groundwater conditions at the site:

- LVM inc., Hydrogeology Study – Residential Subdivision Sites South Estates and Williamsburg South, Bleams Road and Fischer-Hallman Road, Kitchener, Ontario. (Report No. 160-P0000300-0-00-301-01-HD-0001-00, December 21, 2012)
- LVM inc., Hydrogeology Study – Kitchener West Area 2 Lands, Bleams Road and Trussler Road, Kitchener, Ontario. (Report No. 160-P037372-301-HD-0001-0A, December 13, 2011)
- LVM inc., Hydrogeology Study – Residential Subdivision Sites South Estates and Williamsburg South, Bleams Road and Fischer-Hallman Road, Kitchener, Ontario. (Report No. 4792H1-7728H1.R01)
- LVM inc., Preliminary Aggregate Resources Assessment – Bleams Road, South Property, Kitchener, Ontario. (Report No. 91G132, January 1992)
LVM inc., Geotechnical Investigation – Mannheim Raw Water Transmission Main Westmount Road to Water Treatment Plant, Bleams Road, Kitchener, Ontario. (Report No. 88G149, November 1988)

The relevant boreholes from the previous investigations are shown on the appended Site Plans, Drawings 2 and 3, and the borehole logs are included in Appendix 2. Relevant information from the above noted reports has been incorporated in this report.

### 2.2 FIELD PROGRAM

The fieldwork for this investigation was carried out on May 13 and 14, 2013 and involved the drilling of eight boreholes (Boreholes BH-01-13 to BH-08-13) to depths ranging between 5.0 and 8.1 m. The borehole locations are shown on the appended Site Plans, Drawing 2 and 3. The boreholes were advanced with a CME 75 track-mounted drilling equipped with continuous flight solid stem augers, supplied and operated by Geo-Environmental Drilling Inc. The previous and current borehole and test pit logs are presented in Appendix 2 in order of appearance along the project corridor starting at the southwest end of the site (Borehole BH-01-13) and heading northwest towards the northwest end of the site (Borehole BH-08-13).

Soil samples were recovered from the boreholes at regular 0.75 and 1.50 m depth intervals using a 50 mm outside diameter split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Pocket penetrometer tests were performed on samples of the cohesive soils to determine approximate shear strengths. The SPT N-values and shear strength test results are plotted on the appended borehole logs.

A dynamic cone penetration test (DCPT) was carried out at Borehole BH-06-13 to obtain a continuous indication of soil relative density changes with depth. The energy used for the dynamic cone penetration tests was the same as that used for the SPT testing. The dynamic cone penetration test values recorded are plotted on the respective borehole log.

Methane gas concentrations were measured in Boreholes BH-03-13 and BH-05-13 to BH-07-13 at the time of drilling using a portable gas analyzer and the results have been included on the appended borehole logs.

Local utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities near the boring locations.

Groundwater observations and measurements were carried out in the open boreholes during and upon completion of drilling, and the observations are summarized on the appended borehole logs.

Upon completion of the drilling the boreholes were backfilled with bentonite in accordance with Ontario Regulation 468/10 (formerly O. Reg. 903) under the province’s Water Resources Act.
The fieldwork was observed by a member of our geotechnical engineering staff who documented the drilling and sampling procedures; recorded the SPT N-values and approximate shear strengths; measured the methane gas concentrations; documented the soil stratigraphies; recorded the groundwater observations; and cared for the recovered soil samples.

The borehole locations and ground surface elevations were surveyed by LVM, using a Sokkia Model GXR 1 Global Navigation Satellite System (GNSS) rover. The borehole locations were referenced to Universal Trans Mercator North American Datum of 1983 (UTM NAD83) coordinates; the zone reference (17T) has been excluded for presentation purposes. The ground surface elevations are geodetic based on GNSS and local base station telemetry with a vertical root mean squared error of less than 20 mm.

2.3 LABORATORY TESTING

The soil samples secured during this investigation were returned to our laboratory for visual examination as well as moisture content tests.

Three soil sample were submitted to ALS Environmental in Waterloo, Ontario for analytical testing for soil sulphates, chloride content, pH, redox potential, resistivity, and sulphides to aid in the assessment of the potential for sulphate attack on concrete and corrosion of ductile iron pipe.

The soil samples will be stored for a period of three months from the date of sampling. After this time, they will be discarded unless prior arrangements have been made for longer storage.

3 SUMMARIZED CONDITIONS

We refer to the appended borehole logs for soil descriptions and stratigraphies, SPT N-values, approximate shear strengths; methane readings; moisture content profiles, and groundwater observations.

The subsurface stratigraphy at the site generally comprises pavement structure, fill, and topsoil overlying native deposits of silt till, silt, and sand/sand and gravel. Descriptions of the various soil deposits encountered in the boreholes are provided in the following subsections.

3.1 PAVEMENT STRUCTURE

Borehole BH-01-13 was advanced through the existing gravel shoulder of the southbound lane of Fischer Hallman Road. The contacted pavement structure comprises 300 mm of Granular 'A'. No granular subbase layer was contacted in the borehole.
3.2 FILL

Fill was contacted surficially in Boreholes BH-02-13 to BH-07-13 advanced along the central-west portion of the project corridor crossing the residential lands. The fill varies in thickness between 0.8 and 6.3 m. The upper fill generally comprises dark brown silt (topsoil) with some sand and trace gravel. The underlying fill ranges in composition from non-cohesive sandy silt to cohesive silty clay with trace sand and gravel. Organics or topsoil mixed into the lower fill material were contacted in Boreholes BH-05-13 to BH-07-13. At the time of fieldwork the non-cohesive fill was moist to wet and the cohesive fill was about to wetter than the plastic limit. Some saturated sand layers were contacted within the fill in Borehole BH-06-13.

SPT N-values in the non-cohesive fill range between 1 and 17 blows per 300 mm penetration of a split spoon sampler indicating variable very loose to compact relative densities. Results of dynamic cone penetration testing completed in Borehole BH-06-13 confirmed these findings. The cohesive portions of the fill have soft to stiff consistencies.

3.3 TOPSOIL

Topsoil was encountered surficially in Borehole BH-08-13 and is 0.3 m thick. The topsoil comprises dark brown silt with traces of sand and was moist at the time of sampling.

3.4 NATIVE MINERAL SOILS

The native mineral soils encountered in the boreholes and test pits across the site generally comprise interlayered silt and silt till deposits in the northwest and southeast ends of the site and sand/sand and gravel deposits through the centre of the site.

The silt till contacted along the subject corridor generally ranges in composition from cohesive clayey silt with traces of sand and gravel to non-cohesive silt with some sand and gravel. Approximate shear strengths in the cohesive silt till range from 25 to 225 kPa indicating variable soft to hard consistencies. The non-cohesive silt till contacted in Borehole 212 (Project No. 88G149) has a dense relative density with an SPT N-value of 46 blows per 300 mm.

Silt deposits or layers of silt were contacted throughout the subject corridor. The silt generally ranges in composition from non-cohesive sandy silt to cohesive silt with some clay. The relative density of the non-cohesive silt varies from compact to dense. The consistency of the cohesive silt varies from firm to stiff.

Sand/sand and gravel deposits were contacted at variable depths throughout the subject corridor. The sand deposit generally ranges in composition from sand with some gravel to silty sand. SPT N-values in the sand range from 13 to greater than 50 blows per 300 mm indicative of variable compact to very dense relative densities.
The sand and gravel deposit contains trace to some silt. Cobbles and boulders were contacted within the sand and gravel deposits in previously advanced test pits and boreholes along the subject corridor. SPT N-values in the sand and gravel range from 11 to greater than 50 blows per 300 mm indicative of variable compact to very dense relative densities.

3.5 GROUNDWATER

Groundwater observations and measurements were carried out in the open boreholes and the results are provided on the appended borehole logs. Groundwater was generally contacted under perched conditions at elevations ranging between 335 and 345 m in the south section of the subject corridor (Fischer Hallman Road to Bleams Road) and between Elevation 357 and 375 m in the north section of the subject corridor (Bleams Road to Ottawa Street South).

Based on our hydrogeological studies completed in the east section of the subject corridor (Fischer Hallman Road to Bleams Road) the regional groundwater aquifer generally occurs near Elevation 333 m. Seasonal fluctuations and local variations in the groundwater levels should be expected at the site.

3.6 METHANE

Methane is a lighter-than-air flammable gas produced by the bacterial decomposition of organic matter under anaerobic conditions. A mixture of 5 to 15% methane in air will explode if ignited and therefore a concentration of 5% methane in air is denoted as the "lower explosive limit" (LEL). Methane gas concentrations equal to or greater than the LEL are considered hazardous. To add a margin of safety, it is considered that concentrations greater than 20% LEL (which is equivalent to 1% methane gas in air) may be associated with still higher concentrations, exceeding the LEL. Therefore, methane gas concentrations greater than 20% LEL warn of conditions that could be potentially hazardous.

Under normal conditions, methane vents more or less vertically to the atmosphere and does not build up to explosive concentrations. However, high concentrations and significant lateral migration can occur beneath impermeable strata, pavement, concrete slabs, perched groundwater, or frozen ground cover.

Methane gas concentrations were measured within Boreholes BH-03-13 and BH-05-13 to BH-07-13 following soil sampling with a portable gas analyzer. The methane readings were converted into % LEL and are presented on the borehole logs in Appendix 2. The meter readings obtained at the time of drilling ranged between 0 to 40% LEL (0 to 2% gas). Concentrations higher than 20% LEL could be potentially hazardous. It is therefore recommended that the Contractor's site specific Health and Safety plan includes methane gas monitoring during the construction work to ensure the safety of workers at any time.
3.7 POTENTIAL FOR CORROSION

Three selected soil samples were tested for various parameters, including resistivity, pH, redox potential, and sulphides to assess the potential for corrosion of ductile iron pipe. The test results, along with The Cast Iron Pipe Research Association (CIPRA) soil test evaluation rating system are shown on Table 101 included in Appendix 3. A total point value of less than ten was determined for the soils at the site and, therefore, no corrosion protection is necessary for ferrous pipe.

3.8 SULPHATE ATTACK ON CONCRETE

Three selected soil sample recovered from the boreholes were submitted to ALS Environmental in Waterloo, Ontario to determine the potential for sulphate attack on concrete. The test results are summarized in Table 1 and are included in the Laboratory Certificates of Analyses in Appendix 4.

Table 1 Soil Sulphate Test Results

<table>
<thead>
<tr>
<th>BOREHOLE NUMBER</th>
<th>SAMPLE DEPTHS (m)</th>
<th>pH</th>
<th>SULPHATE (mg/kg)</th>
<th>CHLORIDE (mg/kg)</th>
<th>DEGREE OF EXPOSURE FOR BURIED CONCRETE STRUCTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01-13, SS2</td>
<td>1.5 - 2.0</td>
<td>7.77</td>
<td>&lt;20</td>
<td>138</td>
<td>negligible</td>
</tr>
<tr>
<td>BH-04-13, SS4</td>
<td>2.3 - 2.7</td>
<td>8.04</td>
<td>&lt;20</td>
<td>&lt;5</td>
<td>negligible</td>
</tr>
<tr>
<td>BH-08-13, SS2</td>
<td>1.5 - 2.0</td>
<td>7.68</td>
<td>&lt;20</td>
<td>15.8</td>
<td>negligible</td>
</tr>
</tbody>
</table>

The soil sulphate test results indicate soluble sulphate concentrations significantly less than 0.1%, which indicates a negligible degree of exposure for buried concrete structures. It is the responsibility of the foundation engineer to determine the appropriate cement type to be used based on these results.

4 DISCUSSION AND RECOMMENDATIONS

The project involves the construction of an approximately 3.5 m long trunk watermain within the existing hydro easement located between Fischer Hallman Road and Ottawa Street South in Kitchener, Ontario. The design of the new watermain is currently conceptual and preliminary; however, it is understood that open cut as well as trenchless technologies are being considered to install the new trunk watermain.

The subsurface soil conditions encountered in the current and previous test holes advanced along the subject section of the hydro easement generally comprise pavement structure, fill, and topsoil overlying native deposits of silt till, silt, and sand/sand and gravel. Fill was generally contacted in the central-west portion of the hydro corridor crossing the residential lands. Shallow perched groundwater generally occurs at multiple depths within the various soil deposits encountered in the subject corridor.
The following subsections provide general geotechnical recommendations pertaining to excavations and dewatering as well as open cut and trenchless pipe installation methods. Once the design of the trunk watermain has been finalized, LVM would be pleased to review invert depths and installation methods and provide additional geotechnical recommendations, if required.

4.1 EXCAVATIONS AND DEWATERING

Temporary excavations to conventional depths for installation of the watermain at this site must comply with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The predominant soils encountered in the boreholes would be classified as Type 3 soils and temporary side slopes must be cut at an inclination of 1 horizontal to 1 vertical or less from the base of the excavation for open cut pipe installation (exclusive of groundwater effects).

Where saturated deposits are contacted in the trench sides, the soil should be classified as Type 4, and temporary side slopes should be cut at a minimum gradient of 3 horizontal to 1 vertical from the base of the excavation.

Where space limitations (from utility poles, existing underground services, above ground structures, etc.) do not permit overburden cut slopes at inclinations specified above, a steeper cut slope can be employed if trench liner boxes (prefabricated support system) are used to protect workers. Some movement/slumping of the cohesionless sandy and silty soils adjacent to the trench boxes is to be expected if this option is used. If ground movement adjacent to the trench is unacceptable then a braced sheeting system may be used to support structures such as pipes located above the proposed trunk watermain.

The trench side slopes should be inspected for evidence of instability, particularly following periods of heavy rainfall, thawing or when the trench has been left open for an extended period of time. Appropriate remedial action should be taken to ensure the continued stability of the slopes.

Minor to moderate groundwater inflow should be expected for excavation extending into the perched groundwater encountered in the subject corridor between Elevations 335 and 345 m in the south section and between Elevation 356 and 376 m in the north section. It is believed that this groundwater inflow can be controlled using a gravity dewatering system with perimeter interceptor ditches and (high capacity) pumps where excavations extend below 0.5 m below the groundwater table. In order to facilitate excavation extending more than 0.5 m below the stabilized groundwater table, a dewatering system installed by a specialist dewatering contractor may be required to lower the groundwater level prior to excavation.

The design of the dewatering system should be left to the contractors' discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.30 m below the excavation base. Successful dewatering operations will depend on the contractor's own experience, construction techniques, sequencing, and efficiency of work force and plant.
4.2 OPEN CUT INSTALLATION

4.2.1 Pipe Bedding

It is anticipated that the majority of subgrade soils along the east section (Fischer Hallman Road to Bleams Road) and the west section near Ottawa Street South will comprise native mineral soils. Fill of variable thickness must be expected along the central-west section.

The fill is not considered suitable to support the proposed watermain without undergoing possible detrimental post-construction settlement. The fill should therefore be subexcavated from below the pipe invert level and replaced with well-compacted granular material such as OPSS Granular 'B' to ensure adequate support for the pipe. The granular fill should be placed in thin lifts (maximum 300 mm thick) and compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Alternatively, the new watermain may be constructed in structurally supported pipe conduits in areas where fill extends below the proposed pipe invert.

Prior to the installation of the new watermain, the pipe subgrade should be inspected by a geotechnical engineer. Any loose zones noted during the inspection must be subexcavated and replaced with well-compacted Granular material such as OPSS Granular 'A'. Where wet silty soils are exposed in the subgrade care should be taken to avoid excessive vibration or disturbance from foot traffic in the base of the trenches.

No bearing problems are anticipated for flexible or rigid pipes founded on compact native mineral soils or aforementioned well compacted Granular ‘B’ material.

Pipe bedding for the new watermain should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular ‘A’ aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 100% standard Proctor maximum dry density (SPMDD).

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) could be used in the trench as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

4.2.2 Backfilling

The east section of the new trunk watermain (Fischer Hallman Road to Bleams Road) follows the hydro easement through agricultural lands currently considered for residential developments and it is recommended that the trench backfill be placed in 150 mm thick lifts and compacted to a minimum of 98% SPMDD.
The west section of the new trunk watermain (Bleams Road to Ottawa Street South) follows the hydro easement through existing residential developments. Trench backfill located outside of existing or future roadways may be placed in 150 mm thick lifts and compacted to a minimum of 95% SPMDD; however, this should be confirmed with the Regional Municipality of Waterloo.

Depending on the moisture content at the time of construction portions of the material may require some time to dry prior to its reuse on-site; however wet or saturated deposits excavated from the trenches are not considered suitable for reuse as backfill. Analytical testing of the fill was not included in the scope of work. Any non-impacted fill free of organics may be suitable for reuse on-site as trench backfill following approval by a geotechnical engineer.

Where cohesive soils (silt till and silt) are reused as trench backfill (especially in the southeast portion of the corridor) extra effort may be required to break blocky/lumpy texture of the soils. If the large interlump voids are not closed completely by thorough compaction, then long-term softening/settlement will occur. The trench backfill should be placed in thin lifts (less than 300 mm) and compacted with a sheepfoot roller. If work is carried out during very dry weather, then water could be added to the backfill to improve compaction.

To minimize potential problems, backfilling operations should follow closely after excavations so that only a minimal length of trench is exposed. Care should be taken to direct surface run-off away from open excavations.

If construction extends into the winter months, then the backfilling operations should be planned so that exposure of the backfill material to frost is kept to a minimum and to ensure that frozen material is not used as backfill.

Frequent inspection and compaction testing by experienced geotechnical personnel should be carried out to verify that the specified degree of compaction has been achieved.

4.3 THRUST BLOCKS

Thrust blocks, if required for the watermain, should be designed using current OPSS Standards and shall conform to OPSD 1103.010 and 1103.020. The following soil parameters may be used for thrust restraint design for thrust blocks placed in the native mineral soils or approved Granular 'B' as described in Section 4.2.1, Pipe Bedding:

- Angle of internal friction (ϕ) = 30°
- Soil cohesion (c) = 0 kPa
- Soil unit weight (γ) = 20 kN/m³

The interface friction coefficient (tanφ) for granular bedding and smooth ductile iron pipe or PVC pipe would be 0.60 and for concrete pipe would be 0.55. An appropriate factor of safety should be employed.

160-P-0002897-0-01-100-GE-R-0001-01

SOUTHERN KITCHENER TRUNK WATERMAIN, FISCHER HALLMAN ROAD TO OTTAWA STREET SOUTH, KITCHENER
4.4 TRENCHLESS PIPE INSTALLATION

It is understood that trenchless construction is currently considered for an approximately 300 m long section within the west portion of the hydro corridor. The subsurface soils encountered within this section of the proposed watermain (Boreholes BH-05-13 and BH-06-13) comprise 5.0 to 6.3 m of fill overlying native deposits of sand. Saturated granular layers were contacted within the fill in Borehole BH-06-13 at a 1.8 m depth (Elevation 356.9 m).

Installing the proposed watermain by horizontal directional drilling, microtunneling or jack and bore would be geotechnically feasible. However, where fill material extends below the new watermain, the pipe will need to be structurally supported in order to avoid possible detrimental post-construction settlements. Where groundwater inflow from saturated seams or deposits is envisaged into the open end of the tunnel appropriate dewatering should be in place.

During the jack and bore procedure the casing must be continuously advanced to the tunnel/bore face and the contractor must ensure no over-mining of soil at the face, which may create voids above the casing. During installation of the casing, careful inspection should be conducted by a geotechnical engineer. The casing should have an appropriate wall thickness to withstand both the jacking forces during construction as well as loading from the overburden.

Tunnels and shafts must comply with O.Reg. 213/91, sections 243 to 331. The work must be undertaken in compliance with the relevant Ontario Provincial Standard Specification OPSS 415 for Tunnelling and OPSS 416 for Jacking and Boring.

Excavations for the sending and receiving pits must be carried out in compliance with O.Reg. 213/91 under the Occupational Health and Safety Act and we refer to Section 4.1, Excavations and Dewatering for further details.

The trenchless pipe installation should be conducted by a specialist contractor. The encountered subsurface stratigraphy (i.e. presence of cobbles and boulders as well as inconsistency of the encountered fill material) should be considered by the bidding contractor when assessing production rates and project costs.

It is recommended that the trenchless installation system be left to the contractor’s discretion, but the contractors must be required to submit a detailed summary of the procedures for review and approval.

This geotechnical investigation report was prepared for the guidance of the design engineers in preparing the design, and may not be sufficient for the detailed design and construction by the contractor. It is the responsibility of the contractor to conduct further investigations or tests as necessary to confirm the appropriateness of the designs and techniques selected. It is recommended that LVM be retained later in the design process to provide further geotechnical input for the trenchless work.
5 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. Also, if any further clarification and/or elaboration are needed concerning the geotechnical aspects of the project, LVM inc. should be contacted. We recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the test holes and to ensure that our recommendations are properly understood.

The geotechnical recommendations provided in this report are intended for the use of the owner and its retained designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work. LVM inc. accepts no responsibility and denies any liability whatsoever for any damages arising from improper or unauthorized use of the report or parts thereof.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface geotechnical, hydrogeological, environmental and geologic conditions between and beyond the test holes will differ from those encountered at the test holes. Also such conditions are not uniform and can vary over time. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.
Appendix 1  Drawings

Drawing 1: Location and Key Plan
Drawing 2: Site Plan, Bleams Road to Fischer Hallman Road
Drawing 3: Site Plan, Ottawa Street South to Bleams Road
Southern Kitchener
Trunk Watermain

Fisher Hallman Road to Ottawa Street South, Kitchener, Ontario

LOCATION KEY PLAN

NOTES:
1-REFERENCES: © OpenStreetMap contributors (2013).

SCALE 1:20000

LVM inc.
353, Bridge Street East
Kitchener (Ontario) NOC 2L3
Telephone: 519.741.3313
Fax: 519.741.5422

Prepared
A.Higgins

Drawn
A.Higgins

Checked
K.Thrams

Discipline
GEOTECHNICAL

Scale
1 : 20000

Date
2013-06-21

Project manager
K.Thrams

Sequence no.
01 of 03

M. dept.
160

Project
P-0002897-0-01-100

Dist.
GE

Dwg no.
001

Rev.
01
Southern Kitchener
Trunk Watermain

NOTES:
2-REFERENCES: GENVAR, Kitchener Zone 4 Trunk Watermain Class Environmental Assessment, Region of Waterloo, Project 11-50-128-00, Figure 1A, 2013-03-14.
3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.
Appendix 2  Borehole Logs in Order of Appearance Along the Subject Corridor Beginning at the Southeast End

List of Abbreviations

Borehole BH-01-13 (current investigation)
Borehole BH106 (LVM inc., Report No. 4792H1-7728H1.R01)
Test Pits TP10, TP8, TP9, TP7, TP18, and TP5 (LVM inc., Report No. 91G132)
Boreholes 13 and 12 (LVM inc., Report No. 160-P037372-301-HD-0001-0A)
Borehole BH212 (LVM inc., Report No. 88G149)
Boreholes BH-02-13 to BH-07-13 (current investigation)
Borehole BH1 (LVM inc., Report No. 7945G1.R01)
Test Pits TP10, TP3, TP4, TP5 (LVM inc., Report No. 7945G1.R01)
Borehole BH3 (LVM inc., Report No. 7945G1.R01)
Borehole BH-08-13 (current investigation)
## LIST OF ABBREVIATIONS

The abbreviations commonly employed on the borehole logs, on the figures, and in the text of the report, are as follows:

<table>
<thead>
<tr>
<th>Sample Types</th>
<th>Soil Tests and Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>Auger Sample</td>
</tr>
<tr>
<td>CS</td>
<td>Core Sample</td>
</tr>
<tr>
<td>RC</td>
<td>Rock Core</td>
</tr>
<tr>
<td>SS</td>
<td>Split Spoon</td>
</tr>
<tr>
<td>TW</td>
<td>Thinwall, Open</td>
</tr>
<tr>
<td>WS</td>
<td>Wash Sample</td>
</tr>
<tr>
<td>BS</td>
<td>Bulk Sample</td>
</tr>
<tr>
<td>GS</td>
<td>Grab Sample</td>
</tr>
<tr>
<td>WC</td>
<td>Water Content Sample</td>
</tr>
<tr>
<td>TP</td>
<td>Thinwall, Piston</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Penetration Resistances

**Dynamic Penetration Resistance**

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60° cone a distance 300 mm (12 in.).

The cone is attached to 'A' size drill rods and casing is not used.

**Standard Penetration Resistance, N (ASTM D1586)**

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.).

- WH | sampler advanced by static weight of hammer |
- PH | sampler advanced by hydraulic pressure |
- PM | sampler advanced by manual pressure |

## Soil Description

### Cohesionless Soils

**Compactness Condition**

<table>
<thead>
<tr>
<th>Consistency</th>
<th>SPT N-Value (blows per 0.3 m)</th>
<th>Relative Density ($D_r$) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0 to 4</td>
<td>0 to 20</td>
</tr>
<tr>
<td>Loose</td>
<td>4 to 10</td>
<td>20 to 40</td>
</tr>
<tr>
<td>Compact</td>
<td>10 to 30</td>
<td>40 to 60</td>
</tr>
<tr>
<td>Dense</td>
<td>30 to 50</td>
<td>60 to 80</td>
</tr>
<tr>
<td>Very Dense</td>
<td>over 50</td>
<td>80 to 100</td>
</tr>
</tbody>
</table>

### Cohesive Soils

**Consistency**

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Undrained Shear Strength ($C_u$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kPa</td>
</tr>
<tr>
<td>Very Soft</td>
<td>less than 12</td>
</tr>
<tr>
<td>Soft</td>
<td>12 to 25</td>
</tr>
<tr>
<td>Firm</td>
<td>25 to 50</td>
</tr>
<tr>
<td>Stiff</td>
<td>50 to 100</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>100 to 200</td>
</tr>
<tr>
<td>Hard</td>
<td>over 200</td>
</tr>
</tbody>
</table>

| DTPL | Drier than plastic limit | Low Plasticity, $W_L < 30$ |
| APL  | About plastic limit     | Medium Plasticity, $30 < W_L < 50$ |
| WTPL | Wetter than plastic limit | High Plasticity, $W_L > 50$ |
**Ground Elevation:** 348.51 m  
**Borehole Number:** BH-01-13  
**Job No:** P-0002897-0-01-100  
**Drill Date:** 2013-05-14  
**Field Tech:** R. McMillan  
**Drill Method:** Solid Stem Auger

**Project:** Southern Kitchener Trunk Watermain  
**Location:** Fischer Hallman Road to Ottawa Street South, Kitchener, Ontario

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Depth (m)</th>
<th>Type and Number</th>
<th>Dynamic Cone</th>
<th>Shear Strength (PP) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>348.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.30</td>
<td>Silty Till: Granular 'A': 300 mm</td>
<td></td>
<td>348.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.52</td>
<td>Firm to very stiff brown silt, some clay and sand, trace gravel DTPL</td>
<td>SS-1</td>
<td>346.99</td>
<td>0.30</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.13</td>
<td>Very stiff to hard, DTPL</td>
<td>SS-2</td>
<td>345.35</td>
<td>0.25</td>
<td></td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.87</td>
<td>Silty: dense brown fine sandy silt, very moist to wet</td>
<td>SS-3</td>
<td>344.70</td>
<td>0.13</td>
<td></td>
<td>31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.91</td>
<td>Compact, saturated, diastatic</td>
<td>SS-4</td>
<td>343.46</td>
<td>0.03</td>
<td></td>
<td>43</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Borehole terminated at 5.03 m

Reviewed by: K. Thrams  
Drafted by: A. Higgins  
Sheet: 1 of 1
**Project:** Hydrogeology Study - Williamsburg South  
**Location:** Bleams Road and Fischer-Hallman Road, Kitchener, Ontario

**Borehole Number:** 106  
**Ground Elevation:** 342.11 m ASL  
**Job No.:** 7728H1  
**Drill Date:** August 8, 2008

### SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>342.11</td>
</tr>
<tr>
<td>1.00</td>
<td>TOPSOIL: dark brown silt, moist</td>
<td>1</td>
<td>AS</td>
</tr>
<tr>
<td>1.00</td>
<td>SILT: brown silt, some sand, moist</td>
<td>2</td>
<td>SS</td>
</tr>
<tr>
<td></td>
<td>very moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>saturated</td>
<td>3</td>
<td>AS</td>
</tr>
<tr>
<td>3.00</td>
<td>stiff brown silt, some clay, APL</td>
<td>4</td>
<td>SS</td>
</tr>
<tr>
<td>4.00</td>
<td>SILT TILL: hard grey clayey silt, trace sand and</td>
<td>5</td>
<td>SS</td>
</tr>
<tr>
<td></td>
<td>fine gravel, APL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.08</td>
<td>Borehole terminated at 8.08 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SAMPLE

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>V-Value</th>
<th>Dynamic Cone</th>
<th>Shear Strength (Ff) kPa</th>
<th>Shear Strength (Fy) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>AS</td>
<td></td>
<td>40 40 40 80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SS</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SS</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SS</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>SS</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater Observations and Standpipe Details**

- Protective cover
- Bentonite seal
- Sand pack
- 19 mm pipe
- 1.52 m slotted filter

**Field Tech.:** RM  
**Sheet:** 1 of 1  
**Drafted by:** SM (01a)  
**Reviewed by:** CH  
**Drill Method:** Solid Stem Auger  
**Notes:** *Sampler bouncing on gravel*
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>ELEV.</th>
<th>WATER CONTENT (%)</th>
<th>SAMPLE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GROUND ELEVATION: 353.00</td>
<td>353</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>TOPSOIL: brown sandy silt, numerous pebbles, rootlets, moist</td>
<td>352</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAND: grey/brown coarse sand with some gravel, cross-bedding, damp</td>
<td>351</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>350</td>
<td></td>
<td>BS1</td>
<td></td>
</tr>
<tr>
<td>4.00</td>
<td>SAND AND SILT: light beige fine sand and silt, wavy cross-bedding, moist</td>
<td>349</td>
<td></td>
<td></td>
<td>no groundwater seepage observed</td>
</tr>
<tr>
<td></td>
<td>Erosional contact between upper coarse sand and lower fine material. Contact surface dips shallowly toward the northeast</td>
<td>348</td>
<td></td>
<td>BS2</td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td>Test pit terminated at approximately 5.4m depth</td>
<td>348</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES: Moderate caving over full height of the open cut
## Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td><strong>TOPSOIL</strong>: dark reddish brown silt, occasional pebbles, corn stalks and rootlets, moist</td>
</tr>
<tr>
<td></td>
<td><strong>SILT</strong>: highly weathered mottled reddish brown silt, trace sand, moist</td>
</tr>
<tr>
<td>2.50</td>
<td><strong>CLAY TILL</strong>: soft to hard dark grey to greenish grey silty clay till, occasional pebbles, clayey silt lenses, moist to wet</td>
</tr>
<tr>
<td>4.50</td>
<td><strong>STONEY TILL</strong>: dense brown silt, sand and gravel, numerous cobbles and boulders, moist to wet</td>
</tr>
<tr>
<td>5.50</td>
<td>Test pit terminated at 5.5m depth</td>
</tr>
</tbody>
</table>

### Water Content (%)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wp</td>
</tr>
<tr>
<td>0.30</td>
<td>10</td>
</tr>
</tbody>
</table>

### Groundwater Observations and Remarks

- minor seepage observed at 3.0 m depth

### Notes

- Moderate caving above 3.0m depth
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>LEGEND</th>
<th>ELEV.</th>
<th>SAMPLE</th>
<th>WATER CONTENT (%)</th>
<th>GROUNDWATER OBSERVATIONS AND REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GROUND ELEVATION: 355.00</td>
<td></td>
<td>355</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>TOPSOIL: dark brown silt, occasional cobbles, corn stalks and rosets, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SILT: weathered reddish brown sandy silt, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.20</td>
<td>SAND: light grey medium to coarse sand, cross-bedding, thin gravel lenses, gravel and cobble layer at approximately 2.8m depth. Sand becomes finer and occasional coarse pockets below 2.8</td>
<td>BS1</td>
<td>354</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.60</td>
<td>BS2</td>
<td></td>
<td>353</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.80</td>
<td>BS3</td>
<td></td>
<td>352</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td>Test pit terminated at approximately 5.0m depth</td>
<td></td>
<td>350</td>
<td></td>
<td></td>
<td>no groundwater seepage observed</td>
</tr>
</tbody>
</table>

NOTES: Severe caving over full height of the open cut
**SOIL PROFILE**

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GROUND ELEVATION: 352.00</td>
</tr>
<tr>
<td>0.20</td>
<td><strong>TOPSOIL</strong>: dark reddish brown silt, occasional pebbles, corn stalks and rootlets, gradational contact with lower silt, moist</td>
</tr>
<tr>
<td>1.90</td>
<td><strong>SAND</strong>: grey medium grained sand, trough cross-bedding, damp</td>
</tr>
<tr>
<td>2.30</td>
<td><strong>SILT</strong>: brown silt with some sand, blocky layering, moist</td>
</tr>
<tr>
<td>3.30</td>
<td><strong>SILT TILL</strong>: extremely dense light brown silt, occasional pebbles, trace sand and clay, oxidized fractures, damp</td>
</tr>
<tr>
<td>4.20</td>
<td>Test pit terminated at 4.2m depth</td>
</tr>
</tbody>
</table>

**NOTES:** Open cut remained stable throughout excavation
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>LEGEND</th>
<th>ELEV.</th>
<th>WATER CONTENT (%)</th>
<th>GROUNDWATER OBSERVATIONS AND REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>GROUND ELEVATION: 352.00</td>
<td></td>
<td>352</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>TOPSOIL: dark brown silt, occasional pebbles, rootlets, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.90</td>
<td>SILT: light reddish brown silt, damp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>SILT TILL: dense dark brown clayey silt with trace sand and occasional pebbles, oxidized fractures, damp</td>
<td></td>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.60</td>
<td>SAND AND GRAVEL: grey/brown coarse sand and gravel, numerous cobbles and boulders</td>
<td></td>
<td>349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.60</td>
<td>Test pit terminated at 4.6m depth</td>
<td></td>
<td>348</td>
<td></td>
<td>no groundwater seepage observed</td>
</tr>
</tbody>
</table>

NOTES: Open cut remained stable throughout excavation
# SOIL PROFILE

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>DESCRIPTION</th>
<th>LEGEND</th>
<th>ELEV.</th>
<th>WATER CONTENT (%)</th>
<th>GROUNDWATER OBSERVATIONS AND REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GROUND ELEVATION:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.40</td>
<td>TOPSOIL: dark reddish brown silt, occasional pebbles, rootlets, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.30</td>
<td>SILT TILL: dense weathered brown silt, trace sand and gravel, infrequent cobbles, oxidized fractures, damp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td>SAND AND GRAVEL: grey/brown sand and gravel, clast supported, numerous cobbles, occasional boulders</td>
<td></td>
<td>BS1</td>
<td></td>
<td>no groundwater seepage observed</td>
</tr>
<tr>
<td></td>
<td>Test pit terminated at 5.0m depth</td>
<td></td>
<td>BS2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:** Open cut remained stable throughout excavation
# SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>TOPSOIL: dark brown sand, some silt, trace gravel, moist</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>SAND: brown with red streaks sand, trace silt and gravel, moist</td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>brown silty sand, moist</td>
<td></td>
</tr>
<tr>
<td>4.00</td>
<td>compact light grey sand, some gravel, trace silt, moist</td>
<td></td>
</tr>
<tr>
<td>6.00</td>
<td>light brown sand, some silt, moist</td>
<td></td>
</tr>
<tr>
<td>7.00</td>
<td>light brown sand, trace silt, moist</td>
<td></td>
</tr>
<tr>
<td>8.00</td>
<td>SILT: dense brown silt, some sand, trace clay and gravel, saturated</td>
<td></td>
</tr>
<tr>
<td>10.00</td>
<td>SAND: dense light brown sand, trace silt and gravel, moist</td>
<td></td>
</tr>
<tr>
<td>12.00</td>
<td>very dense, some gravel</td>
<td></td>
</tr>
<tr>
<td>14.00</td>
<td>dense gravelly sand</td>
<td></td>
</tr>
<tr>
<td>15.00</td>
<td>occasional cobbles, saturated</td>
<td></td>
</tr>
<tr>
<td>16.00</td>
<td>coarse sand, some gravel</td>
<td></td>
</tr>
<tr>
<td>22.00</td>
<td>SAND AND GRAVEL: dense light brown and grey sand and gravel, trace silt, saturated</td>
<td></td>
</tr>
<tr>
<td>25.00</td>
<td>Borehole terminated at 21.79 m</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample</th>
<th>Number</th>
<th>Type</th>
<th>N-Value</th>
<th>Dynamic Cone X</th>
<th>Shear Strength (PP) kPa</th>
<th>Shear Strength (FV) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater Observations and Standpipe Details**

- 2011-07-29 water level at 16.55 m (B.R.: 329.95 m)
- bentonite seal
- 50 mm pipe, 3.95 m slotted filter
- sand pack
- native cave
- At drilling completion, well cave at 21.03 m

**Reviewed by:** CHelmer  
**Drill Method:** Hollow Stem Auger  
**Notes:**

**Field Tech.:** BPick

**Sheet:** 1 of 1

**Drafted by:** JGray
**Borehole Number:** 12-10  
**Ground Elevation:** 348.91 m  
**Job No.:** PO37372-301  
**Drill Date:** 2011-01-06

### LVM

**Project:** Kitchener West Side Area 2 Lands  
**Location:** Bleams Road and Trussler Road, Kitchener, Ontario

#### SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Number</th>
<th>N-Value</th>
<th>Dynamic Cone X</th>
<th>Shear Strength (PP kPa)</th>
<th>Shear Strength (FV kPa)</th>
<th>Water Content (%)</th>
<th>Groundwater Observations and Standpipe Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>348.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bentonite seal</td>
</tr>
<tr>
<td>1.00</td>
<td>TOPSOIL: dark brown sand, some silt, trace gravel, moist</td>
<td></td>
<td>347.00</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bentonite gravel</td>
</tr>
<tr>
<td>2.00</td>
<td>SAND: brown sand, some silt, very moist</td>
<td></td>
<td>346.00</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2011-07-29</td>
</tr>
<tr>
<td>3.00</td>
<td>SAND AND GRAVEL: very dense brown sand and gravel, small silt seams, very moist</td>
<td></td>
<td>345.00</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>07/31/2011 water level at 15.99 m [Elev. 332.93 m]</td>
</tr>
<tr>
<td>4.00</td>
<td>SAND: compact coarse sand, some gravel, moist</td>
<td></td>
<td>344.00</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bentonite seal</td>
</tr>
<tr>
<td>5.00</td>
<td>SAND AND GRAVEL: very dense light brown and gray sand, moist</td>
<td></td>
<td>343.00</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50 mm pipe 1.52 m slotted screen</td>
</tr>
<tr>
<td>6.00</td>
<td>SAND: compact brown sand, some gravel, trace silt, moist</td>
<td></td>
<td>342.00</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sand pack</td>
</tr>
<tr>
<td>7.00</td>
<td>SAND: light brown sand, trace silt, moist</td>
<td></td>
<td>341.00</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>native cave</td>
</tr>
<tr>
<td>8.00</td>
<td>SAND: dense fine silty sand</td>
<td></td>
<td>340.00</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.00</td>
<td>SAND: compact silt</td>
<td></td>
<td>339.00</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.00</td>
<td>SILT: dense brown silt and sand, moist</td>
<td></td>
<td>338.00</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.00</td>
<td>SAND: dense light brown sand, some silt, moist</td>
<td></td>
<td>337.00</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.00</td>
<td>SAND: dense light brown sand, some silt, moist</td>
<td></td>
<td>336.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.00</td>
<td>SAND: occasional cobbles</td>
<td></td>
<td>335.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.00</td>
<td>SAND AND GRAVEL: very dense brown sand and gravel, trace silt, moist saturated</td>
<td></td>
<td>334.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.00</td>
<td>Borehole terminated at 20.27 m</td>
<td></td>
<td>333.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.00</td>
<td></td>
<td></td>
<td>332.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.00</td>
<td></td>
<td></td>
<td>331.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.00</td>
<td></td>
<td></td>
<td>330.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.00</td>
<td></td>
<td></td>
<td>329.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.00</td>
<td></td>
<td></td>
<td>328.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.00</td>
<td></td>
<td></td>
<td>327.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.00</td>
<td></td>
<td></td>
<td>326.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.00</td>
<td></td>
<td></td>
<td>325.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.00</td>
<td></td>
<td></td>
<td>324.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.00</td>
<td></td>
<td></td>
<td>323.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.00</td>
<td></td>
<td></td>
<td>322.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.00</td>
<td></td>
<td></td>
<td>321.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.00</td>
<td></td>
<td></td>
<td>320.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29.00</td>
<td></td>
<td></td>
<td>319.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.00</td>
<td></td>
<td></td>
<td>318.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.00</td>
<td></td>
<td></td>
<td>317.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32.00</td>
<td></td>
<td></td>
<td>316.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.00</td>
<td></td>
<td></td>
<td>315.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34.00</td>
<td></td>
<td></td>
<td>314.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Reviewed by:** CHelmer  
**Drill Method:** Hollow Stem Auger  
**Notes:**

**Field Tech.:** BPick  
**Sheet:** 1 of 1  
**Drafted by:** JGray
## Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>PENETRATION RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td><strong>GROUND ELEVATION:</strong> 353.84</td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td><strong>FILL:</strong> 15 mm tar and chip</td>
<td><em>B</em></td>
</tr>
<tr>
<td>0.65</td>
<td>brown sand and fine gravel</td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>brown sand and gravel, damp</td>
<td></td>
</tr>
<tr>
<td>1.20</td>
<td><strong>TOPSOIL:</strong> black silt, moist</td>
<td></td>
</tr>
<tr>
<td>1.50</td>
<td><strong>SILT:</strong> loose rusty brown silt, trace sand, moist</td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td><strong>SAND:</strong> loose to compact brown fine to medium sand, some gravel, damp</td>
<td></td>
</tr>
<tr>
<td>3.33</td>
<td>cobbles</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td><strong>SILT TILL:</strong> dense brown silt, some sand and gravel, trace clay, moist</td>
<td></td>
</tr>
<tr>
<td>4.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.05</td>
<td>Borehole terminated at 5.05 m</td>
<td></td>
</tr>
<tr>
<td>6.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Water Content (%)

- 13%
- 20%
- 30%

### Notes:

- **Drilling Method:** Hollow Stem Auger
- **Engineer:** DN

**Groundwater Observations and Piezometer Details:**

- At drilling completion, borehole open to 4.25 m and no free groundwater.
## Project: Southern Kitchener Trunk Watermain

### Location: Fischer Hallman Road to Ottawa Street South, Kitchener, Ontario

**Ground Elevation:** 366.55 m  
**Borehole Number:** BH-03-13  
**Northing:** 4805509.59  
**Easting:** 539019.95  
**Job N:** P-0002897-0-01-100  
**Drill Date:** 2013-05-13  
**Field Tech:** J. Stroeder  
**Drill Method:** Solid Stem Auger

### Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Type and Number</th>
<th>Density (g/cm³)</th>
<th>Shear Strength (PP) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>366.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.52</td>
<td>compact brown silt, some sand, trace gravel, moist</td>
<td>SS-1</td>
<td>355.03</td>
<td>5G-8</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.90</td>
<td>compact brown sandy silt, trace to some gravel, moist</td>
<td>SS-2</td>
<td>359.52</td>
<td>5G-9</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.40</td>
<td>compact brown sand and gravel, trace silt, damp to moist</td>
<td>SS-3</td>
<td>361.47</td>
<td>5G-5</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.84</td>
<td>SAND AND GRAVEL:</td>
<td>SS-4</td>
<td>361.72</td>
<td>5G-8</td>
<td>8</td>
<td>9.4</td>
<td></td>
</tr>
<tr>
<td>6.17</td>
<td>SAND:</td>
<td>SS-5</td>
<td>361.72</td>
<td>5G-7</td>
<td>8</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>6.50</td>
<td>compact brown fine sand, some silt, moist</td>
<td>SS-6</td>
<td>361.72</td>
<td>5G-3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.79</td>
<td>borehole terminated at 6.79 m</td>
<td>SS-7</td>
<td>361.72</td>
<td>6-13</td>
<td>13</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater Observations and Standpipe Details:**

- **Methane (% LEL):** 10 20 30
- **Water Content (%):**
  - 20
  - 40
  - 60
  - 80
  - 100
  - 150
  - 200

**Reviewed by:** K. Thrums  
**Drafted by:** A. Higgins  
**Sheet:** 1 of 1

**Notes:** Methane readings expressed as percent lower explosive limit (% LEL).
SOIL PROFILE

Depth (m)

Description

Symbol

Elevation (m)

Type and Number

SPT' N Value

Dynamic Cone

Shear Strength (FV) kPa

WP

WL

Water Content (%)

Methane (% LEL)

FILL: dark brown silt (topsoil), some sand, trace gravel, moist

364.51

5.76

SAND AND GRAVEL: compact brown sand and gravel, trace silt, damp

SS-1

8.10

11

21

SS-2

7.0

10

19

SAND: compact brown fine to medium sand, trace silt, damp to moist

SS-3

5.7

8

15

SS-4

8.11

12

33

SS-5

6.0

11

26

Groundwater Observations and Standpipe Details

At drilling completion, dry core at 5.03 m

bentonite seal

Reviewed by: K. Thrams

Drafted by: A. Higgins

Notes: Bulk Sample BS-3 taken from 0.91 - 1.83 m (moisture content 3.2%).

Ground Elevation: 365.27 m

Borehole Number: BH-04-13

Northing: 4805543.2

Job No: P-0002897-0-01-100

Easting: 538941.6

Drill Date: 2013-05-13

Field Tech: J. Stroeder

Drill Method: Solid Stem Auger

Sheet: 1 of 1
Project: Southern Kitchener Trunk Watermain
Location: Fischer Hallman Road to Ottawa Street South, Kitchener, Ontario

Ground Elevation: 367.93 m
Borehole Number: BH-05-13
Northing: 4805585.75
Easting: 538849.42
Job No: P-0002997-0-01-100
Drill Date: 2013-05-13
Field Tech: J.Stroeder
Drill Method: Solid Stem Auger

SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Depth (m)</th>
<th>Type and Number</th>
<th>&quot;Blow&quot; M-50 mm</th>
<th>Dynamic Cone</th>
<th>Shear Strength (PP) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>FILL: dark brown silt (topsoil), some sand, trace gravel, moist</td>
<td>S-1</td>
<td>367.93</td>
<td>0.00</td>
<td></td>
<td>10-25/125 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.52</td>
<td>very loose, trace clay, moist</td>
<td>S-2</td>
<td>368.41</td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.29</td>
<td>very loose brown sandy silt, some gravel and topsoil, very moist</td>
<td>S-3</td>
<td>305.64</td>
<td>2.29</td>
<td></td>
<td>6-0/0-64 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.16</td>
<td>soft brown silty clay, trace sand and gravel, WTPL</td>
<td>S-4</td>
<td>364.58</td>
<td>3.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.57</td>
<td>loose brown to brown silt, some clay, sand and organics, trace gravel; sand seams, very moist</td>
<td>S-5</td>
<td>363.35</td>
<td>4.57</td>
<td></td>
<td>2-3/2-3 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.32</td>
<td>compact dark brown silt, some sand and clay, trace gravel and organics, very moist</td>
<td>S-6</td>
<td>362.46</td>
<td>5.32</td>
<td></td>
<td>5-3/5-5 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.25</td>
<td>SAND: very dense brown fine to medium sand, some gravel, trace to some silt, damp</td>
<td>S-7</td>
<td>361.46</td>
<td>6.25</td>
<td></td>
<td>11-28/11-28 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.02</td>
<td>dense brown fine to medium sand, trace silt, damp</td>
<td>S-8</td>
<td>360.31</td>
<td>7.02</td>
<td></td>
<td>12-19/12-19 mm*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.08</td>
<td>Borehole terminated at 8.08 m</td>
<td>S-9</td>
<td>350.35</td>
<td>8.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Groundwater Observations and Standpipe Details

Reviewed by: K.Thrams
Drafted by: A.Higgins

Notes: Methane readings expressed as percent lower explosive limit (% LEL).
* Sample boring on gravel.
Ground Elevation: 358.74 m  
Borehole Number: BH-06-13  
Northing: 4805718.97  
Job No.: P-0002897-0-01-100  
Easting: 538706.88  
Drill Date: 2013-05-13  
Field Tech: J. Stroeder  
Drill Method: Solid Stem Auger

**Project:** Southern Kitchener Trunk Watermain  
**Location:** Fischer Hallman Road to Ottawa Street South, Kitchener, Ontario

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Depth (m)</th>
<th>Type and Number</th>
<th>Dynamic Cone</th>
<th>Shear Strength (FP) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.09</td>
<td>Ground Elevation</td>
<td></td>
<td>357.08</td>
<td>6.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.42</td>
<td>loose dark brown silt (topsoil), some sand and clay, trace gravel, moist</td>
<td>SS-1</td>
<td>357.33</td>
<td>1.82</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.52</td>
<td>firm brown silt, some clay and sand, trace organics and gravel, very moist</td>
<td>SS-2</td>
<td>356.91</td>
<td>1.83</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.99</td>
<td>some sand layers, saturated</td>
<td>SS-3</td>
<td>356.45</td>
<td>2.29</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>loose brown to dark brown silt, some sand and organics, trace to some clay,</td>
<td>SS-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>very moist</td>
<td>SS-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>stiff brown silt, some clay and organics, trace gravel, APL</td>
<td>SS-6</td>
<td>354.33</td>
<td>3.01</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>very dense fine to medium sand, some silt, damp</td>
<td>SS-7</td>
<td>353.71</td>
<td>3.03</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>very dense fine to medium sand, some silt, damp</td>
<td>SS-8</td>
<td>352.64</td>
<td>3.19</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Borehole terminated at 6.55 m</td>
<td>SS-9</td>
<td>352.19</td>
<td>3.53</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater Observations and Standpipe Details:**
- bentonite seal
- native cone
- At drilling completion, water level at 5.16 m
- wet cave at 5.79 m

Reviewed by: K. Thrams  
Drafted by: A. Higgins  
Sheet: 1 of 1

**Notes:** Bulk Sample BS-3 taken from 1.52 - 2.29 m (moisture content 20.3 %).  
Methane readings expressed as percent lower explosive limit (% LEL).
### SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>S Symbol</th>
<th>Elevation (m)</th>
<th>Depth (m)</th>
<th>Type and Number</th>
<th>SPT 'N' Value</th>
<th>Dynamic Cone</th>
<th>Shear Strength (FV) kPa</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.63</td>
<td>FILL: loose dark brown silt (topsoil), some sand, trac gravel and clay, very moist to wet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>wood compact, very moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Borehole terminated at 6.71 m**

---

**NOTES:**
- Methane readings expressed as percent lower explosive limit (% LEL).
- Sampler bouncing on wood.

**Reviewed by:** K. Thrams  
**Drafted by:** A. Higgins  
**Sheet:** 1 of 1
### Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>N-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>372.69</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>TOPSOIL: dark brown silt, moist</td>
<td>1</td>
<td>SS</td>
<td>51</td>
</tr>
<tr>
<td>2.00</td>
<td>SILT: brown silt, some sand, moist</td>
<td>2</td>
<td>SS</td>
<td>51</td>
</tr>
<tr>
<td>3.00</td>
<td>SAND: dense brown fine to coarse sand, trace silt, damp</td>
<td>3</td>
<td>SS</td>
<td>55</td>
</tr>
<tr>
<td>4.00</td>
<td>SAND AND GRAVEL: dense to very dense brown sand and gravel, some silt, damp</td>
<td>4</td>
<td>SS</td>
<td>49</td>
</tr>
<tr>
<td>5.00</td>
<td>some cobbles and boulders</td>
<td>5</td>
<td>SS</td>
<td>60, 150mm</td>
</tr>
<tr>
<td>6.00</td>
<td>trace cobbles</td>
<td>6</td>
<td>SS</td>
<td>98</td>
</tr>
<tr>
<td>7.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>7</td>
<td>SS</td>
<td>86</td>
</tr>
<tr>
<td>8.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.00</td>
<td>SAND AND GRAVEL: very dense brown sand and fine gravel, trace silt and cobbles, damp</td>
<td>8</td>
<td>SS</td>
<td>77</td>
</tr>
<tr>
<td>10.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>9</td>
<td>SS</td>
<td>65</td>
</tr>
<tr>
<td>11.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.00</td>
<td>SAND AND GRAVEL: very dense brown sand and fine gravel, trace silt and cobbles, damp</td>
<td>10</td>
<td>SS</td>
<td>80, 150mm</td>
</tr>
<tr>
<td>13.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>11</td>
<td>SS</td>
<td>76</td>
</tr>
<tr>
<td>14.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>12</td>
<td>SS</td>
<td>80, 275mm</td>
</tr>
<tr>
<td>16.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>13</td>
<td>SS</td>
<td>54</td>
</tr>
<tr>
<td>18.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>14</td>
<td>SS</td>
<td>70</td>
</tr>
<tr>
<td>20.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.00</td>
<td>SILT: brown silt and clayey silt, moist, DTPL</td>
<td>15</td>
<td>SS</td>
<td>65</td>
</tr>
<tr>
<td>22.00</td>
<td>SAND: very dense brown fine to coarse sand, some gravel, damp</td>
<td>16</td>
<td>SS</td>
<td>102</td>
</tr>
<tr>
<td>23.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.00</td>
<td>Borehole terminated at 21.79 m</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Drill Method:** Hollow Stem Auger

**Notes:**

**Reviewed by:** VM  
**Drill Method:** Hollow Stem Auger  
**Notes:**
# Preliminary Geotechnical Investigation

**Location:** Laurentian West Community, Kitchener, Ontario  
**Test Pit Number:** 10  
**Ground Elevation:** 369.93 m  
**Job No.:** 7945G1  
**Excavation Date:** December 9, 2008

## Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation</th>
<th>Number</th>
<th>Water Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td>369.93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOPSOIL:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>brown silt, some sand, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td><strong>SILT:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>brown silt, some sand, trace gravel, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>Test Pit terminated at 3.05 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater Observations and Measurements (m):**

- Upon completion of excavation, test pit sidewalls stable
- No free groundwater encountered

---

**Reviewed by:** VM  
**Field Tech:** VM  
**Sheet:** 1 of 1  
**Drafted by:** SM  
**Notes:**
### Test Pit Number: 3

**Ground Elevation:** 375.95 m

**Job No.:** 7945G1

**Excavation Date:** December 9, 2008

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation</th>
<th>Number</th>
<th>Water Content (%)</th>
<th>Groundwater Observations and Measurements (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>375.95</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOPSOIL:</td>
<td>brown silt, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILT:</td>
<td>reddish brown silt, some sand, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILT TILL:</td>
<td>brown silt, some sand and gravel, very moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAND:</td>
<td>brown fine to medium sand, some gravel and silt, very moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test Pit terminated at 3.05 m

Upon completion of excavation, test pit sidewalls stable
No free groundwater encountered

Reviewed by: VM

Field Tech: VM

Notes:

Sheet: 1 of 1

Drafted by: SM
### Test Pit Number: 4

**Ground Elevation:** 377.67 m

*Project:* Preliminary Geotechnical Investigation  
*Location:* Laurentian West Community, Kitchener, Ontario  
*Job No.:* 7945G1  
*Excavation Date:* December 9, 2008

#### SOIL PROFILE

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation</td>
<td></td>
<td>377.67</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td><strong>TOPSOIL:</strong> dark brown silt, moist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td><strong>SILT TILL:</strong> brown silt, some sand, trace gravel, mold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>some gravel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>very dense, occasional cobbles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>Test Pit terminated at 2.59 m of refusal on hard layer (possible cemented sand and gravel)</td>
<td></td>
<td>375.00</td>
<td></td>
</tr>
</tbody>
</table>

#### Groundwater Observations and Measurements (m)

<table>
<thead>
<tr>
<th>WP</th>
<th>WL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Water Content (%)
  - 10
  - 20
  - 30

- Upon completion of excavation, test pit sidewalls stable
- No free groundwater encountered

**Reviewed by:** VM  
**Field Tech:** VM  
**Sheet:** 1 of 1  
**Drafted by:** SM

**Notes:**
**SOIL PROFILE**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Symbol</th>
<th>Elevation (m)</th>
<th>Number</th>
<th>Type</th>
<th>N-Value</th>
<th>Dynamic Cone (kPa)</th>
<th>Shear Strength (SV) (kPa)</th>
<th>Shear Strength (PV) (kPa)</th>
<th>Water Content (%)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Ground Elevation: dark brown silt, moist</td>
<td></td>
<td>372.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>SILT TILL: firm to stiff brown clayey silt, trace sand and fine gravel, APL, DPL</td>
<td>1</td>
<td>372.00</td>
<td>SS</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>SAND: compact brown fine to coarse sand, trace silt, damp</td>
<td>2</td>
<td>371.00</td>
<td>SS</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>SILT TILL: stiff to very stiff brown clayey silt, trace sand and fine gravel, DPL; some thin sand seams, damp</td>
<td>3</td>
<td>370.00</td>
<td>SS</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.00</td>
<td>SAND: compact to dense brown fine to coarse sand, trace silt and gravel, damp</td>
<td>4</td>
<td>369.00</td>
<td>SS</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td>Dense, fine to medium fine to coarse some fine gravel</td>
<td>5</td>
<td>368.00</td>
<td>SS</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.00</td>
<td>SAND AND GRAVEL: very dense brown sand and gravel, some cobbles, trace silt, damp</td>
<td>6</td>
<td>367.00</td>
<td>SS</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.00</td>
<td></td>
<td>7</td>
<td>365.00</td>
<td>SS</td>
<td>50, 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.00</td>
<td>Borehole terminated at 7.92 m</td>
<td></td>
<td>365.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Borehole Number: 3**

Ground Elevation: 372.99 m

Job No.: 7945G1

Drill Date: December 4, 2008

Reviewed by: VM

Drill Method: Hollow Stem Auger

Notes: Bulk sample taken from 0.30 to 1.52 m.

Field Tech.: RM

Sheet: 1 of 1

Drafted by: SM (01a)
Appendix 3  Tables

Table 101: Corrosion Potential
### TABLE 101

**CORROSION POTENTIAL**

Southern Kitchener Trunk Watermain  
Fischer Hallman Road to Ottawa Street South  
Kitchener, Ontario

<table>
<thead>
<tr>
<th>SOIL CHARACTERISTICS</th>
<th>CIPRA RATING SYSTEM</th>
<th>BH-01-13, SS2 1.5 – 2.0 m</th>
<th>BH-04-13, SS4 2.3 – 2.7 m</th>
<th>BH-08-13, SS2 1.5 – 2.0 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Result</td>
<td>Points</td>
<td>Result</td>
<td>Points</td>
</tr>
<tr>
<td>Resistivity (ohm-cm)</td>
<td>&lt;700</td>
<td>10</td>
<td>2990</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>700-1,000</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,000-1,200</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,200-1,500</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,500-2,000</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;2,000</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>0-2</td>
<td>5</td>
<td>7.77</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2-4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-6.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.5-7.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.5-8.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;8.5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redox Potential (mV)</td>
<td>&gt;=+100</td>
<td>0</td>
<td>256</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>+50-+100</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0-+50</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphides</td>
<td>positive</td>
<td>3.5</td>
<td>&lt;0.20</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>trace</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>wet</td>
<td>2</td>
<td>11.4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>moist</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>dry</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL POINTS**  
4 3 4

**Notes:**  
1. If point value exceeds 10, then corrosion protection is required for ferrous pipe.
Appendix 4  Analytical Laboratory Test Results

ALS Laboratory Group Work Order No. L1302097
Certificate of Analysis

Lab Work Order #: L1302097
Project P.O. #: 208824
Job Reference: 160-P-0002897-0-01-100-01
C of C Numbers: 133817
Legal Site Desc:

Nancy Smith
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]
## ALS ENVIRONMENTAL ANALYTICAL REPORT

<table>
<thead>
<tr>
<th>Sample Details/Parameters</th>
<th>Result</th>
<th>Qualifier*</th>
<th>D.L.</th>
<th>Units</th>
<th>Extracted</th>
<th>Analyzed</th>
<th>Batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1302097-1 BH-01-13, SS2 5-6.5'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampled By: R. MCMLLАН on 13-MAY-13 @ 08:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matrix: SOIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Tests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td>11.4</td>
<td>0.10</td>
<td>%</td>
<td>15-MAY-13</td>
<td>16-MAY-13</td>
<td>R2608027</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.77</td>
<td>0.10</td>
<td>pH units</td>
<td>16-MAY-13</td>
<td>16-MAY-13</td>
<td>R2608238</td>
<td></td>
</tr>
<tr>
<td>Redox Potential</td>
<td>256</td>
<td>-1000</td>
<td>mV</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609837</td>
<td></td>
</tr>
<tr>
<td>Resistivity</td>
<td>2990</td>
<td>100</td>
<td>ohm cm</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609838</td>
<td></td>
</tr>
<tr>
<td><strong>Leachable Anions &amp; Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>138</td>
<td>5.0</td>
<td>ug/g</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611639</td>
<td></td>
</tr>
<tr>
<td>Sulphide</td>
<td>&lt;0.20</td>
<td>0.20</td>
<td>mg/kg</td>
<td>23-MAY-13</td>
<td>23-MAY-13</td>
<td>R2614778</td>
<td></td>
</tr>
<tr>
<td><strong>Anions and Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td>&lt;20</td>
<td>20</td>
<td>mg/kg</td>
<td>15-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611648</td>
<td></td>
</tr>
<tr>
<td>L1302097-2 BH-04-13, SS4 7.5-9'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampled By: R. MCMLLАН on 13-MAY-13 @ 15:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matrix: SOIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Tests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td>3.65</td>
<td>0.10</td>
<td>%</td>
<td>15-MAY-13</td>
<td>16-MAY-13</td>
<td>R2608020</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>8.04</td>
<td>0.10</td>
<td>pH units</td>
<td>16-MAY-13</td>
<td>16-MAY-13</td>
<td>R2608238</td>
<td></td>
</tr>
<tr>
<td>Redox Potential</td>
<td>274</td>
<td>-1000</td>
<td>mV</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609837</td>
<td></td>
</tr>
<tr>
<td>Resistivity</td>
<td>15600</td>
<td>100</td>
<td>ohm cm</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609838</td>
<td></td>
</tr>
<tr>
<td><strong>Leachable Anions &amp; Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>&lt;5.0</td>
<td>5.0</td>
<td>ug/g</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611639</td>
<td></td>
</tr>
<tr>
<td>Sulphide</td>
<td>&lt;0.20</td>
<td>0.20</td>
<td>mg/kg</td>
<td>23-MAY-13</td>
<td>23-MAY-13</td>
<td>R2614778</td>
<td></td>
</tr>
<tr>
<td><strong>Anions and Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td>&lt;20</td>
<td>20</td>
<td>mg/kg</td>
<td>15-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611648</td>
<td></td>
</tr>
<tr>
<td>L1302097-3 BH-08-13, SS2 5-6.5'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampled By: R. MCMLLАН on 13-MAY-13 @ 09:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matrix: SOIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Tests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td>11.8</td>
<td>0.10</td>
<td>%</td>
<td>15-MAY-13</td>
<td>16-MAY-13</td>
<td>R2609020</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.68</td>
<td>0.10</td>
<td>pH units</td>
<td>16-MAY-13</td>
<td>16-MAY-13</td>
<td>R2608238</td>
<td></td>
</tr>
<tr>
<td>Redox Potential</td>
<td>271</td>
<td>-1000</td>
<td>mV</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609837</td>
<td></td>
</tr>
<tr>
<td>Resistivity</td>
<td>8500</td>
<td>100</td>
<td>ohm cm</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2609838</td>
<td></td>
</tr>
<tr>
<td><strong>Leachable Anions &amp; Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>15.8</td>
<td>5.0</td>
<td>ug/g</td>
<td>17-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611639</td>
<td></td>
</tr>
<tr>
<td>Sulphide</td>
<td>&lt;0.20</td>
<td>0.20</td>
<td>mg/kg</td>
<td>23-MAY-13</td>
<td>23-MAY-13</td>
<td>R2614778</td>
<td></td>
</tr>
<tr>
<td><strong>Anions and Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td>&lt;20</td>
<td>20</td>
<td>mg/kg</td>
<td>15-MAY-13</td>
<td>17-MAY-13</td>
<td>R2611648</td>
<td></td>
</tr>
</tbody>
</table>

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

### Test Method References:

<table>
<thead>
<tr>
<th>ALS Test Code</th>
<th>Matrix</th>
<th>Test Description</th>
<th>Method Reference**</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL-R511-WT</td>
<td>Soil</td>
<td>Chloride-O.Reg 153/04 (July 2011)</td>
<td>EPA 300.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 grams of dried soil is mixed with 10 grams of distilled water for a minimum of 30 minutes. The extract is filtered and analyzed by ion chromatography.</td>
<td></td>
</tr>
<tr>
<td>MOISTURE-WT</td>
<td>Soil</td>
<td>% Moisture</td>
<td>Gravimetric: Oven Dried</td>
</tr>
<tr>
<td>PH-R511-WT</td>
<td>Soil</td>
<td>pH-O.Reg 153/04 (July 2011)</td>
<td>MOEE E3137A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A minimum 10g portion of the sample is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil and then analyzed using a pH meter and electrode.</td>
<td></td>
</tr>
<tr>
<td>REDOX-POTENTIAL-WT</td>
<td>Soil</td>
<td>Redox Potential</td>
<td>APHA 2580</td>
</tr>
<tr>
<td>RESISTIVITY-WT</td>
<td>Soil</td>
<td>Resistivity</td>
<td>MOEE E3137A</td>
</tr>
<tr>
<td>SO4-WT</td>
<td>Soil</td>
<td>Sulphate</td>
<td>EPA 300.0</td>
</tr>
<tr>
<td>SULPHIDE-WT</td>
<td>Soil</td>
<td>Sulphide</td>
<td>APHA 4500S2D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphide in Soil analysis is based on APHA 4500 S2D. A sub-sample of the soil sample is distilled, sulphuric acid and sodium hydroxide are added to the distillate. The sample is then analyzed on a spectrophotometer.</td>
<td></td>
</tr>
</tbody>
</table>

** 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:

<table>
<thead>
<tr>
<th>Laboratory Definition Code</th>
<th>Laboratory Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT</td>
<td>ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA</td>
</tr>
</tbody>
</table>

## Chain of Custody Numbers:

133817

## 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 lw** - 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

**Workorder:** L1302097  
**Report Date:** 23-MAY-13

**Client:** LVM INC.  
353 BRIDGE ST. E.  
KITCHENER ON N2K 2Y5

**Contact:** KAREN THRAMS

<table>
<thead>
<tr>
<th>Test</th>
<th>Matrix</th>
<th>Reference</th>
<th>Result</th>
<th>Qualifier</th>
<th>Units</th>
<th>RPD</th>
<th>Limit</th>
<th>Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL-R511-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2611639</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671716-2</td>
<td>DUP</td>
<td>L1302097-3</td>
<td>15.8</td>
<td>ug/g</td>
<td>0.1</td>
<td>30</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td></td>
<td>15.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671716-3</td>
<td>LCS</td>
<td></td>
<td>102.3</td>
<td>%</td>
<td>70-130</td>
<td>17-MAY-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671716-1</td>
<td>MB</td>
<td></td>
<td>&lt;5.0</td>
<td>ug/g</td>
<td>5</td>
<td></td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671716-4</td>
<td>MS</td>
<td>L1302097-3</td>
<td>101.9</td>
<td>%</td>
<td>70-130</td>
<td>17-MAY-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOISTURE-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2608020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670933-3</td>
<td>DUP</td>
<td>L1302097-2</td>
<td>3.65</td>
<td>%</td>
<td>10</td>
<td>30</td>
<td>16-MAY-13</td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td>3.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670933-2</td>
<td>LCS</td>
<td></td>
<td>74.1</td>
<td>%</td>
<td>70-130</td>
<td>16-MAY-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670933-1</td>
<td>MB</td>
<td></td>
<td>&lt;0.10</td>
<td>%</td>
<td>0.1</td>
<td></td>
<td>16-MAY-13</td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2608027</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670874-3</td>
<td>DUP</td>
<td>L1302059-9</td>
<td>12.4</td>
<td>%</td>
<td>4.0</td>
<td>30</td>
<td>16-MAY-13</td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td>11.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670874-2</td>
<td>LCS</td>
<td></td>
<td>91.6</td>
<td>%</td>
<td>70-130</td>
<td>16-MAY-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670874-1</td>
<td>MB</td>
<td></td>
<td>&lt;0.10</td>
<td>%</td>
<td>0.1</td>
<td></td>
<td>16-MAY-13</td>
<td></td>
</tr>
<tr>
<td>% Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH-R511-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2606238</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670662-1</td>
<td>DUP</td>
<td>L1301189-1</td>
<td>8.07</td>
<td>pH units</td>
<td>0.06</td>
<td>0.3</td>
<td>16-MAY-13</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td>8.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671973-1</td>
<td>LCS</td>
<td></td>
<td>7.01</td>
<td>pH units</td>
<td>6.7-7.3</td>
<td>16-MAY-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REDOX-POTENTIAL-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2609837</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671216-1</td>
<td>DUP</td>
<td>L1302097-1</td>
<td>256</td>
<td>mV</td>
<td>4.8</td>
<td>25</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>Redox Potential</td>
<td></td>
<td></td>
<td>244</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESISTIVITY-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Quality Control Report

**Client:** LVM INC.  
353 BRIDGE ST. E.  
KITCHENER ON N2K 2Y5

**Contact:** KAREN THRAMS

<table>
<thead>
<tr>
<th>Test</th>
<th>Matrix</th>
<th>Reference</th>
<th>Result</th>
<th>Qualifier</th>
<th>Units</th>
<th>RPD</th>
<th>Limit</th>
<th>Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESISTIVITY-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2609838</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1671840-1</td>
<td>CVS</td>
<td>RESISTIVITY</td>
<td>102.9</td>
<td>%</td>
<td></td>
<td>70-130</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>RG1671216-1</td>
<td>DUP</td>
<td>L1302097-1</td>
<td>2990</td>
<td>ohm cm</td>
<td>4.6</td>
<td>25</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>SO4-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2611648</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1670795-1</td>
<td>DUP</td>
<td>L1302097-2</td>
<td>&lt;20</td>
<td>RPD-NA</td>
<td>mg/kg</td>
<td>N/A</td>
<td>30</td>
<td>17-MAY-13</td>
</tr>
<tr>
<td>RG1670795-4</td>
<td>LCS</td>
<td>&lt;20</td>
<td>103</td>
<td>%</td>
<td></td>
<td>70-130</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>RG1670795-5</td>
<td>MB</td>
<td>&lt;20</td>
<td></td>
<td>mg/kg</td>
<td></td>
<td>20</td>
<td>17-MAY-13</td>
<td></td>
</tr>
<tr>
<td>SULPHIDE-WT</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>R2614778</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WG1674987-1</td>
<td>CVS</td>
<td>SULPHIDE</td>
<td>88.2</td>
<td>%</td>
<td></td>
<td>50-120</td>
<td>23-MAY-13</td>
<td></td>
</tr>
<tr>
<td>RG1674983-2</td>
<td>DUP</td>
<td>L1302097-2</td>
<td>&lt;0.20</td>
<td>RPD-NA</td>
<td>mg/kg</td>
<td>N/A</td>
<td>20</td>
<td>23-MAY-13</td>
</tr>
<tr>
<td>RG1674983-1</td>
<td>MB</td>
<td>&lt;0.20</td>
<td></td>
<td>mg/kg</td>
<td></td>
<td>0.2</td>
<td>23-MAY-13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>Qualifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Duplicate results and limits are expressed in terms of absolute difference.</td>
</tr>
<tr>
<td>RPD-NA</td>
<td>Relative Percent Difference Not Available due to result(s) being less than detection limit.</td>
</tr>
</tbody>
</table>
Quality Control Report
Workorder: L1302097  Report Date: 23-MAY-13

Client: LVM INC.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5

Contact: KAREN THRAMS

Hold Time Exceedances:

<table>
<thead>
<tr>
<th>ALS Product Description</th>
<th>Sample ID</th>
<th>Sampling Date</th>
<th>Date Processed</th>
<th>Rec. HT</th>
<th>Actual HT</th>
<th>Units</th>
<th>Qualifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leachable Anions &amp; Nutrients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13-MAY-13 08:30</td>
<td>23-MAY-13 15:51</td>
<td>7</td>
<td>10</td>
<td>days</td>
<td>EHT</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>13-MAY-13 15:00</td>
<td>23-MAY-13 15:52</td>
<td>7</td>
<td>10</td>
<td>days</td>
<td>EHT</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>13-MAY-13 09:00</td>
<td>23-MAY-13 15:54</td>
<td>7</td>
<td>10</td>
<td>days</td>
<td>EHT</td>
<td></td>
</tr>
</tbody>
</table>

Legend & Qualifier Definitions:
EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1302097 were received on 15-MAY-13 14:00.

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 predetermined 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.
Appendix F

Stage 2 Archeological Investigation
DRAFT

Stage 1 and 2 Archaeological Assessments
New Kitchener Zone 4 Trunk Watermain
Class Environmental Assessment
City of Kitchener, Regional Municipality of Waterloo
Multiple Lots and Concessions
Geographic of Township of Waterloo, Former
Waterloo County, Ontario

Prepared for
GENIVAR Inc.
1-367 Woodlawn Road West
Guelph, ON N1H 7K9
Tel: (519) 827-1453 Fax: (519) 827-1483
&
The Ministry of Tourism, Culture and Sport

By
Archaeological Research Associates Ltd.
154 Otonabee Drive
Kitchener, ON N2C 1L7
Tel: (519) 804-2291 Fax: (519) 286-0493

Licenced under
P.J. Racher, M.A., CAHP
MTCS Licence #P007
Project #P007-501
PIF #P007-501-2012

17/06/2013

Original Report
EXECUTIVE SUMMARY

Under a contract awarded by GENIVAR Inc. in December 2012, Archaeological Research Associates Ltd. carried out Stage 1 and 2 archaeological assessments of lands with the potential to be impacted by the proposed New Kitchener Zone 4 Trunk Watermain in the City of Kitchener, Regional Municipality of Waterloo, Ontario. This report documents the background research and fieldwork involved in these assessments, and presents conclusions and recommendations pertaining to archaeological concerns within the project lands. The assessments were completed as a component of a Municipal Class Environmental Assessment and Preliminary Design study, in compliance with the Environmental Assessment Act.

The Region of Waterloo Water Services Division completed an update to the Tri-City Distribution Master Plan early in 2009. One of the master plan recommendations included a detailed review of Kitchener Pressure Zone 2 West and Kitchener Pressure Zone 2 East because of the area’s growth potential. The review identified that the existing 450 mm diameter watermain supplying the southern area of the Kitchener Pressure Zone 4 is approaching its carrying capacity. During period of high demand the 450 mm diameter watermain experiences elevated head losses in Kitchener Pressure Zone 4 constraining the flow of water to the south end of the zone and to Kitchener Pressure Zone 2 West. In addition, the southwest end of Kitchener is an area of immediate and rapid growth as many plans of subdivisions have been approved and are moving forward to construction. For these reasons it was recommended that a detailed review of Kitchener Pressure Zone 4 be completed to identify opportunities to alleviate existing operational constraints and to strengthen the supply of water to the south end of Kitchener Pressure Zone 4. A Municipal Class Environmental Assessment (EA) and Preliminary Design was therefore required for the preferred alignment.

A large part of the preferred alignment for the project was previously subjected to Stage 1 assessment in September 2011 under licence #P007, PIF #P007-339-2011 (ARA 2011c). The study area for this assessment encompassed the preliminary alignment for the watermain, comprising a 5.5 km long corridor extending along the existing Hydro One corridor between Ottawa Street South and Strasburg Road. This alignment crossed private and public land, and avoided a small provincially-sensitive wetland located east of Fischer-Hallman road. Numerous areas of past assessment (conducted between 1987 and 2011 and cleared of further archaeological concerns) and disturbance were identified within the study area, but some portions still had archaeological potential. Accordingly, Archaeological Research Associates Ltd. recommended that all lands with archaeological potential within the proposed alignment that had not already been cleared of further archaeological concerns be subjected to a Stage 2 archaeological assessment in advance of construction (ARA 2011c:32–33).

Following the completion of the original investigation, the preferred alignment for the project was revised. The new route follows the existing Hydro One corridor in the northwest, but turns south at Fisher-Hallman Road and extends approximately 150 m south of Huron Road. At this point, the route turns east and crosses lands under development, Plains Road, and additional lands under development before terminating at the connection to future Strasburg Road. A large portion of this new route was previously subjected to Stage 1 assessment under licence #P007, PIF #P007-339-2011, but the remainder required Stage 1 and 2 assessments.
The Stage 1 and 2 archaeological assessments were conducted in May 2013 under licence #P007, PIF #P007-501-2012. The Stage 1 study area consisted of all portions of the project lands that were not previously assessed under PIF #P007-339-2011 (8.88 ha), whereas the Stage 2 study area consisted of the entirety of the project lands (14.04 ha). As mentioned above, large parts of this study area were assessed between 1987 and 2011 and have been cleared of further archaeological concerns.

The results of the Stage 1 assessment indicated that the previously un-assessed portions of the project lands had potential for Pre-Contact and Euro-Canadian archaeological sites. Numerous features of archaeological potential were identified in the immediate vicinity, including historically-surveyed roadways, primary water sources and secondary water sources. Multiple areas of disturbance were also identified. The study area clearly warranted further assessment.

The Stage 2 property assessment encompassed all areas of archaeological potential within the study area. Legal permission to enter and conduct all necessary fieldwork activities on project lands was granted by the property owners. This assessment, completed under optimal conditions, did not result in the discovery of any archaeological materials. Based on these findings, Archaeological Research Associates Ltd. recommends that no further archaeological assessment be required within the project lands. A Letter of Review and Acceptance into the Ontario Public Register of Archaeological Reports is requested, as provided for in Section 65.1 of the Ontario Heritage Act.
# TABLE OF CONTENTS

**EXECUTIVE SUMMARY**  
1  
**GLOSSARY OF ABBREVIATIONS**  
VI  
**PERSONNEL**  
VII  

## 1.0 PROJECT CONTEXT  

1.1 Development Context  
1  
1.2 Historical Context  
2  
1.2.1 Pre-Contact  
3  
1.2.1.1 Palaeo-Indian Period  
3  
1.2.1.2 Archaic Period  
3  
1.2.1.3 Early and Middle Woodland Periods  
4  
1.2.1.4 Late Woodland Period  
5  
1.2.2 Early Contact  
7  
1.2.2.1 European Explorers  
7  
1.2.2.2 Trading Contacts and Conflict  
8  
1.2.2.3 Five Nations Invasion  
8  
1.2.2.4 Anishinabeg Influx  
9  
1.2.2.5 Relations and Ambitions  
10  
1.2.3 The Euro-Canadian Era  
11  
1.2.3.1 British Colonialism  
11  
1.2.3.2 Waterloo County  
14  
1.2.3.3 Township of Waterloo  
15  
1.2.3.4 Study Area  
17  
1.2.4 Summary of Past and Present Land Use  
19  
1.2.5 Additional Background Information  
19  

1.3 Archaeological Context  
20  
1.3.1 Previous Archaeological Work  
20  
1.3.1.1 Subdivision on Parts of Biehn’s Tract and Parts of Registered Plan 640  
21  
1.3.1.2 Subdivision 30T-84004, 30T-89020 and 30T-90024  
21  
1.3.1.3 Gehl Place and Bleams Road  
21  
1.3.1.4 Huron West Community  
22  
1.3.1.5 Becker Estates  
22  
1.3.1.6 Activa Fischer-Hallman  
22  
1.3.1.7 Bleams Road  
23  
1.3.1.8 Williamsburg South  
23  
1.3.1.9 Weiss Lands  
23  
1.3.1.10 Kitchener Watermain – Stage 1  
24
1.3.2 Summary of Registered Archaeological Sites 24
1.3.3 Natural Environment 30
1.3.4 Archaeological Fieldwork and Property Conditions 31

2.0 STAGE 1 BACKGROUND STUDY 33
2.1 Summary 33
2.2 Field Methods (Property Inspection) 33
2.3 Analysis and Conclusions 34
2.4 Recommendations 35

3.0 STAGE 2 PROPERTY ASSESSMENT 36
3.1 Field Methods 36
3.2 Record of Finds 38
3.3 Analysis and Conclusions 38
3.4 Recommendations 38

4.0 SYNTHESIS OF CONCLUSIONS AND RECOMMENDATIONS 39

5.0 ADVICE ON COMPLIANCE WITH LEGISLATION 40

6.0 IMAGES 41

7.0 MAPS 52

8.0 BIBLIOGRAPHY AND SOURCES 78

LIST OF IMAGES

Image 1: View of Crewmembers Test Pitting at a Maximum Interval of 5 m 41
Image 2: View of Typical Test Pit Excavated into Subsoil 41
Image 3: View of Crewmember Screening Soil through 6 mm Mesh 42
Image 4: View of Crewmembers Test Pitting to Confirm Disturbance 42
Image 5: View of Crewmembers Test Pitting to Confirm Disturbance 43
Image 6: View of Crewmembers Test Pitting to Confirm Disturbance 43
Image 7: View of Disturbed Test Pit 44
Image 8: View of Disturbed Test Pit 44
Image 9: View of Disturbed Test Pit 45
Image 10: View of Disturbed Test Pit 45
Image 11: View of Disturbed Test Pit 46
Image 12: Area of No Archaeological Potential – Disturbed Lands 46
Image 13: Area of No Archaeological Potential – Disturbed Lands 47
Image 14: Area of No Archaeological Potential – Disturbed Lands 47
Image 15: Area of No Archaeological Potential – Disturbed Lands 48
Image 16: Area of No Archaeological Potential – Disturbed Lands 48
Image 17: Area of No Archaeological Potential – Disturbed Lands 49
Image 18: Area of No Archaeological Potential – Disturbed Lands 49
LIST OF MAPS

Map 1: Location of the Study Area in the Province of Ontario 52
Map 2: Location of the Study Area in the City of Kitchener 53
Map 3: Key Map of the Project Lands, Showing the Stage 1 and 2 Assessment Areas and all Previously Assessed Areas 54
Map 4: Middle Woodland Period Complexes 55
Map 5: Princess Point Site Clusters in Southern Ontario 55
Map 6: Pre-Contact Iroquoian Site Clusters 56
Map 7: Detail from S. de Champlain’s Carte de la Nouvelle France (1632) 56
Map 8: Detail from N. Sanson’s Le Canada, ou Nouvelle France (1656) 57
Map 9: Detail from the Map of Galinée’s Voyage (1670) 57
Map 10: Detail from H. Popple’s A Map of the British Empire in America (1733) 58
Map 11: Detail from R. Sayer and J. Bennett’s General Map of the Middle British Colonies in America (1776) 58
Map 12: The Haldimand Tract (Left) and the Haldimand Proclamation (Right) 59
Map 13: Detail from D.W. Smyth’s A Map of the Province of Upper Canada (1800) 59
Map 14: Detail from J. Purdy’s A Map of Cabotia (1814) 60
Map 15: Detail from D.W. Smyth’s A Map of the Province of Upper Canada, 2nd Edition (1818) 60
Map 16: Detail from J. Arrowsmith’s Upper Canada (1837) 61
Map 17: Detail from J. Bouchette’s Map of the Provinces of Canada (1846) 61
Map 18: Waterloo County from W.J. Gage and Co.’s Gage’s County Atlas (1886) 62
Map 19: Euro-Canadian Land Tracts in Southern Waterloo Township 63
Map 20: Waterloo Township in 1818 63
Map 21: Detail of The Township of Waterloo from G. Tremaine’s Map of the County of Waterloo, Canada West (1861), Showing the Study Area 64
Map 22: Detail of the Township of Waterloo from H. Parsell & Co.’s Illustrated Historical Atlas of the County of Waterloo (1881), Showing the Study Area 65
Map 23: Overview of the Study Area, Showing Insets of Assessment Results 66
Map 24: Assessment Results – Image Locations and Field Methods 67
Map 25: Assessment Results – Image Locations and Field Methods 68
Map 26: Assessment Results – Image Locations and Field Methods 69
Map 27: Assessment Results – Image Locations and Field Methods 70
Map 28: Assessment Results – Image Locations and Field Methods 71
Map 29: Assessment Results – Image Locations and Field Methods 72
LIST OF TABLES

Table 1: Euro-Canadian Residents and Structures within the Study Area 18
Table 2: Registered Archaeological Sites within 1 km of the Study Area 25
Table 3: Summary of Utilized Field Methods 37
Table 4: GPS Co-ordinates for the Fixed Reference Landmarks 38
Table 5: Inventory of the Documentary Record 38

LIST OF APPENDICES

Appendix A: Project Mapping for the New Kitchener Zone 4 Trunk Watermain 86

GLOSSARY OF ABBREVIATIONS

ARA – Archaeological Research Associates Ltd.
ASI – Archaeological Services Inc.
AI – Archaeologix Inc.
CHVI – Cultural Heritage Value or Interest
GCT – German Company Tract
MTC – (Former) Ministry of Tourism and Culture
MTCS – Ministry of Tourism, Culture and Sport
MPA – Mayer, Poulton and Associates Inc.
PIF – Project Information Form
ROW – Right-of-Way
SD – Supplementary Documentation
PERSONNEL

Project Director: P.J. Racher, M.A., CAHP (MTCS licence #P007)
Deliverables Manager: C.J. Gohm, M.A.
Assistant Project Manager: V. Cafik (MTCS licence #R437)
Field Operations Manager: S. Brown (MTCS licence #R302)
Field Director: P. Hoskins (MTCS licence #R415)
Field Cartographers (GPS): P. Hoskins
Additional Field Crewmembers: O. LaFlamme, S. Timmons, H. Triggs
Technical Photographer: P. Hoskins
Historical Researchers: C.J. Gohm, A. Wong (MTCS licence #R326)
Cartographer: K. Brightwell, P.G. (GIS) (MTCS licence #R341)
Technical Writers: V. Cafik, C.J. Gohm
Licensee Revision: P.J. Racher
1.0 PROJECT CONTEXT

1.1 Development Context

Under a contract awarded by GENIVAR Inc. in December 2012, ARA carried out Stage 1 and 2 archaeological assessments of lands with the potential to be impacted by the proposed New Kitchener Zone 4 Trunk Watermain in the City of Kitchener, Regional Municipality of Waterloo, Ontario. This report documents the background research and fieldwork involved in these assessments, and presents conclusions and recommendations pertaining to archaeological concerns within the project lands. The assessments were completed as a component of a Municipal Class Environmental Assessment and Preliminary Design study, in compliance with the Environmental Assessment Act.

The Region of Waterloo Water Services Division completed an update to the Tri-City Distribution Master Plan early in 2009. One of the master plan recommendations included a detailed review of Kitchener Pressure Zone 2 West and Kitchener Pressure Zone 2 East because of the area’s growth potential. The review identified that the existing 450 mm diameter watermain supplying the southern area of the Kitchener Pressure Zone 4 is approaching its carrying capacity. During period of high demand the 450 mm diameter watermain experiences elevated head losses in Kitchener Pressure Zone 4 constraining the flow of water to the south end of the zone and to Kitchener Pressure Zone 2 West. In addition, the southwest end of Kitchener is an area of immediate and rapid growth as many plans of subdivisions have been approved and are moving forward to construction. For these reasons it was recommended that a detailed review of Kitchener Pressure Zone 4 be completed to identify opportunities to alleviate existing operational constraints and to strengthen the supply of water to the south end of Kitchener Pressure Zone 4. A Municipal Class Environmental Assessment (EA) and Preliminary Design was therefore required for the preferred alignment.

A large part of the preferred alignment for the project was previously subjected to Stage 1 assessment in September 2011 under licence #P007, PIF #P007-339-2011 (ARA 2011c). The study area for this assessment encompassed the preliminary alignment for the watermain, comprising a 5.5 km long corridor extending along the existing Hydro One corridor between Ottawa Street South and Strasburg Road. This alignment crossed private and public land, and avoided a small provincially sensitive wetland located east of Fischer-Hallman road. Numerous areas of past assessment (conducted between 1987 and 2011 and cleared of further archaeological concerns) and disturbance were identified within the study area, but some portions still had archaeological potential. Accordingly, ARA recommended that all lands with archaeological potential within the proposed alignment that had not already been cleared of further archaeological concerns be subjected to a Stage 2 archaeological assessment in advance of construction (ARA 2011c:32–33).

Following the completion of the original investigation, the preferred alignment for the project was revised. The new route follows the existing Hydro One corridor in the northwest, but turns south at Fisher-Hallman Road and extends approximately 150 m south of Huron Road. At this point, the route turns east and crosses lands under development, Plains Road, and additional lands under development before terminating at the connection to future Strasburg Road (see Appendix A). A large portion of this new route was previously subjected to Stage 1
assessment under licence #P007, PIF #P007-339-2011, but the remainder required Stage 1 and 2 assessments. As mentioned above, large parts of this study area were assessed between 1987 and 2011 and have been cleared of further archaeological concerns.

The Stage 1 study area consisted of all portions of the project lands that were not previously assessed under PIF #P007-339-2011 (8.88 ha), whereas the Stage 2 study area consisted of the entirety of the project lands (14.04 ha). These lands comprise portions of the Ottawa Street South ROW, the existing Hydro corridor, the Bleams Road ROW, the Fischer-Hallman Road, the Plains Road ROW, and numerous previously assessed lands (see Map 1–Map 3). In legal terms, the study area falls partly within five historically-surveyed road allowances (Ottawa Street, Bleams Road, Fischer-Hallman Road, Huron Road and Plains Road) and partly within Lots 46, 130, 131, 138–141 and 152–159, German Company Tract; Lot 13, Biehns Tract; Bechtels Tract; and Heistands Tract in the Geographic Township of Waterloo (former Waterloo County).

The Stage 1 and 2 archaeological assessments were conducted in May 2013 under MTCS licence #P007, PIF #P007-501-2012. In compliance with the objectives set out in Section 1.0 and Section 2.0 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:13–41), these investigations were carried out in order to:

- Provide information concerning the study area’s geography, history and current land condition;
- Determine the presence of known archaeological sites in the study area;
- Evaluate in detail the study area’s archaeological potential;
- Empirically document all archaeological resources within the study area;
- Determine whether the study area contains resources requiring further assessment; and
- Recommend appropriate Stage 3 assessment strategies for identified archaeological sites.

The assessments were conducted in accordance with the provisions of the Ontario Heritage Act, R.S.O. 1990, c. O.18. All notes, photographs and records pertaining to the project are currently housed in ARA’s processing facility located at 154 Otonabee Drive, Kitchener. Subsequent long-term storage will occur at ARA’s head office located at 97 Gatewood Road, Kitchener.

The MTCS is asked to review the results and recommendations presented in this report and provide their endorsement through a Letter of Review and Acceptance into the Ontario Public Register of Archaeological Reports.

### 1.2 Historical Context

After a century of archaeological work in southern Ontario, scholarly understanding of the historic usage of lands in the Regional Municipality of Waterloo has become very well-developed. What follows is a detailed summary of the archaeological cultures that have settled in the vicinity of the study area over the past 11,000 years; from the earliest Palaeo-Indian hunters to the most recent Euro-Canadian farmers.
1.2.1 Pre-Contact

1.2.1.1 Palaeo-Indian Period

The first documented evidence of occupation in southern Ontario dates to around 9000 BC, after the retreat of the Wisconsinan glaciers and the formation of Lake Algonquin, Early Lake Erie and Early Lake Ontario (Karrow and Warner 1990; Jackson et al. 2000:416–419). At that time small Palaeo-Indian bands moved into the region, leading mobile lives based on the communal hunting of large game and the collection of plant-based food resources (Ellis and Deller 1990:38; MCL 1997:34). Current understanding suggests that Palaeo-Indian peoples ranged over very wide territories in order to live sustainably in a post-glacial environment with low biotic productivity. This environment changed considerably during this period, developing from a sub-arctic spruce forest to a boreal forest dominated by pine (Ellis and Deller 1990:52–54, 60).

An Early Palaeo-Indian period (ca. 9000–8400 BC) and a Late Palaeo-Indian period (ca. 8400–7500 BC) are discernable amongst the lithic spear and dart points. Early points are characterized by grooves or ‘flutes’ near the base while the later examples lack such fluting. All types would have been used to hunt caribou and other ‘big game’. Archaeological sites from both time-periods typically served as small campsites or ‘way-stations’ (occasionally with hearths or fire-pits), where tool manufacture/maintenance and hide processing would have taken place. For the most part, these sites tend to be small (less than 200 sq. m) and ephemeral (Ellis and Deller 1990:51–52, 60–62). Many parts of the Palaeo-Indian lifeway remain unknown.

1.2.1.2 Archaic Period

Beginning in the early 8th millennium BC, the biotic productivity of the environment began to increase as the climate warmed and southern Ontario was colonized by deciduous forests. This caused the fauna of the area to change as well, and ancient peoples developed new forms of tools and alternate hunting practices to better exploit both animal and plant-based food sources. These new archaeological cultures are referred to as ‘Archaic’. Thousands of years of gradual change in stone tool styles allows for the recognition of Early (7500–6000 BC), Middle (6000–2500 BC) and Late Archaic periods (2500–900 BC) (MCL 1997:34).

The Early and Middle Archaic periods are characterized by substantial increases in the number of archaeological sites and a growing diversity amongst stone tool types and exploited raw materials. Notable changes in Archaic assemblages include a shift to notched or stemmed projectile points, a growing prominence of net-sinkers (notched pebbles) and an increased reliance on artifacts like bone fish hooks and harpoons. In addition to these smaller items, archaeologists also begin to find evidence of more massive wood working tools such as ground stone axes and chisels (Ellis et al. 1990:65–67).

Towards the end of the Middle Archaic (ca. 3500 BC), the archaeological evidence suggests that populations were 1) increasing in size, 2) paying more attention to ritual activities, 3) engaging in long distance exchange (e.g. in items such as copper) and 4) becoming less mobile (Ellis et al. 1990:93; MCL 1997:34). Late Archaic peoples typically made use of shoreline/riverine sites located in rich environmental zones during the spring, summer and early fall, and moved further inland to deer hunting and fruit-gathering sites during late fall and winter (Ellis et al. 1990:114).
During the Late Archaic these developments continued, and new types of projectile points appeared along with the first true cemeteries. Excavations of burials from this time-frame indicate that human remains were often cremated and interred with numerous grave goods, including items such as projectile points, stone tools, red ochre, materials for fire-making kits, copper beads, bracelets, beaver incisors, and bear maxilla masks (Ellis et al. 1990:115–117). Interestingly, these true cemeteries may have been established in an attempt to solidify territorial claims, linking a given band or collection of bands to a specific geographic location.

From the tools unearthed at Archaic period sites it is clear that these people had an encyclopaedic understanding of the environment that they inhabited. The number and density of the sites that have been found suggest that the environment was exploited in a successful and sustainable way over a considerable period of time. The success of Archaic lifeways is attested to by clear evidence of steady population increases over time. Eventually, these increases set the stage for the final period of Pre-Contact occupation—the Woodland Period (Ellis et al. 1990:120).

1.2.1.3 Early and Middle Woodland Periods

The beginning of the Woodland period is primarily distinguished from the earlier Archaic by the widespread appearance of pottery. Although this difference stands out prominently amongst the archaeological remains, it is widely believed that hunting and gathering remained the primary subsistence strategy throughout the Early Woodland period (900–400 BC) and well into the Middle Woodland period (400 BC–AD 600). In addition to adopting ceramics, communities also grew in size during this period and participated in developed and widespread trade relations (Spence et al. 1990; MCL 1997:34).

The first peoples to adopt ceramics in the vicinity of the study area are associated with the Meadowood archaeological culture. This culture is characterized by distinctive Meadowood preforms, side-notched Meadowood points and Vinette 1 ceramics (thick and crude handmade pottery with cord-marked decoration). Meadowood peoples are believed to have been organized in bands of roughly 35 people, and some of the best documented sites are fall camps geared towards the hunting of deer and the gathering of nuts (Spence et al. 1990:128–137).

Ceramic traditions continued to develop during the subsequent Middle Woodland period, and three distinct archaeological cultures emerged in southern Ontario: ‘Point Peninsula’ north and northeast of Lake Ontario, ‘Couture’ near Lake St. Clair and ‘Saugeen’ in the rest of southwestern Ontario (see Map 4). These cultures all shared a similar method of decorating pottery, using either dentate or pseudo-scallop shell stamp impressions, but they differed in terms of preferred vessel shape, zones of decoration and surface finish (Spence et al. 1990:142–43).

The local Saugeen complex, which appears to have extended from Lake Huron to as far east as the Humber River, is characterized by stamped pottery, distinctive projectile points, cobblespall scrapers and a lifeway geared towards the exploitation of seasonally-available resources such as game, nuts and fish (Spence et al. 1990:147–156). Although relatively distant from the study area, the Donaldson site along the Saugeen River may be representative of a typical Saugeen settlement; it was occupied in the spring by multiple bands that came to exploit spawning fish and bury members who had died elsewhere during the year (Finlayson 1977:563–578). The
archaeological remains from this site include post-holes, hearth pits, garbage-dumps (middens), cemeteries and even a few identifiable rectangular structures (Finlayson 1977:234–514).

During the Middle to Late Woodland transition (AD 600–900), major developments took place at the western end of Lake Ontario as maize (corn) horticulture was introduced and settled agriculturalists emerged (Fox 1990:171, Figure 6.1). This shift is linked to the development of the Princess Point complex, which is characterized by distinctively decorated ceramic vessels (combining cord roughening, impressed lines and punctuate designs), triangular projectile points, T-based drills, steatite and ceramic pipes and ground stone chisels and adzes (Fox 1990:174–188).

The Grand Banks site near Cayuga is one of the best known Princess Point sites, and a calibrated radiocarbon date of AD 406–586 indicates that it was home to the first maize horticulturalists in northeastern North America (Warrick 2000:427). Generally, Princess Point sites consist of what are called ‘incipient’ longhouses, circular or square houses and even rudimentary palisades. Excavated evidence suggests that a typical village would have contained upwards of five contemporary houses at any one time, serving a population of roughly 75 people for perhaps 40–50 years. The evidence also indicates that many of these villages were reoccupied repeatedly over the centuries (Warrick 2000:429–434).

Intriguingly, approximately half of the documented Princess Point sites in Ontario have been discovered along the Grand River, but examples have also been found in the vicinity of the Credit and Humber Rivers (see Map 5). The distinctive artifacts and horticultural practices of Princess Point peoples have led to the suggestion that they were the ancestors of the later Iroquoian-speaking populations of southern Ontario (Warrick 2000:427).

1.2.1.4 Late Woodland Period

In the Late Woodland period (ca. AD 900–1600), the practice of maize horticulture spread beyond the western end of Lake Ontario, allowing for population increases which in turn led to larger settlement sizes, higher settlement density and increased social complexity among the peoples involved. These developments are believed to be linked to the spread of Iroquoian-speaking populations in the area; ancestors of the historically-documented Huron, Neutral and Haudenosaunee Nations. Other parts of southern Ontario, including the Georgian Bay littoral, the Bruce Peninsula and the vicinity of Lake St. Clair, were inhabited by Algonkian-speaking peoples, who were much less agriculturally-oriented.

Late Woodland archaeological remains from the greater vicinity of the study area show three major stages of cultural development prior to European contact: ‘Early Iroquoian’, ‘Middle Iroquoian’ and ‘Late Iroquoian’ (Dodd et al. 1990; Lennox and Fitzgerald 1990; Williamson 1990).

Early Iroquoians (AD 900–1300) lived in small villages (ca. 0.4 ha) of between 75 and 200 people, and each settlement consisted of four or five longhouses up to 15 m in length. The houses contained central hearths and pits for storing maize (which made up 20–30% of their diet), and the people produced distinctive pottery with decorative incised rims (Warrick 2000:434–438). The best documented Early Iroquoian culture in the local area is the
Glen Meyer complex, which is characterized by well-made and thin-walled pottery, ceramic pipes, gaming discs, and a variety of stone, bone, shell and copper artifacts (Williamson 1990:295–304).

Over the next century (AD 1300–1400), Middle Iroquoian culture became dominant in southwestern Ontario, and distinct ‘Uren’ and ‘Middleport’ stages of development have been identified. Both houses and villages dramatically increased in size during this time: longhouses grew to as much as 33 m in length, settlements expanded to 1.2 ha in size and village populations swelled to as many as 600 people. Middle Iroquoian villages were also better planned, suggesting emerging clan organization, and most seem to have been occupied for perhaps 30 years prior to abandonment (Dodd et al. 1990:356–359; Warrick 2000:439–446).

During the Late Iroquoian period (AD 1400–1600), the phase just prior to widespread European contact, it becomes possible to differentiate between the archaeologically-represented groups that would become the Huron and the Neutral Nations. The study area itself lies on the outskirts of the territorial boundaries of the Pre-Contact Neutral Nation, documented in lands as far west as Chatham and as far east as New York State.

The Neutral Nation is well represented archaeologically: typical artifacts include ceramic vessels and pipes, lithic chipped stone tools, ground stone tools, worked bone, antler and teeth, and exotic goods obtained through trade with other Aboriginal (and later European) groups (Lennox and Fitzgerald 1990:411–437). The population growth so characteristic of earlier Middleport times appears to have slowed considerably during the Late Iroquoian period, and the Pre-Contact Neutral population likely stabilized at around 20,000 by the early 16th century (Warrick 2000:446).

Pre-Contact Neutral villages were much larger than Middleport villages, with average sizes in the neighbourhood of 1.7 ha. Exceptional examples of these could reach 5 ha in size, containing longhouses over 100 m in length and housing 2,500 individuals. This seemingly rapid settlement growth is thought to have been linked to Middleport ‘baby boomers’ starting their own families and needing additional living space (Warrick 2000:446–449).

It has been suggested that the size of these villages, along with the necessary croplands to sustain them, may have had some enduring impacts on the landscapes that surrounded them. In particular, there has been a correlation postulated between Pre-Contact era corn fields and modern stands of white pine (Janusas 1987:69–70, Figure 7). Aside from these villages, the Pre-Contact Neutral also made use of hamlets, agricultural field cabins, specialized camps (e.g. fishing camps) and cemeteries (MCL 1997:35; Warrick 2000:449).

For the most part, Pre-Contact Neutral archaeological sites occur in isolated clusters defined by some sort of geographic region, usually within a watershed or another well-defined topographic feature. It is believed that these clusters represent distinct tribal units, which may have been organized as a larger confederacy akin to the historic Five Nations Iroquois (Lennox and Fitzgerald 1990:410). Nineteen main clusters of villages have been identified, the closest manifestation of which is known simply as the ‘Kitchener Cluster’. This cluster, which includes the Moyer, Reidel, William Barrie, Mannheim, Coleman, Baden Wagler, Dry Lake and Waterloo...
sites, appears to have flourished primarily in the 15th century (Lennox and Fitzgerald 1990: Table 13.1).

Late Pre-Contact Neutral sites are largely absent in this part of southern Ontario, indicative of substantial shifts in local settlement patterns (see Map 6). By the early 16th century there was a definite contraction of earlier territories, perhaps linked to the consolidation of tribal units, and by AD 1534 the Neutral appear to have moved east of the Grand River (Warrick 2000:454). Although scholars once thought that this shift was linked to a desire for better access to European goods, the fact that the fur trade did not begin for several decades has led to the recognition of an alternate reason—war. Later historical sources suggest that the Neutral were engaged in hostilities with the Fire Nation (possibly the Mascouten), an Algonkian-speaking people to the southwest known archaeologically as the Western Basin Tradition. Remains from the frontier zone include strongly fortified villages and earthworks, clearly illustrating a defensive mindset (Lennox and Fitzgerald 1990:437–438; Warrick 2000:449–451).

The end of the Late Woodland period can be conveniently linked to the arrival and spread of European fur traders in southern Ontario, and a terminus of AD 1600 effectively serves to demarcate some substantial changes in Aboriginal material culture. Prior to the establishment of the fur trade, items of European manufacture are extremely rare on Pre-Contact Neutral sites, save for small quantities of reused metal scrap. With the onset of the fur trade ca. AD 1580, European trade goods appear in ever-increasing numbers, and glass beads, copper kettles, iron axes and iron knives have all been found during excavations (Lennox and Fitzgerald 1990:425–432).

1.2.2 Early Contact

1.2.2.1 European Explorers

The first European to venture into what would become southern Ontario was Étienne Brûlé, who was sent by Samuel de Champlain in the summer of 1610 to accomplish three goals: 1) to consolidate an emerging friendship between the French and the First Nations, 2) to learn their languages, and 3) to better understand their unfamiliar customs. Other Europeans would subsequently be sent by the French to train as interpreters. These men became coureurs de bois, “living Indian-style ... on the margins of French society” (Gervais 2004:182). Such ‘woodsmen’ played an essential role in all later communications with the First Nations.

Champlain himself made two trips to Ontario: in 1613, he journeyed up the Ottawa River searching for the North Sea, and in 1615/1616, he travelled up the Mattawa River and descended to Lake Nipissing and Lake Huron to explore Huronia (Gervais 2004:182–185). He learned about many First Nations groups during his travels, including prominent Iroquoian-speaking peoples such as the Wendat (Huron), Petun (Tobacco) and ‘la nation neutre’ (the Neutrals), and a variety of Algonkian-speaking Anishinabeg bands. Champlain’s map of Nouvelle France from 1632 encapsulates his accumulated knowledge of the area (see Map 7). Although the distribution of the Great Lakes is clearly an abstraction, prolific Neutral village sites can be seen ‘west’ of Lac St. Louis (Lake Ontario).
1.2.2.2 Trading Contacts and Conflict

The first half of the 17th century saw a marked increase in trading contacts between the First Nations and European colonists, especially in southern Ontario. Archaeologically, these burgeoning relations are clearly manifested in the widespread appearance of items of European manufacture by AD 1630, including artifacts such as red and turquoise glass beads, scissors, drinking glasses, keys, coins, firearms, ladles and medallions. During this time, many artifacts such as projectile points and scrapers began to be manufactured from brass, copper and iron scrap, and some European-made implements completely replaced more traditional tools (Lennox and Fitzgerald 1990:432–437).

Nicholas Sanson’s *Le Canada, ou Nouvelle France* (1656) provides an excellent representation of southern Ontario at this time of heightened contact. Here the lands of the Neutral Nation are clearly labelled with the French rendering of their Huron name, ‘*Attawandaron*’ (see Map 8). Unfortunately, this increased contact had the disastrous consequence of introducing European diseases into First Nations communities. These progressed from localized outbreaks to much more widespread epidemics (MCL 1997:35; Warrick 2000:457). Archaeological evidence of disease-related population reduction appears in the form of reduced longhouse sizes, the growth of multi-ossuary cemeteries and the loss of traditional craft knowledge and production skills (Lennox and Fitzgerald 1990:432–433).

1.2.2.3 Five Nations Invasion

The importance of European trading contacts eventually led to increasing factionalism and tension between the First Nations, and different groups began to vie for control of the lucrative fur trade (itself a subject of competition between the French and British). In what would become Ontario, the Huron, the Petun, and their Anishinabeg trading partners allied themselves with the French. In what would become New York, the League of the Haudenosaunee (the Five Nations Iroquois at that time) allied themselves with the British. The latter alliance may have stemmed from Champlain’s involvement in Anishinabeg and Huron attacks against Iroquoian strongholds in 1609 and 1615, which engendered enmity against the French (Lajeunesse 1960:xxix). Interposed between the belligerents, the members of the Neutral Nation refused to become involved in the conflict.

Numerous military engagements occurred between the two opposing groups during the first half of the 17th century, as competition over territories rich in fur-bearing animals increased. These tensions boiled over in the middle of the 17th century, leading to full-scale regional warfare (MNCFN 2010:5). In a situation likely exacerbated by epidemics brought by the Europeans and the decimation of their population, a party of roughly 1,000 Mohawk and Seneca warriors set upon Huronia in March 1649. The Iroquois desired to remove the Huron Nation altogether, as they were a significant obstacle to controlling the northern fur trade (Hunt 1940:91–92).

The Huron met their defeat in towns such as Saint Ignace and Saint Louis (Sainte-Marie was abandoned and burned by the Jesuits in the spring of 1649). Those that were not killed were either adopted in the Five Nations as captives or dispersed to neighbouring regions and groups (Ramsden 1990:384). The Petun shared a similar fate, and the remnants of the affected groups formed new communities outside of the disputed area, settling in Quebec (modern-day
Wendake), in the area of Michilimackinac and near Lake St. Clair (where they were known as the Wyandot).

Anishinabeg populations from southern Ontario, including the Ojibway, Odawa, and Pottawatomi, fled westward to escape the Iroquois (Schmalz 1977:2). The Neutral were targeted in 1650 and 1651, and the Iroquois took multiple frontier villages (one with over 1,600 men) and numerous captives (Coyne 1895:18). The advance of the Iroquois led to demise of the Neutral Nation as a distinct cultural entity (Lennox and Fitzgerald 1990:456).

For the next four decades, southern Ontario remained an underpopulated wilderness (Coyne 1895:20). This rich hunting ground was exploited by the Haudenosaunee to secure furs for trade with the Dutch and the English, and settlements were established along the north shore of Lake Ontario at places like Teiaiagon on the Humber River and Ganatswekwyagon on the Rouge River (Williamson 2008:51). The Haudenosaunee are also known to have traded with the northern Anishinabeg during the second half of the 17th century (Smith 1987:19).

Due to their mutually violent history, the Haudenosaunee did not permit French explorers and missionaries to travel directly into southern Ontario for much of the 17th century. Instead, they had to journey up the Ottawa River to Lake Nipissing and then paddle down the French River into Georgian Bay (Lajeunesse 1960:xxix). New France was consequently slow to develop in southern Ontario, at least until the fall of several Iroquoian strongholds in 1666 and the opening of the St. Lawrence and Lake Ontario route to the interior (Lajeunesse 1960:xxxii).

In 1669, the Haudenosaunee allowed an expedition of 21 men to pass through their territory. This expedition, which included François Dollier de Casson (a Sulpician priest) and René Bréhant de Galinée, managed to reach and explore the Grand River, which they named le Rapide after the swiftness of its current. These men descended the Grand to reach Lake Erie, and they wintered at the future site of Port Dover (Coyne 1895:21). Galinée’s map is one of the earliest documented representations of the interior of southwestern Ontario (see Map 9). In it, he notes the locations of several former Neutral villages at the western end of Lake Ontario, likely consisting of abandoned ruins.

1.2.2.4 Anishinabeg Influx

The fortunes of the Five Nations began to change in the 1690s, as disease and casualties from battles with the French took a toll on the formerly-robust group (Smith 1987:19). On July 19, 1701, the Haudenosaunee ceded lands in southern Ontario to King William III with the provision that they could still hunt freely in their former territory (Coyne 1895:28). However, this agreement appears to have lacked any sort of binding formality.

According to the traditions of the Algonkian-speaking Anishinabeg, Ojibway, Odawa and Potawatomi bands began to mount an organized counter-offensive against the Iroquois in the late 17th century (MNCFN 2010:5). Around the turn of the 18th century, the Anishinabeg of the Great Lakes expanded into Haudenosaunee lands, and attempted to trade directly with the French and the English (Smith 1987:19). This led to a series of battles between the opposing groups, in which the Anishinabeg were more successful (Coyne 1895:28).
Haudenosaunee populations subsequently withdrew into New York State, and Anishinabeg bands established themselves in southern Ontario. Many of these bands were mistakenly grouped together by the immigrating Europeans under the generalized designations of ‘Chippewa/Ojibway’ and ‘Mississauga’. ‘Mississauga’, for example, quickly became a term applied to many Algonkian-speaking groups around Lake Erie and Lake Ontario (Smith 1987:19), despite the fact that the Mississaugas were but one part of the larger Ojibway Nation (MNCFN 2010:3).

The Anishinabeg are known to have taken advantage of the competition between the English and French over the fur trade, and they were consequently well-supplied with European goods. The Mississaugas, for example, traded primarily with the French and received “everything from buttons, shirts, ribbons to combs, knives, looking glasses, and axes” (Smith 1987:22). The British, on the other hand, were well-rooted in New York State and enjoyed mutually beneficial relations with the Haudenosaunee.

As part of this influx, many members of the Algonkian-speaking Ojibway, Potawatomi and Odawa First Nations came back to Lake Huron littoral. Collectively, these people came to be known as the Chippewas of Saugeen Ojibway Territory (also Saugeen Ojibway Nation). These Algonkian-speakers established themselves in the Bruce Peninsula, all of Bruce and Grey Counties, and parts of Huron, Dufferin, Wellington, and Simcoe Counties (Schmalz 1977:233).

Throughout the 1700s and into the 1800s, Anishinabeg populations hunted, fished, gardened and camped along the rivers, floodplains and forests of southern Ontario (Warrick 2005:2). However, their ‘footprint’ was exceedingly light, and associated archaeological sites are both rare and difficult to detect. Historical records often play a pivotal role in reconstructing Anishinabeg lifeways during the timeframe, as the first European colonists often wrote about the locations of Aboriginal camps and hunting grounds.

Historical maps from the 18th century likewise shed valuable light on the contemporary cultural landscape. H. Popple’s *A Map of the British Empire in America* (1733), for example, does not show any prominent settlements in the vicinity of the study area, which is a result of the ephemeral environmental impact of the mobile Ojibway (see Map 10).

**1.2.2.5 Relations and Ambitions**

The late 17th and early 18th centuries bore witness to the continued growth and spread of the fur trade across all of what would become the Province of Ontario. The French, for example, established and maintained trading posts along the Upper Great Lakes, offering enticements to attract fur traders from the First Nations. Even further north, Britain’s Hudson Bay Company dominated the fur trade. Violence was common between the two parties, and peace was only achieved with the Treaty of Utrecht in 1713 (Ray 2013). Developments such as these resulted in an ever-increasing level of contact between European traders and local Aboriginal communities.

As the number of European men living in Ontario increased, so too did the frequency of their relations with Aboriginal women. Male employees and former employees of French and British companies began to establish families with these women, a process which resulted in the ethnogenesis of a distinct Aboriginal people: the Métis. Comprised of the descendants of those
born from such relations (and subsequent intermarriage), the Métis emerged as a distinct Aboriginal people during the 1700s (MNO 2011).

Métis settlements developed along freighting waterways and watersheds, and were tightly linked to the spread and growth of the fur trade. These settlements were part of larger regional communities, connected by “the highly mobile lifestyle of the Métis, the fur trade network, seasonal rounds, extensive kinship connections and a shared collective history and identity” (MNO 2011).

In 1754, hostilities over trade and the territorial ambitions of the French and the British led to the Seven Years’ War (often called the French and Indian War in North America), in which many Anishinabeg bands fought on behalf of the French. After the French surrender in 1760, these bands adapted their trading relationships accordingly, and formed a new alliance with the British (Smith 1987:22). In addition to cementing British control over the Province of Quebec, the Crown’s victory over the French also proved pivotal in catalyzing the Euro-Canadian settlement process. The resulting population influx caused the demographics of many areas to change considerably.

R. Sayer and J. Bennett’s General Map of the Middle British Colonies in America (1776) provides an excellent view of the ethnic landscape of southern Ontario prior to the widespread arrival of European settlers. This map clearly depicts Grand and Humber Rivers, the territory of the Ojibway, and the virtually untouched lands of southwestern Ontario (see Map 11).

1.2.3 The Euro-Canadian Era

1.2.3.1 British Colonialism

With the establishment of absolute British control came a new era of land acquisition and organized settlement. In the Royal Proclamation of 1763, which followed the Treaty of Paris, the British government recognized the title of the First Nations to the land they occupied. In essence, the ‘right of soil’ had to be purchased by the Crown prior to European settlement (Lajeunesse 1960:cix). Numerous treaties and land surrenders were accordingly arranged by the Crown, and great swaths of territory were acquired from the Ojibway and other First Nations. These first purchases established a pattern “for the subsequent extinction of Indian title” (Gentilcore and Head 1984:78).

The first land purchases in Ontario took place along the shores of Lake Ontario and Lake Erie, as well as in the immediate ‘back country’. Such acquisitions began in August 1764, when a strip of land along the Niagara River was surrendered by Six Nations, Chippewa and Mississauga chiefs (NRC 2010a). Although many similar territories were purchased by the Crown in subsequent years, it was only with the conclusion of the American Revolutionary War (1775–1783) that the British began to feel a pressing need for additional land. In the aftermath of the conflict, waves of United Empire Loyalists came to settle in the Province of Quebec, driving the Crown to seek out property for those who had been displaced. This influx had the devastating side effect of sparking the slow death of the fur trade, which was a primary source of income for many First Nations groups.
By the mid-1780s, the British recognized the need to 1) secure a military communication route from Lake Ontario to Lake Huron other than the vulnerable passage through Niagara, Lake Erie and Lake St. Clair; 2) acquire additional land for the United Empire Loyalists; and 3) modify the administrative structure of the Province of Quebec to accommodate future growth. The first two concerns were addressed through the negotiation of numerous ‘land surrenders’ with Anishinabeg groups north and west of Lake Ontario, and the third concern was mitigated by the establishment of the first administrative districts in the Province of Quebec.

In response to the second need, the ‘Between the Lakes Purchase’ of 1784 (a.k.a. the Haldimand Tract Purchase) was orchestrated by the Governor of the Province of Quebec, Sir Frederick Haldimand. This purchase was completed to obtain land for those members of the Haudenosaunee (now Six Nations) who supported the Loyalist/British cause. In 1779, two years after joining the American Revolutionary War as allies of the British, many Seneca, Onondaga and Cayuga towns were targeted by American forces and destroyed. This caused the Iroquois Confederacy to seek retribution, and under the leadership of the Mohawk captain Joseph Brant, Haudenosaunee forces attacked and burned rebel forts and settlements as far east as Schenectady, New York (Ramsden 2013).

After the war ended, the Haudenosaunee were forced to leave New York State, and Governor Haldimand purchased a tract of land from the Mississaugas in 1784 for the Six Nations Loyalists to settle (Johnston 1964:xxxviii–xli; NRC 2010a). Approximately 384,750 ha were discussed in this agreement (see Map 12), extending for 9.6 km on either side of the Grand River from its source to its mouth (Six Nations Council 2010:2).

Due to the fact that the colonial British ‘government’ at this time was largely nominal, rather than legislatively effective and decisive, the question was left open as to whether the Six Nations could dispose of their land directly to whomever they chose. Regardless of this significant hurdle, Brant moved quickly to lease some of the Six Nations’ holdings to raise investment income for the Confederacy. In 1787, a number of European families were issued rough land titles with the condition that they could never be transferred to another individual. With less than 2,000 Six Nations members living in the Haldimand Tract and the imminent death of the fur trade, Brant realized that he would need the assistance of European settlers to bring new technologies to his people and transform them into successful agriculturalists (Johnston 1964:xlii–xliii).

On July 24, 1788, Sir Guy Carleton, Baron of Dorchester and Governor-General of British North America, divided the Province of Quebec into the administrative districts of Hesse, Nassau, Mecklenburg and Lunenburg (Archives of Ontario 2009). The vicinity of the study area fell within the Hesse District at this time, which consisted of a massive tract of land encompassing all of the western and inland parts of the province extending due north from the tip of Long Point on Lake Erie in the east. According to early historians, “this division was purely conventional and nominal, as the country was sparsely inhabited … the necessity for minute and accurate boundary lines had not become pressing” (Mulvany et al. 1885:13).
Further change came in December 1791, when the Parliament of Great Britain’s Constitutional Act created the Provinces of Upper Canada and Lower Canada from the former Province of Quebec. Colonel John Graves Simcoe was appointed as Lieutenant-Governor of Upper Canada, and he became responsible for governing the new province, directing its settlement and establishing a constitutional government modelled after that of Britain (Coyne 1895:33).

Simcoe initiated several schemes to populate and protect the newly-created province, employing a settlement strategy that relied on the creation of shoreline communities with effective transportation links between them. These communities, inevitably, would be composed of lands obtained from the First Nations, and many more purchases were subsequently arranged. For example, on December 7, 1792 another ‘Between the Lakes Purchase’ was conducted to enhance Governor Haldimand’s original purchase. In this transaction, the Mississugas received goods worth 1,180.74 Quebec pounds as compensation for approximately 1,215,000 ha (NRC 2010a).

In July 1792, Simcoe divided the province into 19 counties consisting of previously-settled lands, new lands open for settlement and lands not yet acquired by the Crown. These new counties stretched from Essex in the west to Glengarry in the east. Three months later, in October 1792, an Act of Parliament was passed whereby the four districts established by Lord Dorchester were renamed as the Western, Home, Midland and Eastern Districts (Archives of Ontario 2009).

The vicinity of the study area nominally fell within the boundaries of Kent County at this time, which comprised all of the territory of Upper Canada that was not included in the other 18 counties (Archives of Ontario 2009). In essence, Kent was the largest county ever created, stretching from Lake Erie to Hudson’s Bay (McGeorge 1939:36). This arrangement would not last, however, and the ‘northern’ parts of Kent County would soon be sectioned off to form separate counties. This area was populated primarily by the Anishinabeg, and was generally known as the ‘Queen’s Bush’ or the ‘Great Tract of Woodland’.

In 1793, the Lieutenant-Governor issued a patent confirming the Six Nations’ title to the Haldimand Tract, but at the same time he reduced the size of the grant by 111,292 ha (the ‘Source Lands’ of the Grand River), arguing that the Crown could not grant lands that they did not own (Cumming 1972:2). Simcoe further specified that ‘Tract’ land could only be sold to the Crown, as he was concerned that ‘land jobbers’ (speculators) might take advantage of Six Nations (Johnston 1964:xlv–xlvii). Brant was in favour of such sales, and in 1796 he was granted Power of Attorney to surrender “In Trust” four blocks of the Haldimand Tract (Blocks 1–4) in exchange for 999 annual payments for the “perpetual care and maintenance” of Six Nations. On February 5, 1798, Brant exceeded his Power of Attorney and surrendered Blocks 1–6 (142,845 ha) “In Trust” to the Crown (Six Nations Council 2010:Insert 1).

While the eastern part of what would become Waterloo County consisted of Blocks 1–3 of the Haldimand Tract, the western part would be formed from Reserved and Crown Lands acquired by the government in the second ‘Between the Lakes Purchase’. Parts of these lands would become the future Townships of Wellesley and Wilmot, respectively. The Township of Wilmot, for example, was initially a Clergy Reserve: part of the 1/7th of all Crown lands designated for the Protestant clergy under the Constitutional Act of 1791. These lands were originally intended
to be spread evenly throughout Upper Canada, but instead they were typically reserved in large blocks adjacent to the nearest established townships. Eventually a clergy corporation was created to make leases, but few settlers were interested in these comparably expensive lands. After some 60 years of issues and agitation by both clergy and colonists, these reserves were abolished in 1854 (Cumming 1972:2).

1.2.3.2 Waterloo County

Shortly after the creation of Upper Canada, the original arrangement of the province’s districts and counties was deemed inadequate. As population levels increased, smaller administrative bodies became desirable, resulting in the division of the largest units into more ‘manageable’ component parts. The first major changes in the vicinity of the study area took place in 1798, when an Act of Parliament called for the realignment of the Home and Western Districts and the formation of the London and Niagara Districts. Many new counties and townships were subsequently created (Archives of Ontario 2009).

The vicinity of the study area became part of York County’s West Riding in the Home District at this time (Archives of Ontario 2009). D.W. Smyth’s *A Map of the Province of Upper Canada* map (1800) and J. Purdy’s *A Map of Cabotia* (1814) show the layout of the first townships in this area, as well as the various Crown and Reserve Lands discussed above (see Map 13–Map 14).

Eventually, as even smaller units of government became desirable, the Home and Niagara Districts were further divided. In 1816, large parts of York County and Haldimand County were reincorporated as the newly-formed Halton and Wentworth Counties in the Gore District. The vicinity of the study area remained part of York County’s West Riding at this time, as Halton County comprised only the Townships of Beverley, Flamborough West and East, Nelson and Trafalgar, save for numerous Crown Lands, Church Lands and Reserve lands (see Map 15).

By 1817, the Gore District had 6,684 inhabitants (the majority of which were United Empire Loyalists), 18 grist mills and 41 saw mills (Cumming 1971:54). The southern townships of the Gore District were the best settled (Smith 1846:213).

In 1837 and 1838, the layout of what would become southwestern Ontario was significantly altered through the creation of the Huron, Brock, Wellington, Talbot and Simcoe Districts, which resulted in modifications to the layouts of many counties in Upper Canada (Archives of Ontario 2009). The Townships of Wilmot, Puslinch, Guelph, Eramosa, Erin and Garafraxa were transferred to the newly-formed Wellington District at this time, as were the townships of the Haldimand Tract (Waterloo, Woolwich, Pilkington and Nichol). Waterloo County was created at this time from parts of Halton, Huron and Simcoe Counties, and it comprised all of these townships and the future townships of Wellesley and Peel. Waterloo County became part of Canada West in the new United Province of Canada in February 1841, and additional lands to the north and west (e.g., the Townships of Derby, Sydenham, Normanby, Egremont, Mornington and Maryborough) were added in 1845 (Map 17).

Following the abolition of the district system in 1849, the counties of Canada West were reconfigured once again. The boundaries of Waterloo County were largely redefined, as the northern townships were transferred to Grey County and the western townships were added to Perth County. For the remainder of the Euro-Canadian era, Waterloo County would consist of the
historic Townships of Waterloo, Woolwich, Wilmot, Wellesley and North Dumfries (see Map 18).

1.2.3.3 Township of Waterloo

The historic Township of Waterloo (Block 2 of the Haldimand Tract) was bordered on the north by the Township of Woolwich, on the east by the Townships of Guelph and Puslinch, on the south by the Township of Dumfries and on the west by the Township of Wilmot. In addition to being the first inland township settled in Upper Canada, it was also the focal point of settlement in the Waterloo County. As such, the pace of development in the Township of Waterloo far exceeded that of its neighbours, and the area became home to the major centres of Waterloo and Berlin (later Kitchener).

On behalf of Six Nations, Brant arranged for the sale of Block 2 to United Empire Loyalist Richard Beasley and his partners James Wilson and Jean-Baptiste Rousseaux. The transaction was finalized in February 1798. Beasley became solely responsible for the mortgage soon after, and it was quickly realized that full payment to Six Nations was required before any deeds could be given to the grantees. As such, Beasley could not legally subdivide the land until the entire price had been paid, and any purchasers would be encumbered with the mortgage as well. Beasley then tried to clear portions of Block 2 piece-by-piece, dividing the land into Upper, Middle and Lower Blocks. Some portions of the Upper Block were given to his creditors (e.g. J. Horning and J. Wilson), and Beasley began to sell lots in the Lower Block, despite his inability grant clear title (Bloomfield 1995:20).

Jacob Bechtel was one of the first men sent to scout the lands of Block 2 prior to the settlement process. Provided with an Aboriginal guide by Beasley, Bechtel spent several months exploring and documenting the area, and upon his return to Pennsylvania he presented his findings to Sherk and Betzner (Hayes 1997:3). Satisfied with the “soil, surface and timber” of this area, these and other early settlers purchased lands directly from Beasley and relocated their families to York County (Parsell & Co. 1881:6).

Beasley sold nearly 14,200 acres in 1800, to both German Mennonites from Pennsylvania (including farmers, millers and tradesmen) and non-Mennonites. Records indicate that some 25 families arrived in Block 2, and that the first school and grist mill were built around the same time (Sprung 1984:11). Unfortunately, these settlers did not realize that Beasley’s mortgage prevented them from having clear title to their lands, and Brant began complaining that Six Nations had not received funds for the settled lands. Settlement in the Township of Waterloo virtually halted in 1803 and 1804 due to these troubles (Bloomfield 1995:21).

Beasley and Brant realized that the only solution would be a bulk sale to a group of Pennsylvania Mennonites (Bloomfield 1995:22). One major player in this endeavour was Samuel Bricker, who convinced members of his community to form the ‘German Company’ which provided the capital needed to allow for the full purchase of the remaining Block 2 lands. Bricker was appointed the agent for the company, and Daniel Erb became his assistant (Janusas 1988a:10). The full balance of the purchase price was finally paid in July 1805 when the German Company purchased 60,000 acres of Block 2 (see Map 19); nearly the entirety of the Upper and Middle
Blocks (Bloomfield 1995:22–25). The land was surveyed by Augustus Jones and divided into 128 large lots of 181 ha (448 acres) and 32 smaller lots (83 acres).

Families who contributed to the purchase (the shareholders) received lots in proportion to the number of shares they held. These people drew lots fairly back in Pennsylvania, with no knowledge of any of the properties, for titles to each piece of land (Sprung 1984:12). Prominent individuals involved in the lot drawing process included Susannah Erb Brubacher, Abraham Erb, Daniel Erb, John Erb, Peter Erb, Jacob Erb, Jacob Wissler, Henry Weber, George Eby, John Eby, Christian Eby, Joseph Eby, John Bricker, Sam Bricker and Christian Schneider. Many of these new landowners subsequently sold parts of their lands to their fellow Mennonites.

The rapid and steady influx of settlers into the area enabled landowners to sell land for a profitable sum. Similarly, the influx of immigrants enabled newly established businesses to flourish. Although it was originally conceived as an act of Christian duty to help fellow Mennonites, the creation of the Germany Company and the land transactions also made its investors quite wealthy. Upon completion of the deed between Beasley and the Germany Company, a renewed vigour set in concerning the settlement of the area, which had been suspended during the previous period of uncertainty. The resulting population growth left an enduring mark on the Township of Waterloo, as many of the local roads were informally laid out by the new arrivals, a problem compounded by the odd shapes of the lots assigned by the German Company (Bloomfield 1995:25).

The Napoleonic Wars and the War of 1812 disrupted this settlement process—up until 1815 Block 2 was almost exclusively inhabited by the original Mennonite settlers (Hayes 1997:8). The eventual cessation of the hostilities brought in an influx of Pennsylvanian Mennonites and other Loyalists from America. Large numbers of Scottish, German and other European immigrants also began to make the Township of Waterloo their home (Bloomfield 1995:45–50). Although the settlers could most likely discern which land had the best soil, these properties were not necessarily settled or cultivated first, as prior to the 1820s problems of accessibility existed (see Map 20). The earliest settlement clusters were located around the forks of the Grand and Speed Rivers in the south, while in the north the majority of settlement was concentrated along the road connecting John Erb’s mills and Abraham Erb’s mills, now the Cities of Cambridge and Waterloo (Bloomfield 1995:61).

The southern part of the Township of Waterloo owes much of its early development to the establishment of new east-west roads in the first quarter of the 19th century. Most prominent in the vicinity of the study area was Bleams Road, built by Philip Bleam in the 1820s to link the western part of the Township of Waterloo and the Township of Wilmot to his businesses at German Mills in the east (Bloomfield 1995:73–76).

Much of the subsequent settlement growth in this area resulted from the construction of the Canada Company’s communication road, which was first surveyed in 1828 and served to link Guelph to Lake Huron and the newly 'opened' lands to the west. This ‘Stage Road' or ‘Huron Road’ passed through the southern part of the Township of Waterloo, and served as a major attractor for settlement.
Several significant settlements developed in the vicinity of the study area, including Williamsburg and New Aberdeen. Williamsburg was located along Bleams Rd about halfway between the Township of Wilmot and German Mills, was first settled in the 1840s. Here sawmills were built by Abraham Clemens in 1844 and William Moyer in 1845 (Janusas 1988a:164). The village itself was formally founded in 1846 by Anton Wilhelm and Philip Fischer, and by 1861 it had a blacksmith, a shoemaker, a turner, two carpenters, two cooperers and two tailors. Williamsburg also had a school house which served the local community from the 1840s onwards (Bloomfield 1995:51, 206).

New Aberdeen was situated southeast of Williamsburg along the Huron Road. Although the area was settled as early as 1824, the village proper was formally laid out by Scottish entrepreneur George Davidson in 1846 (Sutherland 1864:161). Davidson purchased a total of 500 acres for his ‘Village of New Aberdeen’, and he developed a sawmill, a grist mill and a general store in an effort to attract prospective settlers. His efforts worked, particularly after attracting a post office in 1847, and the population of New Aberdeen grew to 120 by 1851 (Bloomfield 1995:89–90, 142). By 1864 the settlement also had a boot and shoe store, a weaver, a cabinet-maker, a wagon-maker and a blacksmith’s shop (Sutherland 1864:161). However, with the coming of the railways in the mid-19th century and the reduction of traffic along the Huron Rd, New Aberdeen began to decline. After decreasing in population considerably in the 1860s, it did not long survive the closing of the local post office in 1877 (Bloomfield 1995:422).

By 1846, the Township of Waterloo had a population of 4,424, with 20 sawmills and 8 grist mills (Smith 1846:205). Euro-Canadian settlers and their offspring established farmsteads across the landscape, the earliest of which were one or two-storey log structures. Prior to 1850, log houses and shanties were exempt from taxes if they only contained a single fireplace; therefore, many homesteads in the Township of Waterloo were built in this style. In 1861, nearly one-third of habitation dwellings were still log cabins. Local materials, such as brick, dolomite stone, white pine and red cedar began to be used in the 1840s, as larger farmhouses became more common (Bloomfield 1995:69–70).

The introduction of the railway systems in the 1850s ushered in a golden era for the Township of Waterloo, and wheat and barley became the main exports (with approximately 60% of cultivated fields growing wheat crops at that time). Between 1854 and 1855, Block 2 experienced exceptional prosperity due to the Crimean War, which raised British demands for Canadian wheat. Production was increased from over ½ million bushels in 1851 to over 1.1 million bushels less than a decade later (Hayes 1997:40). The livestock industry also thrived at this time, and acreage under oats, hay and root crops continued to grow exponentially (Bloomfield 1995:178). In the second half of the 19th century, many farmstead and homesteads became more than just simple one-storey log houses, and large, often two-storey stone houses became commonplace.

1.2.3.4 Study Area

As discussed in Section 1.1, the study area for these assessments falls partly within five historically-surveyed road allowances (Ottawa Street, Bleams Road, Fischer-Hallman Road, Huron Road and Plains Road) and partly within Lots 46, 130, 131, 138–141 and 152–159, German Company Tract; Lot 13, Biehns Tract; Bechtels Tract; and Heistands Tract in the Geographic Township of Waterloo (former Waterloo County). The lots in this area were laid out...
during the initial surveys of the township in the early 19th century, and the vicinity of the study area was very well-settled for the remainder of the Euro-Canadian period.

In an attempt to reconstruct the historic land use of the study area, ARA examined two historical maps that documented past residents, structures (e.g. homes, businesses and public buildings) and features during the mid- and late 19th centuries. These maps, published in G. Tremaine’s *Map of the County of Waterloo, Canada West* (1861) and H. Parsell & Co.’s *Illustrated Historical Atlas of Waterloo County* (1881), were of the most detailed scale available (e.g., 70 chains to 1 inch). Georeferenced views of these historical maps, showing the study area, appear in Map 21–Map 22.

G. Tremaine’s *Map of the County of Waterloo, Canada West* (1861) and H. Parsell & Co.’s *Illustrated Historical Atlas of Waterloo County* (1881) demonstrate that the vicinity of the study area was well-settled in the mid- and late 19th centuries, and numerous Euro-Canadian owners are listed. These maps also provide useful information concerning historically-surveyed roadways, public buildings and prominent natural features in the area. Sutherland’s *County of Waterloo Gazetteer and General Business Directory for 1864* (1864) also provides useful information pertaining to settlement in this area. These data are summarized in Table 1.

<table>
<thead>
<tr>
<th>Lot</th>
<th>Concession</th>
<th>Owner (Source)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>GCT</td>
<td>A. Stoltz (1861)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>46</td>
<td>GCT</td>
<td>Isaac H. Woolner (1881)</td>
<td>One Structure</td>
</tr>
<tr>
<td>130</td>
<td>GCT</td>
<td>J. House (1861), I.H. Woolever (1861)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>131</td>
<td>GCT</td>
<td>Unknown</td>
<td>N/A</td>
</tr>
<tr>
<td>138</td>
<td>GCT</td>
<td>David Bergey (1881)</td>
<td>N/A</td>
</tr>
<tr>
<td>139</td>
<td>GCT</td>
<td>John C. Woods (1881)</td>
<td>One Structure</td>
</tr>
<tr>
<td>140</td>
<td>GCT</td>
<td>George Becker (1864)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>140</td>
<td>GCT</td>
<td>Thomas Wood (1864)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>141</td>
<td>GCT</td>
<td>William Trussler (1864)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>141</td>
<td>GCT</td>
<td>George Becker (1881)</td>
<td>One Structure</td>
</tr>
<tr>
<td>152</td>
<td>GCT</td>
<td>Unknown</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>153</td>
<td>GCT</td>
<td>Unknown</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>154</td>
<td>GCT</td>
<td>Unknown</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>155</td>
<td>GCT</td>
<td>Unknown</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>156</td>
<td>GCT</td>
<td>Leopold Hemhofer (1861)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>157</td>
<td>GCT</td>
<td>Wendel Bushart (1861, 1864)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>158</td>
<td>GCT</td>
<td>Thomas Scott (1861)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>159</td>
<td>GCT</td>
<td>John Linton (1861)</td>
<td>No Structures on the Property</td>
</tr>
<tr>
<td>13</td>
<td>Biehn’s Tract</td>
<td>William Linton, David Guyer (1861)</td>
<td>No Structures on Property</td>
</tr>
<tr>
<td>110</td>
<td>Bechtel Tract</td>
<td>C.K. Hagedorn (1881)</td>
<td>One Structure on the Property</td>
</tr>
<tr>
<td>–</td>
<td>Hiestand Tract</td>
<td>A.S. Clemens (1881)</td>
<td>Two Structures on the Property</td>
</tr>
</tbody>
</table>
1.2.4 Summary of Past and Present Land Use

During Pre-Contact and Early Contact times, the vicinity of the study area would have comprised a mixture of deciduous trees, coniferous trees and open areas. It seems clear that the First Nations managed the landscape to some degree, but the extent of such management is unknown. During the early 19th century, Euro-Canadian settlers arrived in the area and began to clear the forests for agricultural purposes. Over the course of the Euro-Canadian era, this locality would have comprised primarily agricultural lands surrounding the historic communities of Williamsburg and New Aberdeen. Presently, the study area consists of portions of the Ottawa Street South ROW, the existing Hydro corridor, the Bleams Road ROW, the Fischer-Hallman ROW, the Plains Road ROW, and numerous previously assessed lands.

1.2.5 Additional Background Information

In the course of the previous archaeological assessments conducted for the project and other projects in the area, additional research concerning the settlement history and land use of the study area was carried out. In accordance with the requirements set out in Section 7.5.7 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:125), the title, author and PIF number(s) of the related works appear below:


• Title: Archaeological Assessment (Stages 1, 2, & 3), Becker Estates, Part of Lots 159 & 160, German Company Tract Small Lots, Geographic Township of Waterloo, now City of Kitchener; Regional Municipality of Waterloo, Ontario. Final Report (October 2007). Author: Archaeologix Inc. PIF #P084-(redacted)-2006 and P084-(redacted)-2006. (Archeologix 2007).


• Title: Stage 1 Archaeological Assessment, Kitchener Zone 4 Trunk Watermain, From Ottawa Street South to Strasburg Road, City of Kitchener, Regional Municipality of Waterloo, Ontario. Author: Archaeological Research Associates Ltd. PIF #P007-339-2011 (ARA 2011c).

The additional information included in these reports was considered during the formulation of fieldwork strategies and recommendations pertaining to archaeological concerns within the study area (see Section 2.0).

1.3 Archaeological Context

1.3.1 Previous Archaeological Work

In accordance with the requirements set out in Section 7.5.8 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:125), ARA submitted an inquiry to the MTCS in order to determine whether any archaeological assessments had been previously conducted within the limits of, or immediately adjacent to the study area. In a response provided by the Archaeology Data Coordinator, ARA learned that there are 10 reports on record documenting past work within 50 m of the subject lands (MTCS 2012). What follows is a summary of the previous archaeological work conducted for these projects, in fulfillment of the requirements set out in Section 7.5.8 Standards 4–5 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:125–126). Any relevant detailed site location information appears in the Supplementary Documentation report (see SD Map 1).
1.3.1.1 Subdivision on Parts of Biehn’s Tract and Parts of Registered Plan 640

The first assessment in the vicinity of the proposed alignment for the New Kitchener Zone 4 Trunk Watermain was the archaeological resource assessment of lands for the proposed subdivision on Part of Lots 10–13, Biehn’s Tract, Lot 23, 24, Lots 173–180 and Part of Lots 20–21, Registered Plan 640, City of Kitchener, Regional Municipality of Waterloo. This assessment was conducted by ASI in the summer of 1987 (ASI 1989), and covered an area of approximately 74 ha located southeast of the intersection of Plains Road and Huron Road. This survey involved intensive test pitting at intervals of 5 to 10 m on the majority of the property under licence #87-16, with greatly reduced intervals in the vicinity of Huron Road (ASI 1989:8).

Two significant archaeological sites fell within ASI’s study area, including the historic Village of New Aberdeen and the Late Woodland period Van Ordt Cemetery (neither of which have the potential to be impacted by the project). Aside from additional materials associated with the Village of New Aberdeen, this survey did not result in the discovery of any new archaeological sites. ASI accordingly recommended that parts of the New Aberdeen site be stripped by Gradall and monitored by an archaeologist, and that the Van Ordt Cemetery be surrounded by protective fencing (ASI 1989:23–24). The remainder of the property was cleared of further archaeological concerns.

1.3.1.2 Subdivision 30T-84004, 30T-89020 and 30T-90024

The second archaeological assessment in the area was the archaeological resource assessment survey for the proposed subdivision represented by Draft Plans 30T-84008, 30T-89020 and 30T-90024. This assessment was conducted by MPA in July 1989 and May 1990 (MPA 1990), and encompassed a large parcel of land east of Fischer-Hallman Road and north of Huron Road. A total area of 114 ha was pedestrian surveyed and test pitted under CIF# 89-021, 89-049 and 89-064 (MPA 1990:iv).

This assessment identified a total of 18 findspots, and MPA also attempted to relocate AiHc-23 (a site previously identified by the London Museum of Archaeology but never formally reported on), but met with no success (MPA 1990:8). Of the 18 findspots identified by MPA, five were recommended for further work and 3 were recommended to be subjected to an intensive surface collection to determine if further work is necessary (MPA 1990:8). None of these sites have the potential to be impacted by the project.

1.3.1.3 Gehl Place and Bleams Road

The third investigation to involve parts of the current study area was the archaeological assessment of the proposed gravel pit (90/4/G/JW) at Gehl Place and Bleams Road, conducted by ASI in May 1990, May 1991 and November 1991 (ASI 1992). This assessment was concerned with a large parcel of land approximately 43 ha in size, 3 ha of which (a woodlot) was excluded from the study as it was to be protected from development through special setbacks. The remaining 40 ha were pedestrian surveyed at 5 m intervals under licence #90-021 and 91-15 (ASI 1992:1–3).
ASI identified five findspots within their study area (ASI 1992:3). None of the sites located during the assessment were recommended for further work, and ASI recommended that the property be released from further archaeological concerns (ASI 1992:8).

### 1.3.1.4 Huron West Community

The fourth study in the area was the Stage 1 and 2 archaeological assessments for the Huron West Community development (Draft Plan 30T-01201). This assessment was conducted by ARA in June 2001, and considered an irregularly-shaped parcel of land roughly 92.1 ha in size east of Fischer-Hallman Road, north of Huron Road and southwest of Strasburg Creek (ARA 2001). This survey area partly overlapped with the previous study area for Subdivision 30T-84004, 30T-89020 and 30T90024 (MPA 1990), but also included new lands to the southwest and east. A pedestrian survey was conducted at 5 m intervals under CIF #2001-082-001 (ARA 2001:3).

The assessment identified three concentrations of artifacts within the proposed Huron West Community. All three of these sites had “significant heritage potential”, and were accordingly recommended to be subjected to Stage 3 archaeological assessment (ARA 2001:4). Following additional Stage 3 and 4 work on the three sites (under CIF #2001-12-001 and 2001-082-009), ARA recommended that the archaeological concerns for the proposed Huron West Community be considered addressed (ARA 2002:69).

### 1.3.1.5 Becker Estates

The fifth relevant study was the Stage 1, 2 and 3 assessments of the Becker Estates property (Corporate Project Number 2006-054). This assessment was conducted by Archaeologix Inc. in October 2007, and encompassed a 68.8 ha parcel of land south of Huron Road and east of Fischer-Hallman Road. The study area which was deemed to have archaeological potential and was subjected to pedestrian survey at 5 m intervals (Archaeologix 2007:3).

During the Stage 2 assessment, five Pre-Contact archaeological sites were identified. Locations 2, 3, and 4 only produced a small amount of cultural material and were not found to be of further archaeological significance. Locations 1 (AiHc-363) and 5 (AiHc-364) were found to be discrete artifact clusters and additional Stage 3 testing was recommended (Archaeologix 2007:iv). The Stage 3 assessments of Locations 1 and 5 resulted in very low artifact counts, and the sites were not recommended for further work (Archaeologix 2007:iv).

### 1.3.1.6 Activa Fischer-Hallman

The sixth assessment in the area was the Stage 1 and 2 archaeological assessment for the Activa Fischer–Hallman Property, Part Lot 5, Registrar’s Compiled Plan 1471, Kitchener, Ontario. The study area for this assessment consisted of an irregularly-shaped parcel of land roughly 22.6 ha in size located north of Huron Road, east of Fischer-Hallman Road and southwest of the Huron Natural Area. This study area also overlapped with part of the area surveyed by MPP in 1989 and 1990. This assessment was conducted by ARA in November 2005 and May 2008 under PIF #P007-071-2005 (ARA 2006; 2009). Both the pedestrian survey and test pitting methods were used to complete the assessment.
The assessment identified six findspots within the study area, none of which are located in the vicinity of the project lands. Of these six findspots, only Findspot 1 was recommended for Stage 3 archaeological assessment (ARA 2009:17). Following the additional Stage 3 work at Findspot 1 in April and May 2009 (PIF #P007-185-2008), ARA recommended that it be subject to a Stage 4 archaeological assessment and that the remainder of the study area be cleared of further archaeological concerns (ARA 2009:25). To date, ARA has not conducted the Stage 4 assessment, but the remainder of the study area has been cleared of archaeological concerns.

1.3.1.7 Bleams Road

The seventh assessment to involve parts of the study area was the Stage 1 and 2 archaeological assessment of lands located at 1531 Bleams Road (Reference Plan 58R-13572). This assessment was conducted by ARA in May 2008 (ARA 2008b), and encompassed a 27 ha parcel of primarily agricultural land. This area was pedestrian surveyed at 5 m intervals under PIF# P007-157-2008 (ARA 2008b:8–9).

This assessment resulted in the identification of 2 findspots in the southern part of the study area, neither of which is located within the proposed alignment for the New Kitchener Zone 4 Trunk Watermain. Findspot 1 (Bleams 1; AiHd-156) was significant enough to merit a recommendation for Stage 3 archaeological assessment. Following a Stage 3 site-specific assessment in June and July 2008 (PIF# P007-172-2008), ARA recommended that Bleams 1 be subjected to Stage 4 mitigation, and that the remainder of the study area be cleared of further archaeological concerns (ARA 2008b:17). The Stage 4 work at Bleams 1 was completed between May and October 2010 (PIF# P007-219-2010), is currently at the MTCS awaiting review (ARA 2011b:51).

1.3.1.8 Williamsburg South

The eighth assessment to occur in the vicinity of the proposed alignment was the Stage 1 and 2 archaeological assessment of the Williamsburg South Property. This assessment was conducted by ARA in June, August, September and October 2008 (ARA 2008a), and encompassed an irregularly-shaped parcel of land roughly 52.6 ha in size located at 1291 Fischer-Hallman Road. The area was pedestrian surveyed under PIF# P007-167-2008 (ARA 2008a:8–10).

A total of 29 findspots were identified over the course of the assessment, 16 of which were recommended for Stage 3 archaeological assessment. The other findspots and the remainder of the property were recommended to be released from further archaeological concerns (ARA 2008a:22–23). None of these sites have the potential to be impacted by the project (see SD Map 1).

1.3.1.9 Weiss Lands

The ninth archaeological investigation in the vicinity of the project lands was the Stage 1 and 2 archaeological assessment of the Weiss Lands Property (Reference Plan #58R-3628). This assessment was conducted by ARA in August 2005 and April 2011 under PIF #P007-059-2005 and P007-307-2011 (ARA 2006; 2011a). The study area comprised a 4.2 ha parcel of land north of Bleams Road and west of the Laurentian Forest Community. This parcel was subjected to both pedestrian survey and test pit survey (ARA 2006:6; 2011a:24–25).
The assessment of the Weiss Lands Property did not result in the discovery of any archaeological materials. Accordingly, ARA recommended that the property be cleared of archaeological concerns (ARA 2006:7; ARA 2011a:41).

1.3.1.10 Kitchener Watermain – Stage 1

A large portion of the project area for the New Kitchener Zone 4 Trunk Watermain was previously subjected to Stage 1 assessment in September 2011 under licence #P007, PIF #P007-339-2011 (ARA 2011c). This assessment encompassed an earlier alignment measuring approximately 50 m wide and 5.5 km long corridor in the southwestern part of the City of Kitchener. The proposed alignment ran along the existing Hydro One corridor between Ottawa Street South and Strasburg Road, and crossed private and public land. Numerous areas of disturbance were identified in the course of the assessment, including residential developments, paved parking lots, Hydro tower pads, grading below topsoil, major landscaping, trails and paths, paved walkways, infrastructural development (roadways, construction easements and sewers), and an artificially built up area for a Power Station (ARA 2011c:32).

The Stage 1 assessment indicated that only limited parts of the study area that had not been previously cleared of archaeological concerns had potential for Pre-Contact and Euro-Canadian archaeological materials. Based on these findings, ARA recommended that all lands with archaeological potential within the proposed alignment for the Kitchener Zone 4 Trunk Watermain that had not been cleared of such concerns be subjected to a Stage 2 archaeological assessment in advance of construction. Furthermore, ARA recommended that all project lands with no archaeological potential be released from further archaeological concerns. All previously assessed portions within these limits had already been cleared of further archaeological concerns, and accordingly were not recommended for further assessment (ARA 2011c:32–33).

The areas of no archaeological potential identified under PIF #P007-339-2011 are reproduced in the present study (see Section 3.1), in accordance with the requirements set out in Section 7.8.1 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:135).

1.3.2 Summary of Registered Archaeological Sites

An archival search was conducted using the MTCS’s Ontario Archaeological Sites Database in order to determine the presence of any registered archaeological resources which might be located within a 1 km radius of the study area (MTCS 2012). The results of this search, coupled with the results of past assessments carried out in the vicinity of the study area (see Section 1.3.1), indicate that there are 119 sites were identified within these limits. The excavation results from these sites are summarized in Table 2.
### Table 2: Registered Archaeological Sites within 1 km of the Study Area

<table>
<thead>
<tr>
<th>Borden No.</th>
<th>Site Name</th>
<th>Year Assessed</th>
<th>Cultural Affiliation</th>
<th>Site Type/Feature/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>AiHe-2</td>
<td>Moyer</td>
<td>1962, 1973</td>
<td>Late Woodland – Neutral; Iroquoian; Middleport</td>
<td>Village - observed</td>
</tr>
<tr>
<td>AiHe-14</td>
<td>New Aberdeen</td>
<td>1974-2006</td>
<td>Euro-Canadian</td>
<td>Village - Midden, historic well, cellar, building foundations, 2156 artifacts in a 140 x 125 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-20</td>
<td>Van Ordt-Durrstein</td>
<td>1980</td>
<td>Late Woodland - Middleport; Neutral; Iroquoian</td>
<td>Village; Cemetery; Burial - 14 lithic artifacts</td>
</tr>
<tr>
<td>AiHe-22</td>
<td>N/A</td>
<td>1982</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 chert flake</td>
</tr>
<tr>
<td>AiHe-23</td>
<td>N/A</td>
<td>1982</td>
<td>Undetermined Pre-Contact</td>
<td>Campsite - 2 chert flakes and 1 bone</td>
</tr>
<tr>
<td>AiHe-32</td>
<td>Huron Business Park 1</td>
<td>1986</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot – 2 Onondaga chert flakes 15 m apart, no further work recommended</td>
</tr>
<tr>
<td>AiHe-33</td>
<td>Huron Business Park 2</td>
<td>1986</td>
<td>Early Archaic</td>
<td>Findspot – projectile point and core fragment found 10 m apart, no further work recommended</td>
</tr>
<tr>
<td>AiHe-34</td>
<td>Huron Business Park 3</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot – 1 chert flake, no further work recommended</td>
</tr>
<tr>
<td>AiHe-35</td>
<td>Huron Business Park 4</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot – one utilized flake, no further work recommended</td>
</tr>
<tr>
<td>AiHe-36</td>
<td>Steckle</td>
<td>1986</td>
<td>Undetermined</td>
<td>Campsite – 69 artifacts discovered during pedestrian survey; 309 artifact found during further work</td>
</tr>
<tr>
<td>AiHe-37</td>
<td>Huron Business Park 6</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot – 1 piece of Onondaga chert, no further work recommended</td>
</tr>
<tr>
<td>AiHe-38</td>
<td>Huron Business Park 7</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot – 1 piece of Onondaga chert, no further work recommended</td>
</tr>
<tr>
<td>AiHe-39</td>
<td>Huron Business Park 8</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot; No further work recommended</td>
</tr>
<tr>
<td>AiHe-40</td>
<td>Huron Business Park 9</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot - 1 chipping detritus; No further work recommended</td>
</tr>
<tr>
<td>AiHe-41</td>
<td>Huron Business Park 10</td>
<td>1986</td>
<td>Undetermined</td>
<td>Campsite; deer yard? – 6 artifacts identified, no further work recommended</td>
</tr>
<tr>
<td>AiHe-42</td>
<td>Huron Business Park 11</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot - Utilized flake of Onondaga chert; No further work recommended</td>
</tr>
<tr>
<td>AiHe-43</td>
<td>N/A</td>
<td>1986</td>
<td>Late Archaic</td>
<td>Findspot - 1 Brewerton projectile point; no further work recommended</td>
</tr>
<tr>
<td>AiHe-44</td>
<td>N/A</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot - Small knife with excursive edges and a broken base</td>
</tr>
<tr>
<td>AiHe-45</td>
<td>N/A</td>
<td>1986</td>
<td>Archaic</td>
<td>Findspot - 2 lithic artifact, thermally altered</td>
</tr>
<tr>
<td>AiHe-46</td>
<td>N/A</td>
<td>1986</td>
<td>Archaic</td>
<td>Findspot - 3 lithic artifacts; Possibly associated with AiHe-47</td>
</tr>
<tr>
<td>AiHe-47</td>
<td>MacIntosh</td>
<td>1986</td>
<td>Late Archaic</td>
<td>Findspot - 30 flakes in a 400 m² area</td>
</tr>
<tr>
<td>AiHe-48</td>
<td>Glencalvair 1</td>
<td>1986</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot – 3 artifacts of Onondaga chert clustered within 5 m, no further work recommended</td>
</tr>
<tr>
<td>AiHe-49</td>
<td>Glencalvair 2</td>
<td>1986</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot – 1 Onondaga chert flake, no further work recommended</td>
</tr>
<tr>
<td>AiHe-50</td>
<td>Glencalvair 3</td>
<td>1986</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot – 3 Onondaga chert flakes within 5 m square, no further work recommended</td>
</tr>
<tr>
<td>AiHe-55</td>
<td>Williamsburg 1</td>
<td>1986/1989</td>
<td>Late Euro-Canadian</td>
<td>House - 125 artifacts found within a 20 x 20 m area; No further work recommended</td>
</tr>
<tr>
<td>Borden No.</td>
<td>Site Name</td>
<td>Year Assessed</td>
<td>Cultural Affiliation</td>
<td>Site Type/Feature/Comments</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------------</td>
<td>---------------</td>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>AiHe-56</td>
<td>Williamsburg 2</td>
<td>1986/1989</td>
<td>Late Euro-Canadian</td>
<td>Unknown site type - 75 artifacts; No longer exists due to grading</td>
</tr>
<tr>
<td>AiHe-57</td>
<td>Off Corridor</td>
<td>1986</td>
<td>Undetermined</td>
<td>Findspot - 1 Onondaga chert flake; No further work recommended</td>
</tr>
<tr>
<td>AiHe-64</td>
<td>Breslau Farms</td>
<td>1987</td>
<td>Undetermined</td>
<td>Findspot - 3 lithic artifacts; No further work recommended</td>
</tr>
<tr>
<td>AiHe-65</td>
<td>Carynadle</td>
<td>1987</td>
<td>Historic</td>
<td>Homestead - 21 artifacts from a 2 km² area; Site to be destroyed by development</td>
</tr>
<tr>
<td>AiHe-71</td>
<td>Aberdeen 1</td>
<td>1987</td>
<td>Undetermined</td>
<td>Findspot - Fragment of a side-notched projectile point; No further work recommended</td>
</tr>
<tr>
<td>AiHe-85</td>
<td>Huron Business Park 1</td>
<td>1989</td>
<td>Undetermined</td>
<td>Findspot - Onondaga chert biface</td>
</tr>
<tr>
<td>AiHe-86</td>
<td>Huron Business Park 2</td>
<td>1989</td>
<td>Early Archaic</td>
<td>Findspot - Onondaga biface</td>
</tr>
<tr>
<td>AiHe-87</td>
<td>Huron Business Park 3</td>
<td>1989</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 10 chert flakes, biface fragment; No further work recommended</td>
</tr>
<tr>
<td>AiHe-88</td>
<td>Huron Business Park 4</td>
<td>1989</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 triangular biface</td>
</tr>
<tr>
<td>AiHe-89</td>
<td>George Israel</td>
<td>1989</td>
<td>Euro-Canadian</td>
<td>Homestead – extant house remains, historic bottle, window glass and cut nails</td>
</tr>
<tr>
<td>AiHe-90</td>
<td>Breslau Farms III</td>
<td>1989</td>
<td>Archaic</td>
<td>Findspot - 1 corner-notched projectile point</td>
</tr>
<tr>
<td>AiHe-91</td>
<td>Breslau Farms IV</td>
<td>1989</td>
<td>Undetermined</td>
<td>Findspot – Onondaga chert biface</td>
</tr>
<tr>
<td>AiHe-92</td>
<td>Bleams Road - Corduroy Road</td>
<td>1989</td>
<td>Euro-Canadian</td>
<td>Corduroy Road - Pipe stems, ceramic sherds, 13 logs exposed; Road destroyed by development</td>
</tr>
<tr>
<td>AiHe-104</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 1 lithic; No further work recommended</td>
</tr>
<tr>
<td>AiHe-105</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 5 lithics in a 5 x 15 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-106</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 5 lithics in a 5 x 15 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-107</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 8 lithics in a 5 x 5 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-108</td>
<td>N/A</td>
<td>1990</td>
<td>Early Woodland; Meadowood</td>
<td>Campsite - 26 lithics in a 20 x 20 m area; no further work recommended</td>
</tr>
<tr>
<td>AiHe-109</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 5 lithics in a 15 x 40 m area; no further work recommended</td>
</tr>
<tr>
<td>AiHe-110</td>
<td>N/A</td>
<td>1989</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 utilized flake; No further work recommended</td>
</tr>
<tr>
<td>AiHe-111</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 single flake; No further work recommended</td>
</tr>
<tr>
<td>AiHe-112</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 11 lithic artifacts in a 30 x 80 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-113</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 4 lithics in a 15 x 15 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHe-114</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 4 pieces of chipping detritus; no further work recommended</td>
</tr>
<tr>
<td>Borden No.</td>
<td>Site Name</td>
<td>Year Assessed</td>
<td>Cultural Affiliation</td>
<td>Site Type/Feature/Comments</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------</td>
<td>---------------</td>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>AiHc-115</td>
<td>N/A</td>
<td>1990</td>
<td>Late Woodland</td>
<td>Undetermined site type - 98 artifacts over three loci in a 20 x 20 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHc-116</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 52 artifacts in a 25 x 40 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHc-117</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 15 artifacts; No further work recommended</td>
</tr>
<tr>
<td>AiHc-118</td>
<td>N/A</td>
<td>1990</td>
<td>Euro-Canadian</td>
<td>House - 4 piece of mortar, 1 bottle glass, 1 white earthenware ceramic; No further work recommended</td>
</tr>
<tr>
<td>AiHc-119</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 flake; No further work recommended</td>
</tr>
<tr>
<td>AiHc-120</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 3 flakes; No further work recommended</td>
</tr>
<tr>
<td>AiHc-121</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 flake; No further work recommended</td>
</tr>
<tr>
<td>AiHc-122</td>
<td>N/A</td>
<td>1990</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 4 lithics in a 5 x 5 m area; Land to be developed</td>
</tr>
<tr>
<td>AiHc-163</td>
<td>Lujan</td>
<td>1990/1991</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 Biface tip; No further work recommended</td>
</tr>
<tr>
<td>AiHc-164</td>
<td>Keyoke</td>
<td>1990/1991</td>
<td>Undetermined Pre-Contact</td>
<td>Lithic Scatter - 4 flakes in a 15 m² area; No further work recommended</td>
</tr>
<tr>
<td>AiHc-223</td>
<td>Norris-Sternberg</td>
<td>1998</td>
<td>Archaic</td>
<td>Hunting Camp; Tool Maintenance Station - 4 loci totalling 54 artifacts; No further work recommended</td>
</tr>
<tr>
<td>AiHc-255</td>
<td>Strasburg reek</td>
<td>2001</td>
<td>Woodland; Neutral</td>
<td>Village - 10 longhouses and many artifacts; Possibly related to AiHc-256 and AiHc-257</td>
</tr>
<tr>
<td>AiHc-256</td>
<td>Fischer-Hallman</td>
<td>2001</td>
<td>Undetermined Pre-Contact</td>
<td>Longhouse - 60 m long, 7.5 m wide, 13 features, 442 artifacts; Possibly related to AiHc-255 and AiHc-257</td>
</tr>
<tr>
<td>AiHc-257</td>
<td>Cornfield</td>
<td>2001</td>
<td>Undetermined Pre-Contact</td>
<td>Longhouse - 86 m long, 7.5 m wide, 35 features, 999 artifacts; Possibly related to AiHc-255 and AiHc-256</td>
</tr>
<tr>
<td>AiHc-358</td>
<td>Borsh</td>
<td>2007</td>
<td>Mid-19th Century</td>
<td>Homestead – 143 artifacts found within a 94 x 58 m area, avoidance or further work is recommended</td>
</tr>
<tr>
<td>AiHc-359</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - Projectile Point Mid-Section; No further work recommended</td>
</tr>
<tr>
<td>AiHc-360</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot – 1 secondary flake and a side-notched projectile point fragment 27 m apart from each other within the Borsh site (AiHc-358), no further work recommended</td>
</tr>
<tr>
<td>AiHc-361</td>
<td>*</td>
<td>2007</td>
<td>Late Archaic</td>
<td>Lithic Scatter – 14 artifacts found within a 25 m diameter, further work recommended</td>
</tr>
<tr>
<td>AiHc-362</td>
<td>Hewitt Farm Dump Site</td>
<td>2007</td>
<td>Early 20th Century</td>
<td>Dump - 9 artifacts found within a 4 x 3 m area; no further work recommended</td>
</tr>
<tr>
<td>AiHc-363</td>
<td>Becker Estates Location 1</td>
<td>2006</td>
<td>Undetermined</td>
<td>Camp - 13 artifacts in a 10 x 10 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHc-364</td>
<td>Becker Estates Location 5</td>
<td>2006</td>
<td>Undetermined Pre-Contact</td>
<td>Camp; Lithic scatter - 9 artifacts; No further work recommended</td>
</tr>
<tr>
<td>AiHc-368</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Lithic scatter - Avoidance or further work is recommended</td>
</tr>
<tr>
<td>AiHc-369</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 biface fragment; No further work recommended</td>
</tr>
<tr>
<td>Borden No.</td>
<td>Site Name</td>
<td>Year Assessed</td>
<td>Cultural Affiliation</td>
<td>Site Type/Feature/Comments</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------</td>
<td>---------------</td>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>AiHc-370</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Lithic scatter - 2 lithic artifacts 1 m apart; Avoidance or further work is recommended</td>
</tr>
<tr>
<td>AiHc-389</td>
<td>*</td>
<td>2006</td>
<td>Late Woodland</td>
<td>Campsite - 36 artifacts, including a ceramic sherd and a dog tooth, found in 10 positive test pits</td>
</tr>
<tr>
<td>AiHc-393</td>
<td>Wards Pond I</td>
<td>2009</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 4 lithic artifacts from 2 positive test pits; Avoidance or further work is recommended</td>
</tr>
<tr>
<td>AiHc-394</td>
<td>Wards Pond II</td>
<td>2009</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 3 lithic artifacts found in 2 positive test pits; Protection or Avoidance; Further assessment required</td>
</tr>
<tr>
<td>AiHc-413</td>
<td>*</td>
<td>2009</td>
<td>Undetermined</td>
<td>Undetermined site type - 222 artifacts, 61 units contained “post-like” cultural features</td>
</tr>
<tr>
<td>AiHc-414</td>
<td>*</td>
<td>2009</td>
<td>Undetermined</td>
<td>Village/Hamlet - 220 lithic flakes, 3 projectile point tips, 2 biface fragments, 1 end scraper, 1 utilized flake, 1 core fragment</td>
</tr>
<tr>
<td>AiHc-415</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Undetermined site type - 20 lithic flakes, 1 adze, 1 blank, 1 scraper</td>
</tr>
<tr>
<td>AiHc-416</td>
<td>*</td>
<td>2008</td>
<td>Late Woodland</td>
<td>Village/Hamlet - 5 lithic flakes, 1 ceramic body sherd</td>
</tr>
<tr>
<td>AiHc-417</td>
<td>*</td>
<td>2008</td>
<td>Archaic</td>
<td>Undetermined site type - 2 lithic flakes, 1 gorget fragment, 1 slate flake, 1 end scraper, 1 utilized flake</td>
</tr>
<tr>
<td>AiHc-418</td>
<td>*</td>
<td>2008</td>
<td>20th Century</td>
<td>Midden - 49 artifacts, ceramics, bottle glass, container glass, plastic, modern metal</td>
</tr>
<tr>
<td>AiHc-419</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Undetermined site type - 6 lithic flakes in a 18 x 11 m area</td>
</tr>
<tr>
<td>AiHc-420</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Undetermined site type - 7 lithic flakes, 1 thumbnail scraper, 2 utilized primary flakes</td>
</tr>
<tr>
<td>AiHc-422</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Chipping Station - 5 lithics</td>
</tr>
<tr>
<td>AiHc-423</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Chipping Station - 9 lithics</td>
</tr>
<tr>
<td>AiHc-424</td>
<td>*</td>
<td>2008</td>
<td>Late Woodland</td>
<td>Village - 45 lithic flakes, 2 projectile points, 1 scraper, 3 utilized flakes, 2 ceramic body sherds</td>
</tr>
<tr>
<td>AiHc-425</td>
<td>*</td>
<td>2008</td>
<td>Mid- to Late-20th Century</td>
<td>Log Cabin; Midden - 1 Upper Canada Coin, ceramics, bottle glass, window glass, pipe bowl</td>
</tr>
<tr>
<td>AiHc-426</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Chipping Station - 28 lithic artifacts</td>
</tr>
<tr>
<td>AiHc-427</td>
<td>*</td>
<td>2008</td>
<td>Late Woodland</td>
<td>Village/Hamlet - 50+ lithic artifacts, 1 slate tool, 3 ceramic body sherds</td>
</tr>
<tr>
<td>AiHc-428</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Chipping Station - 15 lithic flakes, 1 scraper, 1 utilized flake</td>
</tr>
<tr>
<td>AiHc-429</td>
<td>*</td>
<td>2008</td>
<td>Undetermined</td>
<td>Chipping Station - 50+ lithic flakes, 1 quartzite flake, 1 utilized flake, 1 core fragment</td>
</tr>
<tr>
<td>AiHc-430</td>
<td>*</td>
<td>2008</td>
<td>Euro-Canadian</td>
<td>Farmstead - 27 artifacts and concrete foundations 8 x 10 m in size</td>
</tr>
<tr>
<td>AiHd-8</td>
<td>Suraras Springs Village</td>
<td>N/A</td>
<td>Woodland; Iroquoian; Middleport</td>
<td>Village/burial</td>
</tr>
<tr>
<td>AiHd-15</td>
<td>Mannheim</td>
<td>1974</td>
<td>Late Woodland</td>
<td>Village - observed</td>
</tr>
<tr>
<td>Borden No.</td>
<td>Site Name</td>
<td>Year Assessed</td>
<td>Cultural Affiliation</td>
<td>Site Type/Feature/Comments</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>---------------</td>
<td>----------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>AiHd-26</td>
<td>Code</td>
<td>1985</td>
<td>Archaic</td>
<td>Chipping Station - Biface base and 11 pieces of debitage in a 100 m² area; no further work recommended</td>
</tr>
<tr>
<td>AiHd-52</td>
<td>N/A</td>
<td>1987</td>
<td>Early Woodland</td>
<td>Findspot - 1 Meadowood projectile point; No further work recommended</td>
</tr>
<tr>
<td>AiHd-53</td>
<td>N/A</td>
<td>1987</td>
<td>Undetermined</td>
<td>Findspot - 1 biface fragment; No further work recommended</td>
</tr>
<tr>
<td>AiHd-54</td>
<td>N/A</td>
<td>1987</td>
<td>Undetermined</td>
<td>Findspot – 1 midsection of a projectile point</td>
</tr>
<tr>
<td>AiHd-55</td>
<td>N/A</td>
<td>1987</td>
<td>Undetermined</td>
<td>Findspot – 4 lithics</td>
</tr>
<tr>
<td>AiHd-56</td>
<td>Haist</td>
<td>1987</td>
<td>Mid-late 19th century</td>
<td>Homestead - 42 artifacts in a 50 x 30 m area</td>
</tr>
<tr>
<td>AiHd-88</td>
<td>Equus</td>
<td>1990</td>
<td>Late Woodland; Iroquoian</td>
<td>Undetermined site type - 2 ceramic sherds found on surface, 21 test units yielded sherds, flakes and a pipe bowl; Site mitigation is complete</td>
</tr>
<tr>
<td>AiHd-92</td>
<td>Gehl</td>
<td>1990/1991</td>
<td>Euro-Canadian</td>
<td>Homestead - 9 historic artifacts, foundations of a drive shed, barn, house, and stone lined well; No further work recommended</td>
</tr>
<tr>
<td>AiHd-93</td>
<td>Tarbox</td>
<td>1990/1991</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 end scraper; no further work recommended</td>
</tr>
<tr>
<td>AiHd-94</td>
<td>Nutria</td>
<td>1990/1991</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - Mid-section of notched or stemmed projectile point; No further work recommended</td>
</tr>
<tr>
<td>AiHd-95</td>
<td>Sacalait</td>
<td>1990/1991</td>
<td>Undetermined Pre-Contact</td>
<td>Lithic scatter - 3 flakes, 1 shatter in a 25 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHd-96</td>
<td>Bruly</td>
<td>1990/1991</td>
<td>Early Archaic</td>
<td>Findspot - Stemmed Bifurcate base projectile point; No further work recommended</td>
</tr>
<tr>
<td>AiHd-97</td>
<td>Detzler</td>
<td>1992</td>
<td>Middle Woodland</td>
<td>Cache? Campsite? – 7 lithic artifacts recovered form a 20 x 20 m area, mitigation recommended</td>
</tr>
<tr>
<td>AiHd-101</td>
<td>N/A</td>
<td>1989/1994</td>
<td>Late Archaic; Small Point</td>
<td>Undetermined site type - 8 lithic artifacts in a 45 x 30 m area; No further work recommended</td>
</tr>
<tr>
<td>AiHd-102</td>
<td>N/A</td>
<td>1994</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 23 lithic artifacts in a 640 m² area; Further work recommended</td>
</tr>
<tr>
<td>AiHd-103</td>
<td>N/A</td>
<td>1994</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 50 lithic artifacts in a 32 x 42 m area; Further work recommended</td>
</tr>
<tr>
<td>AiHd-104</td>
<td>N/A</td>
<td>1994</td>
<td>Middle Archaic</td>
<td>Findspot – 1 Brewerton side-notched projectile point, thermally altered; No further work recommended</td>
</tr>
<tr>
<td>AiHd-106</td>
<td>N/A</td>
<td>1994</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 3 lithic artifacts in 5 m area; Further work recommended</td>
</tr>
<tr>
<td>AiHd-107</td>
<td>N/A</td>
<td>1994</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type - 3 lithic artifacts in 9 m area; Further work recommended</td>
</tr>
<tr>
<td>AiHd-108</td>
<td>N/A</td>
<td>1995</td>
<td>Undetermined Pre-Contact</td>
<td>Campsite - 22 lithics in a 20 m area</td>
</tr>
<tr>
<td>AiHd-131</td>
<td>Higgins 1</td>
<td>2005</td>
<td>Undetermined Pre-Contact</td>
<td>Undetermined site type – 30 lithics in a 20 x 20 m area; 58 artifacts recovered in Stage 3, Stage 4 recommended</td>
</tr>
<tr>
<td>AiHd-150</td>
<td>*</td>
<td>2007</td>
<td>Undetermined Pre-Contact</td>
<td>Findspot - 1 chloride schist adze; No further work recommended</td>
</tr>
<tr>
<td>AiHd-155</td>
<td>*</td>
<td>2008</td>
<td>Early Woodland</td>
<td>Undetermined site type - 1 projectile point and 4 flakes</td>
</tr>
</tbody>
</table>
Only one of these sites falls within the proposed alignment for the New Kitchener Zone 4 Trunk Watermain: AiHd-94 (Nutria). This site was identified during ASI’s assessment of Gehl Place and Bleams Road in 1990 and 1991, and was not recommended for any further work. The abundance of registered sites in the vicinity of the study area demonstrates the desirability of this locality for early settlement and resource exploitation.

1.3.3 Natural Environment

Environmental factors played a substantial role in shaping early land-use and site selection processes, particularly in small Pre-Contact societies with non-complex, subsistence-oriented economies. Euro-Canadian settlers also gravitated towards favourable environments, particularly those with agriculturally-suitable soils and a moderate climate. In order to fully comprehend the archaeological context of the study area, the following five features of the local natural environment must be considered: 1) forests; 2) drainage systems; 3) climatic conditions; 4) physiography; and 5) soil types.

The study area lies within the Great Lakes-St. Lawrence forest, which is a transitional zone between the southern deciduous forest and the northern boreal forest covering approximately 20,000,000 ha. Vegetation here consists of a mixture of coniferous trees and deciduous trees, as well as many species of ferns, fungi, shrubs and mosses. The most prominent conifers are eastern white pine, red pine, eastern hemlock and white cedar, while deciduous trees are best represented by yellow birch, sugar and red maple, basswood and red oak. Other species more commonly occurring in the north are also present, including white and black spruce, jack pine, aspen and white birch (MNR 2013).

Only part of the original forest cover remains standing today, however, as early Euro-Canadian agriculturalists conducted large-scale clearing operations to prepare the land for cultivation. In Pre-Contact times, however, this dense forest would have been particularly bountiful. It is believed that the First Nations of the Great Lakes region exploited close to 500 plant species for food, beverages, food flavourings, medicines, smoking, building materials, fibres, dyes and basketry (Mason 1981:59–60). Furthermore, this diverse vegetation would have served as both home and food for a wide range of game animals, including white tailed deer, turkey, passenger pigeon, cottontail rabbit, elk, muskrat and beaver (Mason 1981:60).

In terms of local drainage systems, the subject lands lies within the Strasburg Creek subwatershed, which comprises part of the Schneider Creek minor basin and the Middle Grand major basin (GRCA 2013). Specifically, the study area is situated 1.2 km southwest of Strasburg Creek, 1.7 km northeast of Abler Creek and 4.4 km west of the Grand River. The corridor passes through the Strasburg Creek Wetland Complex west of Fischer-Hallman Road, and is 9 m south of the Laurentian West Wetland Complex at its northern terminus.
The local climatic region is that of the Huron Slopes, which is characterized by considerable regional variation. For Kitchener-Waterloo specifically, average daily temperatures are -2.4 °C in January and 27.4 °C in July, and the growing season begins on April 14 and ends on November 1 (typically lasting 201 days). The first frosts typically arrive on September 30, and the average frost-free period lasts 135 days per year. The mean annual precipitation for the vicinity of the study area is 851 mm, with 394 mm falling between May and September. On the whole, this climate is well suited for the common grain and forage crops grown during the Euro-Canadian period (Presant and Wicklund 1971:17–19).

Physiographically, the study area lies within the region known as the Waterloo Hills. This area consists mainly of sandy hills made up of ridges of sandy till (unsorted glacial sediment), kames and kame moraines (large deposits of till, sand and gravel left after melting), and outwash sands fill the hollows between the hills (Chapman and Putnam 1984:136). Specifically, the study area sits atop the Waterloo Moraine, which consists of silty to sandy till (Presant and Wicklund 1971:Figure 4). These physiographic elements have accumulated over dolostone, shale, gypsum and salt bedrocks belonging to the Upper Silurian Salina formations (Davidson 1989:42).

The soils within the study area are primarily of Brant-Waterloo association, and consist of moderately coarse- and medium-textured materials. The dominant soil series include Waterloo fine sandy loam (gently sloping with good drainage qualities), Heidelberg fine sandy loam (very gently sloping with imperfect drainage qualities) and Bookton sandy loam (gently sloping with good drainage qualities) (Presant and Wicklund 1971:Soil Map 24).

In summary, the study area possesses a number of environmental characteristics which would have made it attractive to both Pre-Contact and Euro-Canadian populations. The rich Great Lakes-St. Lawrence forest and the nearby water sources would have attracted a wide variety of game animals, and consequently, early hunters. The well-drained areas of Waterloo, Heidelberg and Bookton soils would have been ideal for the maize horticulture of Middle to Late Woodland peoples and the mixed agriculture practiced by later Euro-Canadian populations.

1.3.4 Archaeological Fieldwork and Property Conditions

The Stage 1 and 2 assessments were carried out on May 14–15, 2013 under MTCS licence #P007, PIF #P007-501-2012. These assessments encompassed the entirety of the study area, and involved 1) the on-site documentation of all areas of no archaeological potential, 2) test pit survey in the identified areas of archaeological potential, and 3) test pit survey and visual inspection in all areas where potential disturbances required confirmation. Legal permission to enter and conduct all necessary fieldwork activities on project lands was granted by the property owners.

Key personnel involved during the assessments were P. Racher, Project Director; C.J. Gohm, Deliverables Manager; V. Cafik, Assistant Project Manager; S. Brown, Field Operations Manager; P. Hoskins, Field Director; and 3 additional crewmembers.

As discussed in Section 1.2.4, the study area currently consists of portions of the Ottawa Street South ROW, the existing Hydro corridor, the Bleams Road ROW, the Fischer-Hallman ROW, the Plains Road ROW, and numerous previously assessed lands (agricultural, under development,
etc.). Field conditions were ideal during the assessment, with high ground surface visibility and dry soil for screening. The specific weather and lighting conditions for each day of assessment are summarized in Section 3.1.

No unusual physical features were encountered during the assessments that affected fieldwork strategy decisions or the identification of artifacts or cultural features (e.g., dense root mats, boulders, rubble, etc.).
2.0 STAGE 1 BACKGROUND STUDY

2.1 Summary

The Stage 1 assessment of the study area, conducted under MTCS licence #P007, PIF #P007-501-2012, was accomplished through an examination of the archaeology, history, geography and current land condition of the vicinity of the study area. This background study was carried out using archival sources (e.g. historical publications and records) and current academic and archaeological publications (e.g. archaeological studies and reports). It also included the analysis of modern topographic maps (at a 1:50,000 scale), recent satellite imagery, and historical maps/atlases of the most detailed scale available (e.g., 70 chains to 1 inch).

With occupation beginning in the Palaeo-Indian period approximately 11,000 years ago, the greater vicinity of the study area comprises a complex chronology of Pre-Contact and Euro-Canadian histories (see Section 1.2). Evidence of Archaic period, Woodland period and Early Contact period remains are well-attested in the Regional Municipality of Waterloo, and Euro-Canadian archaeological sites dating to pre-1900 and post-1900 contexts are likewise common. The presence of 119 registered sites within 1 km of the study area demonstrates the desirability of this locality for early settlement and resource exploitation (see Section 1.3.2).

As mentioned in Section 1.3.3, the natural environment of the study area would have been attractive to both Pre-Contact and Euro-Canadian populations as a result of proximity to Strasburg Creek, its tributaries and numerous wetlands. The primarily well-drained soils and diverse vegetation of the greater vicinity of the study area would also have encouraged settlement throughout Ontario’s lengthy history. Euro-Canadian populations would have been particularly drawn to the vicinity of Ottawa Street, Bleams Road, Fischer-Hallman Road, Huron Road and Plains Road, all of which were historically-surveyed thoroughfares (see Section 2.3).

In summary, the Stage 1 background study included an up-to-date listing of sites from the MTCS’s archaeological sites database (in a 1 km radius around the study area), the consideration of previous archaeological field work in the area (in a 50 m radius around the study area), the analysis of topographic maps and historic settlement maps (at the most detailed scale available), and the study of aerial photographs/satellite imagery. In this manner, the standards for background research set out in Section 1.1 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:14–15) were met.

2.2 Field Methods (Property Inspection)

A Stage 1 property inspection was not conducted for this background study. Instead, all on-site documentation was carried out over the course of the Stage 2 property survey, in keeping with Standards 2a–b in Section 2.1 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:28). As mentioned in Section 1.3.4, legal permission to enter and conduct all necessary fieldwork activities on project lands was granted by the property owners. The results of ARA’s archaeological potential modelling are discussed below.
2.3 Analysis and Conclusions

In addition to the relevant historical sources and the results of past excavations and surveys (see Section 1.2–Section 1.3), the archaeological potential of a property can be assessed using its soils, hydrology and landforms as considerations. What follows is an in-depth analysis of the archaeological potential of the study area, which incorporates the results of the on-site documentation conducted in May 2013.

Throughout southern Ontario, scholars have noted a strong association between site locations and waterways. Young, Horne, Varley, Racher and Clish, for example, state that "either the number of streams and/or stream order is always a significant factor in the positive prediction of site presence" (1995:23). They further note that certain types of landforms, such as moraines, seem to have been favoured by different groups throughout prehistory (Young et al. 1995:33). According to Janusas (1988b:1), "the location of early settlements tended to be dominated by the proximity to reliable and potable water resources." Site potential modeling studies (Peters 1986; Pihl 1986) have found that most prehistoric archaeological sites are located within 300 m of either extant water sources or former bodies of water, such as post-glacial lakes.

While many of these studies do not go into detail as to the basis for this pattern, Young, Horne, Varley, Racher and Clish (1995) suggest that the presence of streams would have been a significant attractor for a host of plant, game and fish species, encouraging localized human exploitation and settlement. Additionally, lands in close proximity to streams and other water courses were highly valued for the access they provided to transportation and communication routes. Primary water sources (e.g. lakes, rivers, streams and creeks) and secondary water sources (e.g. intermittent streams and creeks, springs, marshes and swamps) are therefore of pivotal importance for identifying archaeological potential (MTC 2011:17).

Section 1.3.1 of the Standards and Guidelines for Consultant Archaeologists emphasizes the following six features/characteristics as being additional indicators of positive potential for Pre-Contact archaeological materials: 1) features associated with extinct water sources (glacial lake shorelines, relic river channels, shorelines of drained lakes, etc.); 2) the presence of pockets of well-drained soils (for habitation and agriculture); 3) elevated topography (e.g. drumlins, eskers, moraines, knolls, etc.); 4) distinctive landforms that may have been utilized as spiritual sites (waterfalls, rocky outcrops, caverns, promontories, etc.); 5) proximity to valued raw materials (quartz, ochre, copper, chert outcrops, medicinal flora, etc.); and 6) accessibility of plant and animal food sources (spawning areas, migratory routes, prairie lands, etc.) (MTC 2011:17–18).

Conversely, it must be understood that non-habitational sites (e.g. burials, lithic quarries, kill sites, etc.) may be located anywhere. Potential modeling appears to break down when it comes to these idiosyncratic sites, many of which have more significance than their habitational counterparts due to their relative rarity. The Stage 1 archaeological assessment practices outlined in Section 1.4.1 of the Standards and Guidelines for Consultant Archaeologist ensure that these important sites are not missed in Ontario, as no area can be exempted from further archaeological work unless it has been subjected to a Stage 1 property inspection or Stage 2 on-site documentation (MTC 2011:20–21).
With the development of integrated 'complex' economies in the Euro-Canadian era, settlement tended to become less dependent upon local resource procurement/production and more tied to wider economic networks. As such, proximity to transportation routes (roads, canals, etc.) became the most significant predictor of site location, especially for Euro-Canadian populations. In the early Euro-Canadian era (pre-1850), when transport by water was the norm, sites tended to be situated along major rivers and creeks—the 'highways' of their day. With the opening of the interior of the Province of Ontario to settlement after about 1850, sites tended to be more commonly located along historically-surveyed roads. Section 1.3.1 of the Standards and Guidelines for Consultant Archaeologists recognizes trails, passes, roads, railways and portage routes as examples of such early historical transportation routes (MTC 2011:18).

In addition to transportation routes, Section 1.3.1 of the Standards and Guidelines for Consultant Archaeologists emphasizes three other indicators of positive potential for Euro-Canadian archaeological materials: 1) areas of early settlement (military outposts, pioneer homesteads or cabins, early wharfs or dock complexes, pioneer churches, early cemeteries, etc.); 2) properties listed on a municipal register, designated under the Ontario Heritage Act or otherwise categorized as a federal, provincial or municipal historic landmark/site; and 3) properties identified with possible archaeological sites, historical events, activities or occupations, as identified by local histories or informants (MTC 2011:18).

Based on the location, drainage and topography of the subject lands and the application of land-use modelling, it seems clear that the study area, in its pristine state, would have potential for both Pre-Contact and Euro-Canadian archaeological sites. Local indicators of archaeological potential include Strasburg Creek (a primary water source); the Strasburg Creek Wetland Complex and the Laurentian West Wetland Complex (secondary water sources), Ottawa Street, Bleams Road, Fischer-Hallman Road, Huron Road and Plains Road (historically-surveyed roadways); and Williamsburg and New Aberdeen (two areas of early settlement).

Multiple zones of disturbance were identified during the on-site documentation conducted in May 2013, however, indicating that the study area currently comprises a mixture of areas of archeological potential and areas of no archaeological potential. Since these areas of no archaeological potential were identified during the Stage 2 property assessment, they are fully documented in Section 3.1. The remainder of the study area retains its archaeological potential, or otherwise requires test-pitting to confirm disturbance.

### 2.4 Recommendations

The results of the Stage 1 archaeological assessment indicated that the study area, in its pristine state, would have clear potential for Pre-Contact and Euro-Canadian archaeological sites. On-site documentation of current land conditions, however, identified several areas of disturbance. The remainder of the study area either 1) had potential for Pre-Contact and Euro-Canadian archaeological materials or 2) required test-pitting to confirm disturbance. These areas of archaeological potential clearly warranted further assessment.
3.0 STAGE 2 PROPERTY ASSESSMENT

3.1 Field Methods

Given that the areas of archaeological potential within the study area consisted of lands where ploughing was not possible or viable, it was necessary to utilize the test pit survey method to complete the Stage 2 property assessment. Weather and lighting conditions were ideal during the assessment, with cloudy skies, a high of 11 °C and good visibility on May 14; and sunny skies, a high of 23 °C and excellent visibility on May 15, 2013. ARA therefore confirms that fieldwork was carried out under weather and lighting conditions that met the requirements set out in Section 2.1 Standard 3 of the Standards and Guidelines for Consultant Archeologists (MTC 2011:29).

Using the test pit survey method, ARA crewmembers hand-excavated small regular test pits with a minimum diameter of 30 cm at prescribed intervals in all areas of archaeological potential. Section 2.1.2 of the Standards and Guidelines for Consultant Archaeologists stipulates that lands within 300 m of any feature of archaeological potential be examined at a maximum interval of 5 m, and any lands more than 300 m from such features be examined at a maximum interval of 10 m (MTC 2011:31 –32). Given the presence of multiple indicators of archaeological potential in the vicinity of the study area (e.g., water sources and historically-surveyed roadways), a maximum interval of 5 m was adopted for the property assessment (see Image 1).

In accordance with Section 2.1.2 of the Standards and Guidelines for Consultant Archaeologists, each test pit was excavated into the first 5 cm of subsoil (MTC 2011:32). The resultant pits were then examined for stratigraphy, cultural features and/or evidence of fill (see Image 2). The soil from each test pit was screened through 6 mm mesh and examined for archaeological materials (see Image 3). If archaeological materials were encountered over the course of the test pitting survey, each Positive Test Pit would be documented and all artifacts would be collected according to their associated test pit. In accordance with Section 2.1.8 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:38), a combination of property inspection and test pitting was used to confirm the extents of any disturbed areas identified during the test pit survey (see Image 4–Image 11). All test pits were backfilled upon completion, as per the property owners’ instruction (MTC 2011:32).

Artifacts that may indicate the presence of significant cultural deposits include bone, charcoal, lithics (stone tools and refuse generated by their production and use), ceramics, glass and metal. Archaeological features such as pits, foundations and other non-portable remains may also be detected during a Stage 2 property assessment. All archaeological materials with potential CHVI are documented, whether associated with Pre-Contact Aboriginal groups or Post-Contact First Nations, Métis and Euro-Canadian populations. Artifact locations are recorded on topographic maps, in field notes and on a GPS handheld unit. Specifically, ARA utilized a Garmin eTrex Legend, WAAS-enabled, GPS handheld unit capable of +/- 2 m accuracy (using the UTM17 NAD83 coordinate system) during the assessment.

All parts of the study area were assessed according to these methods, save for those with no archaeological potential. Section 2.1 of the Standards and Guidelines for Consultant Archaeologists states that only those areas that have steep slopes greater than 20°, are
permanently wet or consist of exposed bedrock, or have been subjected to deep land alterations that have severely damaged the integrity of archaeological resources can be considered exempt from requiring archaeological assessment (MTC 2011:28). As part of its business practice, ARA makes every effort to survey these areas where feasible.

ARA’s on-site documentation resulted in the identification of numerous disturbed areas over the course of the Stage 2 on-site documentation. Specifically, construction activities associated with the creation of roadways, embankments, drainage ditches and culverts have resulted in the removal of archaeological potential from several of the subject ROWs, and deep land alterations associated with residential development have also resulted in the removal of archaeological potential from parts of the study area (see Image 12–Image 22). These areas were not assessed, as they had no archaeological potential.

The results of the Stage 2 assessment are summarized in Map 23–Map 34 (the areas of no archaeological potential identified during the Stage 1 assessments are also shown on these maps, as are all previously assessed areas of no further concern). In fulfillment of the requirements set out in Section 7.8 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:137), the field methods utilized during the assessment are summarized in Table 3. This summary includes the areas of no archaeological potential identified during the Stage 1 assessments in accordance with Section 7.8.1 Standard 3b (MTC 2011:137).

<table>
<thead>
<tr>
<th>Category</th>
<th>Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property assessed by test pit survey at a maximum interval of 5 m</td>
<td>1.74% (0.24 ha)</td>
</tr>
<tr>
<td>Property assessed by pedestrian survey at a maximum interval of 5 m</td>
<td>0.00% (0.00 ha)</td>
</tr>
<tr>
<td>Property assessed by test pit survey and visual inspection to confirm disturbance</td>
<td>8.60% (1.21 ha)</td>
</tr>
<tr>
<td>Property not assessed because of disturbed areas</td>
<td>49.61% (6.97 ha)</td>
</tr>
<tr>
<td>Property not assessed because of permanently wet areas</td>
<td>0.00% (0.00 ha)</td>
</tr>
<tr>
<td>Property not assessed because of sloped areas</td>
<td>0.00% (0.00 ha)</td>
</tr>
<tr>
<td>Property not assessed because of exposed bedrock</td>
<td>0.00% (0.00 ha)</td>
</tr>
<tr>
<td>Property assessed where standard survey intervals could not be maintained</td>
<td>0.00% (0.00 ha)</td>
</tr>
<tr>
<td>Previously assessed and of no further concern</td>
<td>40.05% (5.62 ha)</td>
</tr>
<tr>
<td>Total</td>
<td>100% (14.44 ha)</td>
</tr>
</tbody>
</table>

In keeping with the requirements set out in Section 2.1 Standard 4 of the Standards and Guidelines for Consultant Archaeologists (MTC 2011:29), GPS coordinates were recorded for fixed reference landmarks (e.g. Ontario Land Surveyor benchmarks, Hydro poles, standard iron bars, etc.) located in the vicinity of the study area. The GPS co-ordinates for four telephone poles appear in Table 4, and detailed maps showing the location of these landmarks appear in Map 23–Map 34.
Table 4: GPS Co-ordinates for the Fixed Reference Landmarks

<table>
<thead>
<tr>
<th>Location</th>
<th>UTM Zone</th>
<th>Easting (m)</th>
<th>Northing (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent Fixed Reference</td>
<td>17</td>
<td>537,971</td>
<td>4,806,092</td>
</tr>
<tr>
<td>(Telephone Pole 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent Fixed Reference</td>
<td>17</td>
<td>539,359</td>
<td>4,805,352</td>
</tr>
<tr>
<td>(Telephone Pole 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent Fixed Reference</td>
<td>17</td>
<td>541,117</td>
<td>4,804,564</td>
</tr>
<tr>
<td>(Telephone Pole 3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent Fixed Reference</td>
<td>17</td>
<td>541,473</td>
<td>4,803,099</td>
</tr>
<tr>
<td>(Telephone Pole 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2 Record of Finds

The assessment, conducted under optimal conditions, did not result in the discovery of any archaeological materials. The inventory of the documentary record for the assessment is summarized in Table 5. This inventory includes a quantitative summary of the field notes, photographs and mapping materials involved in the project, all of which are stored at ARA’s processing facility located at 154 Otonabee Drive, Kitchener, Ontario.

Table 5: Inventory of the Documentary Record

<table>
<thead>
<tr>
<th>Field Documents</th>
<th>Total</th>
<th>Nature</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photographs</td>
<td>116</td>
<td>Digital</td>
<td>On server at 154 Otonabee Drive, Kitchener; Folder P007-501-2012</td>
</tr>
<tr>
<td>Field Notes</td>
<td>2</td>
<td>Digital and hard copy</td>
<td>Filed and on server at 154 Otonabee Drive, Kitchener; P007-501-2012</td>
</tr>
<tr>
<td>Field Maps</td>
<td>11</td>
<td>Digital and hard copy</td>
<td>Filed and on server at 154 Otonabee Drive, Kitchener; P007-501-2012</td>
</tr>
</tbody>
</table>

3.3 Analysis and Conclusions

No archaeological sites were identified within the project lands.

3.4 Recommendations

Judging from the results of the Stage 2 property assessment, the study area appears to be devoid of any significant archaeological remains. Based on these findings, ARA recommends that no further archaeological assessment be required within the project lands.
4.0 SYNTHESIS OF CONCLUSIONS AND RECOMMENDATIONS

The Stage 1 and 2 archaeological assessments were completed in May 2013. The Stage 1 study area consisted of all portions of the project lands that were not previously assessed under PIF #P007-339-2011 (8.88 ha), whereas the Stage 2 study area consisted of the entirety of the project lands (14.04 ha). As mentioned above, large parts of this study area were assessed between 1987 and 2011 and have been cleared of further archaeological concerns.

The results of the Stage 1 assessment indicated that the previously un-assessed portions of the project lands had potential for Pre-Contact and Euro-Canadian archaeological sites. Numerous features of archaeological potential were identified in the immediate vicinity, including historically-surveyed roadways, primary water sources and secondary water sources. Multiple areas of disturbance were also identified. The study area clearly warranted further assessment.

The Stage 2 property assessment encompassed all areas of archaeological potential within the study area. Legal permission to enter and conduct all necessary fieldwork activities on project lands was granted by the property owners. This assessment, completed under optimal conditions, did not result in the discovery of any archaeological materials. Based on these findings, ARA recommends that no further archaeological assessment be required within the project lands. A Letter of Review and Acceptance into the Ontario Public Register of Archaeological Reports is requested, as provided for in Section 65.1 of the Ontario Heritage Act.
5.0 ADVICE ON COMPLIANCE WITH LEGISLATION

Section 7.5.9 of the Standards and Guidelines for Consultant Archaeologists requires that the following information be provided for the benefit of the proponent and approval authority in the land use planning and development process (MTC 2011:126–127):

- This report is submitted to the Minister of Tourism, Culture and Sport as a condition of licensing in accordance with Part VI of the Ontario Heritage Act, R.S.O. 1990, c 0.18. The report is reviewed to ensure that it complies with the standards and guidelines that are issued by the Minister, and that the archaeological fieldwork and report recommendations ensure the conservation, protection and preservation of the cultural heritage of Ontario. When all matters relating to archaeological sites within the project area of a development proposal have been addressed to the satisfaction of the Ministry of Tourism, Culture and Sport, a letter will be issued by the ministry stating that there are no further concerns with regard to alterations to archaeological sites by the proposed development.

- It is an offence under Sections 48 and 69 of the Ontario Heritage Act for any party other than a licensed archaeologist to make any alteration to a known archaeological site or to remove any artifact or other physical evidence of past human use or activity from the site, until such time as a licensed archaeologist has completed archaeological fieldwork on the site, submitted a report to the Minister stating that the site has no further cultural heritage value or interest, and the report has been filed in the Ontario Public Register of Archaeology Reports referred to in Section 65.1 of the Ontario Heritage Act.

- Should previously undocumented archaeological resources be discovered, they may be a new archaeological site and therefore subject to Section 48 (1) of the Ontario Heritage Act. The proponent or person discovering the archaeological resources must cease alteration of the site immediately and engage a licensed consultant archaeologist to carry out archaeological fieldwork, in compliance with Section 48 (1) of the Ontario Heritage Act.

6.0 IMAGES

Image 1: View of Crewmembers Test Pitting at a Maximum Interval of 5 m
(Photo Taken on May 14, 2013; Facing South)

Image 2: View of Typical Test Pit Excavated into Subsoil
(Photo Taken on May 14, 2013)
Image 3: View of Crewmember Screening Soil through 6 mm Mesh  
(Photo Taken on May 14, 2013; Facing North)

Image 4: View of Crewmembers Test Pitting to Confirm Disturbance  
(Photo Taken on May 14, 2013; Facing North)
Image 5: View of Crewmembers Test Pitting to Confirm Disturbance  
(Photo Taken on May 14, 2013; Facing Northwest)

Image 6: View of Crewmembers Test Pitting to Confirm Disturbance  
(Photo Taken on May 14, 2013; Facing Southeast)
Image 7: View of Disturbed Test Pit
(Photo Taken on May 14, 2013)

Image 8: View of Disturbed Test Pit
(Photo Taken on May 14, 2013)
Image 9: View of Disturbed Test Pit
(Photo Taken on May 14, 2013)

Image 10: View of Disturbed Test Pit
(Photo Taken on May 14, 2013)
Image 11: View of Disturbed Test Pit
(Photo Taken on May 14, 2013)

Image 12: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing East)
Image 13: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing Northwest)

Image 14: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing Northwest)
Image 15: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing Northwest)

Image 16: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing Northwest)
Image 17: Area of No Archaeological Potential – Disturbed Lands  
(Photo Taken on May 14, 2013; Facing East)

Image 18: Area of No Archaeological Potential – Disturbed Lands  
(Photo Taken on May 14, 2013; Facing South)
Image 19: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing North)

Image 20: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing North)
Image 21: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 14, 2013; Facing South)

Image 22: Area of No Archaeological Potential – Disturbed Lands
(Photo Taken on May 15, 2013; Facing Northeast)
7.0 MAPS

Map 1: Location of the Study Area in the Province of Ontario
(NRC 2004)
Map 2: Location of the Study Area in the City of Kitchener
(NRC 2010b)
Map 3: Key Map of the Project Lands, Showing the Stage 1 and 2 Assessment Areas and all Previously Assessed Areas

(Google Earth 2013)
Map 4: Middle Woodland Period Complexes
(Wright 1972:Map 4)

Map 5: Princess Point Site Clusters in Southern Ontario
(Warrick 2000:Fig. 3)
Map 6: Pre-Contact Iroquoian Site Clusters
(Warrick 2000:Figure 10)

Map 7: Detail from S. de Champlain’s Carte de la Nouvelle France (1632)
(Gentilcore and Head 1984:Map 1.2)
Map 8: Detail from N. Sanson's *Le Canada, ou Nouvelle France* (1656)
(Gentilcore and Head 1984:Map 1.10)

Map 9: Detail from the Map of Galinée’s Voyage (1670)
(Lajeunesse 1960:Map 2)
Map 10: Detail from H. Popple’s *A Map of the British Empire in America* (1733)
(Cartography Associates 2009)

Map 11: Detail from R. Sayer and J. Bennett’s *General Map of the Middle British Colonies in America* (1776)
(Cartography Associates 2009)
Map 12: The Haldimand Tract (Left) and the Haldimand Proclamation (Right)  
(Six Nations Council 2010:2)

Map 13: Detail from D.W. Smyth’s *A Map of the Province of Upper Canada* (1800) 
(Cartography Associates 2009)
Map 14: Detail from J. Purdy’s *A Map of Cabotia* (1814) (Cartography Associates 2009)

Map 16: Detail from J. Arrowsmith’s *Upper Canada* (1837)
(Cartography Associates 2009)

Map 17: Detail from J. Bouchette’s *Map of the Provinces of Canada* (1846)
(Cartography Associates 2009)
Map 18: Waterloo County from W.J. Gage and Co.’s Gage’s County Atlas (1886)
(W.J. Gage and Co. 1886)
Map 19: Euro-Canadian Land Tracts in Southern Waterloo Township
(Eby et al. 1971:N-5)

Map 20: Waterloo Township in 1818
(Bloomfield 1995:Figure 9)
Map 21: Detail of The Township of Waterloo from G. Tremaine’s *Map of the County of Waterloo, Canada West* (1861). Showing the Study Area
(Eby et al. 1971:M-7)
Map 22: Detail of the Township of Waterloo from H. Parsell & Co.’s Illustrated Historical Atlas of the County of Waterloo (1881), Showing the Study Area (McGill University 2001)
Map 23: Overview of the Study Area, Showing Insets of Assessment Results

(Google Earth 2013)
Map 24: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 25: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 26: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 27: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 28: Assessment Results – Image Locations and Field Methods

(Google Earth 2013)
Map 29: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)

1. Image Location and Direction
2. Fixed Reference Landmark

Study Area

Assessment Results
- Shovel Tested at a Maximum Interval of 5 m
- Shovel Tested, Found to be Disturbed
- Disturbed, No Archaeological Potential
- Disturbed, Identified in Stage 1 (PIF #P007-339-2011)

Properties Cleared through Assessment by:
- Archaeologix Inc. (AL)
- Archaeological Research Associates (ARA)
- Archaeological Services Inc. (ASI)
- Mayer, Poulton and Associates (MPA)
- Reassessed by Archaeological Research Associates (ARA)
Map 30: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 31: Assessment Results – Image Locations and Field Methods  
(Google Earth 2013)
Map 33: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
Map 34: Assessment Results – Image Locations and Field Methods
(Google Earth 2013)
8.0 BIBLIOGRAPHY AND SOURCES

Archaeological Research Associates Ltd. (ARA)
2011c Stage 1 Archaeological Assessment, Kitchener Zone 4 Trunk Watermain, From Ottawa Street South to Strasburg Road, City of Kitchener, Regional Municipality of Waterloo, Ontario. PIF #P007-339-2011. Archaeological Research Associates Ltd.

Archaeological Services Inc. (ASI)
Archaeologix Inc. (AI)
2007 Archaeological Assessment (Stages 1, 2 & 3), Becker Estates, Part of Lots 159 & 160, German Company Tract, Geographic Township of Waterloo, now City of Kitchener, Regional Municipality of Waterloo, Ontario. CIF #P084-redacted-2006 and P084-redacted-2006. Archaeologix Inc.

Archives of Ontario

Bloomfield, E.

Cartography Associates

Chapman, L.J. and D.F. Putnam

Coyne, J. H.
1895 The Country of the Neutrals (As Far as Comprised in the County of Elgin): From Champlain to Talbot. St. Thomas: Times Print.

Cumming, R. (ed.)

Davidson, R.J.

Dodd, Christine F., D.R. Poulton, P.A. Lennox, D.G. Smith and G.A. Warrick

Eby, E.E., J.B. Snyder and E.D. Weber
Ellis, C.J. and Deller, D.B.

Ellis, C.J., I.T. Kenyon, and M.W. Spence

Finlayson, W.D.

Fox, W.

Gentilcore, R.L. and C.G. Head
1984 *Ontario’s History in Maps*. Toronto: University of Toronto Press.

Gervais, G.

Google Earth

Grand River Conservation Authority (GRCA)

Hayes, G.

Hunt, G.T.

Jackson, L. J., C. Ellis, A. V. Morgan and J. H. McAndrews
Janusas, S.


Johnston, C.M.

Karrow, P.F. and B.G. Warner

Lajeunesse, E.J.


Mason, R.J.

Mayer, Poulton and Associates Inc. (MPA)

McGill University

Métis Nation of Ontario (MNO)
Ministry of Culture (MCL)

Ministry of Natural Resources (MNR)

Ministry of Tourism and Culture (MTC)

Ministry of Tourism, Culture and Sport (MTCS)
2012 Inquiry Concerning Sites within a One Kilometre Radius of the Project Area (Ontario Archaeological Sites Database) and Past Archaeological Work within 50 m of the Project Area. Via Email, response provided on November 23, 2012. R. Von Bitter, Archaeology Data Coordinator, Ministry of Tourism, Culture and Sport.

Mississaugas of the New Credit First Nation (MNCFN)

Mulvany, C.P., G.M. Adam and C.B. Robinson
1885 History of Toronto and the County of York, Ontario, Volume 1. Toronto: C. Blackett Robinson.

Natural Resources Canada (NRC)

Parsell, H. & Co.
1881 Illustrated Historical Atlas of the County of Waterloo. H. Parsell & Co.

Peters, J.H.

June 2013
Archaeological Research Associates Ltd.
PIF #P007-501-2012
Pihl, R.H.

Presant, E.W. and R.E. Wicklund

Ramsden, P.G.


Ray, A.J.

Schmalz, P.S.

Six Nations Council

Smith, D.B.
1987  *Sacred Feathers: The Reverend Peter Jones (Kahkewaquonaby) and the Mississauga Indians.* Toronto: University of Toronto Press.

Smith, W.H.
1846  *Smith’s Canadian Gazetteer: Comprising Statistical and General Information Respecting all Parts of the Upper Province, or Canada West.* Toronto: H. & W. Rowsell.

Spence, M.W., R.H. Pihl and C. Murphy

Sprung, D.A.
Sutherland, J.

Tremaines, G.

W.J. Gage and Co.
1886  *Gage’s County Atlas*. Toronto: W.J. Gage and Co.

Warrick, G.

Williamson, R.F.

Williamson, R.F. (ed.)
2008  *Toronto: A Short Illustrated History of its First 12,000 Years*. Toronto: James Lorimer & Company Ltd.

Wright, J.V.

Young, P.M., M.R. Horne, C.D. Varley, P.J. Racher and A.J. Clish
APPENDICES
Appendix A: Project Mapping for the New Kitchener Zone 4 Trunk Watermain
(Provided by GENIVAR Inc.)
DRAFT
Stage 1 and 2 Archaeological Assessments
New Kitchener Zone 4 Trunk Watermain
Class Environmental Assessment
City of Kitchener, Regional Municipality of Waterloo
Multiple Lots and Concessions
Geographic of Township of Waterloo, Former
Waterloo County, Ontario

Prepared for
GENIVAR Inc.
1-367 Woodlawn Road West
Guelph, ON N1H 7K9
Tel: (519) 827-1453 Fax: (519) 827-1483

&
The Ministry of Tourism, Culture and Sport

By
Archaeological Research Associates Ltd.
154 Otonabee Drive
Kitchener, ON N2C 1L7
Tel: (519) 804-2291 Fax: (519) 286-0493

Licenced under
P.J. Racher, M.A., CAHP
MTCS Licence #P007
Project #P007-501
PIF #P007-501-2012

17/06/2013

Original Version
TABLE OF CONTENTS

1.0 SUPPLEMENTARY DOCUMENTATION 1
   1.1 Detailed Site Location Information 1
2.0 MAPS 2
3.0 BIBLIOGRAPHY AND SOURCES 3

LIST OF SD MAPS

SD Map 1: Key Map of the Project Lands, Showing Sites of Further Archaeological Concern 2
1.0 SUPPLEMENTARY DOCUMENTATION

1.1 Detailed Site Location Information

In keeping with Section 7.6.1 of the *Standards and Guidelines for Consultant Archaeologists*, detailed site location information was not included within the project report (MTC 2011:130). The locations of the sites of further archaeological concern discussed in Section 1.3.1 are shown in SD Map 1. These data should be excluded from the Ontario Public Register of Archaeological Reports.
2.0 MAPS

SD Map 1: Key Map of the Project Lands, Showing Sites of Further Archaeological Concern
(Google Earth 2013)
3.0 BIBLIOGRAPHY AND SOURCES

Google Earth
Screening for Impacts to Built Heritage and Cultural Heritage Landscapes

This checklist is intended to help proponents determine whether their project could affect known or potential cultural heritage resources. The completed checklist should be returned to the appropriate Heritage Planner or Heritage Advisor at the Ministry of Tourism and Culture.

### Step 1 – Screening for Recognized Cultural Heritage Value

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Is the subject property designated or adjacent* to a property designated under the *Ontario Heritage Act*?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

2. Is the subject property listed on the municipal heritage register or a provincial register/list? (e.g. Ontario Heritage Bridge List)
   - [ ]
   - [ ]
   - [ ]
   - [ ]

3. Is the subject property within or adjacent to a Heritage Conservation District?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

4. Does the subject property have an Ontario Heritage Trust easement or is it adjacent to such a property?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

5. Is there a provincial or federal plaque on or near the subject property?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

6. Is the subject property a National Historic Site?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

7. Is the subject property recognized or valued by an Aboriginal community?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

### Step 2 – Screening Potential Resources

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Built heritage resources**

1. Does the subject property or an adjacent property contain any buildings or structures **over forty years old** that are:
   - Residential structures (e.g. house, apartment building, shanty or trap line shelter)
   - Farm buildings (e.g. barns, outbuildings, silos, windmills)
   - Industrial, commercial or institutional buildings (e.g. a factory, school, etc.)
   - Engineering works (e.g. bridges, water or communications towers, roads, water/sewer systems, dams, earthworks, etc.)
   - Monuments or Landmark Features (e.g. cairns, statues, obelisks, fountains, reflecting pools, retaining walls, boundary or claim markers, etc.)
   - [ ]
   - [ ]
   - [ ]
   - [ ]

2. Is the subject property or an adjacent property associated with a known architect or builder?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

3. Is the subject property or an adjacent property associated with a person or event of historic interest?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

4. When the municipal heritage planner was contacted regarding potential cultural heritage value of the subject property, did they express interest or concern?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

**Cultural heritage landscapes**

5. Does the subject property contain landscape features such as:
   - Burial sites and/or cemeteries
   - Parks or gardens
   - Quarries, mining, industrial or farming operations
   - Canals
   - Prominent natural features that could have special value to people (such as waterfalls, rocky outcrops, large specimen trees, caves, etc.)
   - Evidence of other human-made alterations to the natural landscape (such as trails, boundary or way-finding markers, mounds, earthworks, cultivation, non-native species, etc.)
   - [ ]
   - [ ]
   - [ ]
   - [ ]

6. Is the subject property within a Canadian Heritage River watershed?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

7. Is the subject property near the Rideau Canal Corridor UNESCO World Heritage Site?
   - [ ]
   - [ ]
   - [ ]
   - [ ]

8. Is there any evidence from documentary sources (e.g., local histories, a local recognition program, research studies, previous heritage impact assessment reports, etc.) or local knowledge or Aboriginal oral history, associating the subject property/area with historic events, activities or persons?
   - [ ]
   - [ ]
   - [ ]
   - [ ]
Note:
If the answer is "yes" to any question in Step 1, proceed to Step 3.

The following resources can assist in answering questions in Step 1:

- Municipal Clerk or Planning Department – Information on properties designated under the Ontario Heritage Act (individual properties or Heritage Conservation Districts) and properties listed on a Municipal Heritage register.
- Ontario Heritage Trust – Contact the OHT directly regarding easement properties. A list of OHT plaques can be found on the website: Ontario Heritage Trust
- Parks Canada – A list of National Historic Sites can be found on the website: Parks Canada
- Ministry of Tourism and Culture – The Ontario Heritage Properties Database includes close to 8000 identified heritage properties. Note while this database is a valuable resource, it has not been updated since 2005, and therefore is not comprehensive or exhaustive. Ontario Heritage Properties Database
- Local or Provincial archives
- Local heritage organizations, such as the municipal heritage committee, historical society, local branch of the Architectural Conservancy of Ontario, etc.

Consideration should also be given to obtaining oral evidence of CHRs. For example, in many Aboriginal communities, an important means of maintaining knowledge of cultural heritage resources is through oral tradition.

If the answer is "yes" to any question in Step 2, an evaluation of cultural heritage value is required. If cultural heritage resources are identified, proceed to Step 3.

If the answer to any question in Step 1 or to questions 2-4, 6-8 in Step 2, is “unknown”, further research is required.

If the answer is "yes" to any of the questions in Step 3, a heritage impact assessment is required.

If uncertainty exists at any point, the services of a qualified person should be retained to assist in completing this checklist. All cultural heritage evaluation reports and heritage impact assessment reports must be prepared by a qualified person. Qualified persons means individuals (professional engineers, architects, archaeologists, etc.) having relevant, recent experience in the identification and conservation of cultural heritage resources. Appropriate evaluation involves gathering and recording information about the property sufficient to understand and substantiate its heritage value; determining cultural heritage value or interest based on the advice of qualified persons and with appropriate community input. If the property meets the criteria in Ontario Regulation 9/06 under the Ontario Heritage Act, it is a cultural heritage resource.

† The 40 year old threshold is an indicator of potential when conducting a preliminary survey for identification of cultural heritage resources. While the presence of a built feature that is 40 or more years old does not automatically signify cultural heritage value, it does make it more likely that the property could have cultural heritage value or interest. Similarly, if all the built features on a property are less than 40 years old, this does not automatically mean the property has no cultural heritage value. Note that age is not a criterion for designation under the Ontario Heritage Act.

### Step 3 – Screening for Potential Impacts

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

* For the purposes of evaluating potential impacts of development and site alteration “adjacent” means: contiguous properties as well as properties that are separated from a heritage property by narrow strip of land used as a public or private road, highway, street, lane, trail, right-of-way, walkway, green space, park, and/or easement or as otherwise defined in the municipal official plan.
James Witherspoon, P.Eng  
GENIVAR Inc.  
1-367 Woodlawn Road West  
Guelph, ON N1H 7K9  
E: Jamie.Witherspoon@genivar.com

RE: Notice of Completion, Kitchener Zone 4 Watermain EA  
Region of Waterloo, Ontario  
MTCS file no. 30EA033

Dear James Witherspoon:

Thank you for providing the Ministry of Tourism, Culture and Sport (MTCS) with the Notice of Completion for your project. For this undertaking, it is the mandate of MTCS, under the Ontario Heritage Act (OHA), to conserve, protect and preserve Ontario’s cultural heritage, including:

- Archaeological resources;
- Built heritage resources, including bridges and monuments; and,
- Cultural heritage landscapes.

Under the EA process, a determination of the project’s potential impact on these cultural heritage resources is required.

Archaeological Resources
A Stage 1-2 archaeological assessment (AA) has been conducted by an OHA licensed archaeologist, the AA report forwarded to MTCS for review, and the report has been entered into the Ontario Public Register of Archaeological Reports.

Built Heritage and Cultural Heritage Landscapes
For future projects, please find attached the MTCS Screening for Impacts to Built Heritage and Cultural Heritage Landscapes checklist, to determine whether they may impact cultural heritage resources: in the case of the Zone 4 trunk water main, the clerks for the Region of Waterloo and City of Kitchener respectively could have provided information on property registered or designated under the Ontario Heritage Act. When an EA project may impact known or potential cultural heritage resources, MTCS recommends that a Heritage Impact Assessment (HIA) be prepared by a qualified consultant. The MTCS Info Sheet #5: Heritage Impact Assessments and Conservation Plans outlines the scope of HIAs. Completed HIAs are sent to MTCS and the local municipality for review, and made available to local heritage organizations with an interest.

Environmental Assessment Reporting
HIA and AA reports and their recommendations are part of the EA project. The Environmental Study Report should document and summarize any determinations that no cultural heritage resources are impacted and no technical studies are warranted as part of the EA process. MTCS is in no way liable if the information in the completed checklists is found to be inaccurate or incomplete.
Thank-you for circulating MTCS on this project: please continue to do so through the EA process, and contact me for any questions or clarification.

Sincerely,

Joseph Muller  
Heritage Planner  
Joseph.Muller@ontario.ca

Copied to: Nathan Morris, Coordinator Water Services, Region of Waterloo

Disclaimer: The Ministry of Tourism, Culture and Sport reserves the right to review projects for their potential to impact archaeological, built heritage and cultural heritage landscape resources, and recommend that archaeological and/or heritage impact assessments be undertaken.

Please notify MTCS if archaeological resources are impacted by EA project work. All activities impacting archaeological resources must cease immediately, and a licensed archaeologist is required to carry out a determination of their nature and significance.

If human remains are encountered, all activities must cease immediately and the local police be contacted as well as the Cemeteries Regulation Unit of the Ministry of Consumer Services must be contacted. In situations where human remains are associated with archaeological resources, MTCS should also be notified to ensure that the site is not subject to unlicensed alterations which would be a contravention of the Ontario Heritage Act.
Appendix G

Transient Analysis
1. Introduction

The report summarizes the result of Transient Analysis of the proposed 750 mm Zone 4 watermain in the Kitchener-Waterloo water network. The proposed pipeline is needed to maintain adequate supply to the Southern end of Kitchener Zone 4 and supply Kitchener Zones 2 West and 2 East and further beyond into Cambridge. The proposed pipe alignment is along the Hydro corridor in a Southeasterly direction from Ottawa Street to Strasburg Road.

2. Transient Analysis

Transient analysis or Surge analysis or Waterhammer analysis all refer to analyzing a system of interest under conditions of rapid changes in pressure and flow. The system of interest can consist of a single pipeline to entire distribution and transmission networks. In water networks, pressure and flow conditions are typically approximated as behaving steady and changing slowly. This approximation is a good simplifying mechanism and allows the analyst to ignore the more complicated calculus. Operators of systems also try to maintain the validity of this approach by making slow changes to pressure and flow in the network. However, there are instances in the operation of the network where it is not possible to make changes slowly. Conditions such as a power failure or a pipe break occur without notice and necessitate the need to analyze such rapid changes in flow and pressure and protect the network.

Given the wide range of situations that can give rise to transient conditions, it is necessary to take a systems approach to the analysis. From the perspective of the system a power failure can approximate the extremes of most transient events that can occur in water networks. It is therefore used as a surrogate event to determine the impact of surge and size protective measures.

The transient initiating events modeled in this analysis consist of a power failure at Mannheim Pumping Station (local power failure) and power failure at all pumping stations and supply points (global power failure) in the Kit4 water network. In order to vary the flow in the proposed pipeline, the analysis was conducted under conditions of peak hour and minimum hour demand. Additionally a secondary emergency scenario consisting of closure of the existing 750 mm from Mannheim Plant was simulated as well.
3. **Hammer**

Hammer is a fully functional transient simulating software supplied by Bentley. The engine of the software was developed by EHG now part of GENIVAR. The software is well known internationally and used by engineers all throughout the world. The hydraulic model for Tri-City water network was developed in Infowater. The model was exported to Hammer to simulate the transient scenarios. Additionally the model was truncated at the boundaries of Kit4 to simplify the analysis. Boundary conditions for the Hammer model were taken from the infowater model. Demands for districts supplied by Kit4 were also included in the model. The scenarios modeled were simulated under 2031 demand conditions.

4. **Modeling Runs**

The scenarios modeled are summarized in Table 1.

**Table 1: Transient scenarios modeled**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Peak Hour – Multiple Supply Points – Global Power Failure</td>
</tr>
<tr>
<td>S2</td>
<td>Peak Hour – Multiple Supply Points – Local Power Failure (Mannheim Plant)</td>
</tr>
<tr>
<td>S3</td>
<td>Peak Hour – Mannheim Supply only – Local Power Failure</td>
</tr>
<tr>
<td>S4</td>
<td>Peak Hour – Mannheim Supply only – Other 750 mm out of service – Local Power Failure</td>
</tr>
<tr>
<td>S5</td>
<td>Peak Hour – Other 750 mm out of service – Multiple Supply Points – Global Power Failure</td>
</tr>
<tr>
<td>S6</td>
<td>Peak Hour – Other 750 mm out of service – Multiple Supply Points – Local Power Failure</td>
</tr>
<tr>
<td>S7</td>
<td>Min Hour – Multiple Supply Points – Global Power Failure</td>
</tr>
<tr>
<td>S8</td>
<td>Min Hour – Multiple Supply Points – Local Power Failure (Mannheim Plant)</td>
</tr>
<tr>
<td>S9</td>
<td>Min Hour – Mannheim Supply only – Local Power Failure</td>
</tr>
<tr>
<td>S10</td>
<td>Min Hour – Mannheim Supply only – Other 750 mm out of service – Local Power Failure</td>
</tr>
<tr>
<td>S11</td>
<td>Min Hour – Other 750 mm out of service – Multiple Supply Points – Global Power Failure</td>
</tr>
<tr>
<td>S12</td>
<td>Min Hour – Other 750 mm out of service – Multiple Supply Points – Local Power Failure</td>
</tr>
</tbody>
</table>

The scenarios cover a range of demand conditions and emergency situations.

5. **Pipe Profile**

The pipe profile is shown in Figure 1. As shown in the figure the pipe profile generally drops lower with distance. It starts at an elevation of approximately 376 m near Ottawa Street and ends at an elevation of 328m near Strasburg Road. A dropping elevation profile is preferred from a transient perspective since most of the pipeline will be under positive pressure even under vacuum conditions in the upper reaches.
6. Modeling Results

The modeling results are shown in Appendix A for both peak hour and min hour scenarios. The results show that there are no significant downsurge or upsurge pressures in the proposed watermain from local or global power failures at the supply pumping stations. The minimum head envelop is higher than the pipe elevation and maintains a positive pressure in the pipeline for most of its distance. The upper parts of line near its supply source momentarily goes into negative pressure during the initial downsurge but quickly returns to positive pressure. Under a power failure event, as power is lost to the pumps, pressure downstream of the pumps will decrease until the HGL drops below the suction HGL and water is pushed into the network by the suction side HGL only. Water will be pushed through the bypass pipe at the station and through the pumps. This is ideal for the pipeline as the HGL on the suction side allows replacement of any mass leaving the end of the pipeline maintaining a positive pressure.

On the upsurge side there are no significant reflection points for the downsurge pressure wave as the pipeline connects into a network. Any pressure wave is dissipated into the network before it is reflected back. In all scenarios the reflection upsurge pressure is lower than the initial steady state pressure for all scenarios modeled.

The rest of the Kit 4 network and particularly the lower areas will experience momentary transient pressures of over a 100 psi. Similarly the higher areas will experience momentary transient pressures of less than 40 psi for short durations.
7. Conclusion and Recommendations

The modeling results show that the proposed 750 mm pipeline will not experience significant transient pressures due mainly to its profile and high suction side HGL. These two factors combine to limit downsurge pressures in the pipeline. The upsurge pressure is also limited due to dissipation of pressure waves into the Kit4 network. Only the upper parts of the pipeline experience momentary negative pressure. It should be noted that the bypass line at the Mannheim plant is essential in protecting the proposed pipeline and must be operational at all times. The air valves will provide some protection particularly in the sections where the pressure dips below atmospheric. However, their use will be mainly for air management in the pipeline and thus operational. It is suggested that 2" combination air valves be used for the size of the pipeline.
Appendix A

Modeling Results
Peak Hour Results
Figure 1: S1 - Maximum and Minimum Head (m) profile

Figure 2: S1 – HGL and Flow along the pipeline
Figure 3: S1 - Maximum Transient Pressure in the Kit4 Network

Figure 4: S1 - Minimum Transient Pressure in the Kit4 Network
Figure 5: S2 – Maximum and Minimum Head (m) profile

Figure 6: S2 – HGL and Flow along the pipeline
Figure 7: S2 – Maximum Transient Pressure in the Kit4 Network

Figure 8: S2 – Minimum Transient Pressure in the Kit4 Network
Figure 9: S3 – Maximum and Minimum Head (m) profile

Figure 10: S3 – HGL and Flow along the pipeline
Figure 11: S3 – Maximum Transient Pressure in the Kit4 Network

Figure 12: S3 – Minimum Transient Pressure in the Kit4 Network
Figure 13: S4 – Maximum and Minimum Head (m) profile

Figure 14: S4 – HGL and Flow along the pipeline
Figure 15: S4 – Maximum Transient Pressure in the Kit4 Network

Figure 16: S4 – Minimum Transient Pressure in the Kit4 Network
Figure 17: S5 – Maximum and Minimum Head (m) profile

Figure 18: S5 – HGL and Flow along the pipeline
Figure 19: S5 – Maximum Transient Pressure in the Kit4 Network

Figure 20: S5 – Minimum Transient Pressure in the Kit4 Network
Figure 21: S6 – Maximum and Minimum Head (m) profile

Figure 22: S6 – HGL and Flow along the pipeline
Figure 23: S6 – Maximum Transient Pressure in the Kit4 Network

Figure 24: S6 - Minimum Transient Pressure in the Kit4 Network
Min Hour Results
Figure 1: S7 - Maximum and Minimum Head (m) profile

Figure 2: S7 – HGL and Flow along the pipeline
Figure 3: S7 - Maximum Transient Pressure in the Kit4 Network

Figure 4: S7 - Minimum Transient Pressure in the Kit4 Network
Figure 5: S8 – Maximum and Minimum Head (m) profile

Figure 6: S8 – HGL and Flow along the pipeline
Figure 7: S8 – Maximum Transient Pressure in the Kit4 Network

Figure 8: S8 – Minimum Transient Pressure in the Kit4 Network
Figure 9: S9 – Maximum and Minimum Head (m) profile

Figure 10: S9 – HGL and Flow along the pipeline
Figure 11: S9 – Maximum Transient Pressure in the Kit4 Network

Figure 12: S9 – Minimum Transient Pressure in the Kit4 Network
Figure 13: S10– Maximum and Minimum Head (m) profile

Figure 14: S10 – HGL and Flow along the pipeline
Figure 15: S10 – Maximum Transient Pressure in the Kit4 Network

Figure 16: S10 – Minimum Transient Pressure in the Kit4 Network
Figure 17: S11 – Maximum and Minimum Head (m) profile

Figure 18: S11 – HGL and Flow along the pipeline
Figure 19: S11 – Maximum Transient Pressure in the Kit4 Network

Figure 20: S11 – Minimum Transient Pressure in the Kit4 Network
Figure 21: S12 – Maximum and Minimum Head (m) profile

Figure 22: S12 – HGL and Flow along the pipeline
Figure 23: S12 – Maximum Transient Pressure in the Kit4 Network

Figure 24: S12 - Minimum Transient Pressure in the Kit4 Network