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## HYDROGEOLOGICAL ASSESSMENT

Highway 23  
Structural Rehabilitation and Replacements  
GWP 3043-06-00  
Ministry of Transportation, Ontario - West Region

**Submitted to:**

Mr. Henry Huotari, P.Eng., Senior Project Manager  
Delcan Corporation  
214-1069 Wellington Road South  
London, Ontario  
N6E 2H6

REPORT



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## HYDROGEOLOGICAL ASSESSMENT

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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) was retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a hydrogeological assessment in support of the design for the rehabilitation and reconstruction of bridge and culvert structures on Highway 23 as part of GWP 3043-06-00. The hydrogeological assessment was undertaken to characterize the hydrogeological setting of the area within approximately 250 metres of the individual sites and to evaluate the potential hydrogeological impacts associated with the proposed construction. The approximate locations of the individual sites are shown on the Study Area Location Plan, Figure 1.

### **1.1 Scope of Work**

The hydrogeological assessment was conducted to fulfill the requirements indicated in Section 6.7 of the Request for Proposals (RFP) dated November 2009, and consisted of a desktop review of available information and a site reconnaissance to verify and supplement the information collected during the review. A water well inventory was also undertaken to document the approximate location and construction details of the existing water wells on the properties adjacent to the individual sites. The hydrogeological assessment was completed to support a potential Permit to Take Water application inferred to be required during the proposed construction works. The water well inventory included the following tasks:

- completion of a door to door survey of residences and businesses along the right of way (ROW) within approximately 500 metres of the individual sites;
- compilation and review of available Ministry of the Environment (MOE) water well records for comparison to the results of the door to door survey; and
- determination of whether a piped municipal water supply is available in the vicinity of the proposed works.

The results of the hydrogeological assessment and coincident foundation and pavement investigations carried out at the individual sites were used to assess the potential, if any, for the proposed construction to impact local groundwater receptors and to provide recommendations for monitoring and mitigation, if required.

### **1.2 Proposed Works**

The proposed highway improvements involve the rehabilitation and/or replacement of two bridges and two structural culverts on Highway 23 between Union Line/Perth Line 10 and Perth Line 42, north and south of the Town of Mitchell, County of Perth, Ontario. Specifically, the proposed highway improvements are associated with the following structure sites:

- The replacement of North Thames River Bridge – Site 25-128 – Station 16+065 – Township of West Perth;





- The rehabilitation of Flat Creek Bridge – Site 25-185 – Station 12+828 – Township of West Perth;
- The replacement of Fish Creek Culvert – Site 25-332 – Station 20+023 – Township of South Huron; and
- The replacement of Russeldale Drain Culvert – Site 25-333 – Station 13+030 – Township of West Perth.

On site detours are proposed with the possible use of a temporary bridge at the North Thames River site. As part of the proposed highway improvements outlined above, a Permit to Take Water (PTTW) may be required from the Ministry of the Environment (MOE) for construction dewatering associated with the rehabilitation and/or replacement of the above-noted structures. The hydrogeological assessment was completed to determine if a PTTW was necessary at any or all locations and/or if cost-effective dewatering alternatives (i.e. gravity fed flow diversion systems) could be implemented in an effort to avoid mechanical pumping, where feasible.

### **1.3 Previous Investigations**

Concurrent with the hydrogeological assessment, Golder conducted foundation field investigations for the reconstruction of the bridge and culvert structures on Highway 23 between May 17 and June 8, 2011. Results of the investigation were provided to Delcan in three separate reports as follows:

- Geocres Report No. 40P11-19 titled "Foundation Investigation and Design Report, Highway 23 – North Thames River Bridge (Site 25-128), Highway 23 Structure Replacements From Union Line/Perth Line 10 to Perth Line 42, GWP 3043-06-00, Ministry of Transportation – West Region", dated October 2011.
- Geocres Report No. 40P6-24 titled "Foundation Investigation and Design Report, Culvert Site 25-332/C, Station 20+023, Geographic Township of Blanshard, Highway 23 Structure Replacements From Union Line/Perth Line 10 to Perth Line 42, GWP 3043-06-00, Purchase Order No. 3009-E-0020, Ministry of Transportation, Ontario – West Region", dated November 2011.
- Geocres Report No. 40P6-25 titled "Foundation Investigation and Design Report, Culvert Site 25-333/C, Station 13+030, Geographic Township of Fullarton, Highway 23 Structure Replacements From Union Line/Perth Line 10 to Perth Line 42, GWP 3043-06-00, Purchase Order No. 3009-E-0020, Ministry of Transportation, Ontario – West Region", dated November 2011.

The foundation investigation and design reports listed above were reviewed as part of the current hydrogeological assessment with the relevant information incorporated into the current assessment. The locations of boreholes and associated Record of Borehole Sheets and grain size distribution curves for foundation investigations carried out at Site 25-128, Site 25-332 and Site 25-333 are provided in Appendices A through C, respectively.



## 2.0 REGIONAL SETTING

### 2.1 Physiography and Drainage

Based on Ontario Geological Survey Map P.2715 titled "Physiography of Southern Ontario", the subject section of Highway 23 lies within an undrained till plain characterized by narrow, north-northwest trending, till moraines and adjacent spillways. According to Chapman and Putnam (1984)<sup>1</sup>, the project is located within a broad clay plain identified as the Stratford Till Plain. The area is characterized by a ground moraine interrupted by several terminal moraines. Chapman and Putnam further describe the till as a product of the Huron ice lobe and as fairly uniform, brown calcareous silty clay, both on the ridges and on the more level ground moraine. The central and southern portions of the plain are situated within the Thames watershed.

The overall topography is very gently sloping in a southwesterly direction from a ground surface elevation of approximately 350 metres surrounding the North Thames River Bridge (Site 25-128) to approximately 305 metres surrounding Fish Creek Culvert (Site 25-332). The distance between the north and south project limits is approximately 25 kilometres. The topography surrounding the individual sites is generally flat, as shown on Figure 1.

Drainage for the area is provided by the North Thames River (Site 25-128). Fish Creek (Site 25-332), Russeldale Drain (Site 25-333) and Flat Creek (Site 25-185) are all tributaries of the North Thames River and provide surface water drainage in an east-southeasterly direction toward the North Thames River. Minor associated tributaries and drainage ditches in the southern portion of Perth County drain to the Thames River system. Areas east of Highway 23 are drained by the tributaries of the Grand River and areas in the northern and western portion of Perth County are drained by the Maitland River.

### 2.2 Quaternary Geology

Based on Ontario Geological Survey Preliminary Map No. P.1233 titled "Quaternary Geology, Seaforth Area, Southern Ontario", and Ontario Division of Mines Map No. 2366 titled "Quaternary Geology, St. Mary's, Southern Ontario", surficial deposits within the project limits generally consist of Late Wisconsin Elma Till (north and east of the Town of Mitchell) and Rannoch Till (south and west of the Town of Mitchell). The Elma Till is described as a primarily silt till while the Rannoch Till is described as a clayey to silty till. The tills are widespread in the area and comprise younger lacustrine silt and clay with some outwash silt deposits and associated outwash gravel deposits in the low-lying areas encompassing local tributaries and drainage features. Shallow surficial deposits within individual sites surrounding the associated creeks and drains is characterized by recent alluvium comprising stream deposits of gravel, sand and silt. The Quaternary geology of the individual sites is shown on Figure 2.

<sup>1</sup> Chapman, L.J. and D.F. Putnam, *The Physiography of Southern Ontario*, Third Edition, Ontario Geological Survey, Special Volume 2, 1984.



## 2.3 Bedrock Geology

Based on Geological Survey of Canada Map No. 1263A, titled "Geology, Toronto – Windsor Area, Ontario", the bedrock underlying individual sites located south of the Town of Mitchell consist of Middle Devonian aged rocks of the Dundee Formation. The bedrock underlying the site located north of the Town of Mitchell consists of slightly older, Middle Devonian aged rocks of the Lucas Formation of the Detroit River Group. Armstrong and Carter (2010)<sup>2</sup> indicate that the Dundee Formation is characterized by limestones that overlie the Lucas Formation and consist of grey to tan to brown, fossiliferous, medium to thick bedded limestones and minor dolostones. Bituminous partings and microstylolites are common and chert nodules are locally abundant. The Lucas Formation is described as limestones, dolostones, anhydritic beds and local sandy limestones disconformably overlain by limestones of the Dundee Formation.

Based on Ontario Division of Mines Preliminary Map No. P.266, titled "Bedrock Topography Series, St. Mary's Area, Southern Ontario", the bedrock surface underlying the subject section of Highway 23 generally slopes in a southwesterly direction from a bedrock elevation of approximately 320 metres in the area surrounding the North Thames River Bridge (Site 25-128) to approximately 290 metres in the area surrounding Fish Creek (Site 25-332). The bedrock surface is slightly depressed in the immediate area surrounding Flat Creek (Site 25-185) with an elevation of approximately 282 metres. Based on bedrock and ground surface elevations, the bedrock surface in the vicinity of the subject section of Highway 23 subcrops at depths of between approximately 20 and 45 metres. The bedrock geology and bedrock topography of the individual sites are shown on Figure 2.

## 2.4 Hydrogeological Setting

Based on mapping provided by Goff and Brown (1981)<sup>3</sup>, narrow, shallow overburden aquifers are located within the vicinity of Sites 25-332, 25-185 and 25-333 and are generally associated with Fish Creek and Flat Creek. No shallow overburden aquifers are located in the area surrounding the North Thames River Bridge. No intermediate or deep overburden aquifers are located within the subject section of Highway 23, although smaller intermediate overburden aquifers are located within the vicinity of the individual sites. These are located approximately two kilometres south of Site 25-128 (North Thames River bridge), two kilometres east of Sites 25-333 and 25-185 (Russeldale Drain and Flat Creek Bridge, respectively) and two kilometres south of Site 25-332 (Fish Creek culvert). Based on Goff and Brown, bedrock aquifers in the area are the most important source of large quantities of good quality groundwater derived from Middle Devonian limestones and dolostones. Based on well installations in bedrock aquifers, encountered water levels during well construction reportedly ranged between elevations of approximately 300 and 340 metres.

<sup>2</sup> Armstrong, D.K. and Carter, T.R., *The Subsurface Paleozoic Stratigraphy of Southern Ontario*, Ontario Geological Survey, Special Volume 7, 2010.

<sup>3</sup> Goff, K. and Brown, D.R., *Thames River Basin Water Management Study Technical Report*, Ministry of the Environment, Water Resources Report 14, 1981.



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Based on mapping provided in the Upper Thames River Source Protection Area Assessment Report<sup>4</sup>, the project is generally within an area of groundwater recharge with significant recharge in the area surrounding Flat Creek and Russeldale Drain (Sites 25-185 and 25-333), the area surrounding Fish Creek (immediately south of Site 25-332) and along the North Thames River (immediately west of Site 25-128). The annual groundwater recharge rate for individual sites was reported to be generally between 50 and 150 mm/year. Regionally, shallow groundwater is inferred to generally mimic the local topography and flow in a southeasterly direction. Shallow groundwater flow in the vicinity of the individual sites is likely influenced by local creeks and drainage features.

The project is within the Upper Thames River Conservation Authority (UTRCA) Watershed. The watershed is subdivided into 28 separate sub-watersheds which generally represent the entire basin of a creek or tributary. The following lists the subwatershed associated with each individual site:

- North Mitchell Watershed: Site 25-128 – North Thames River bridge;
- Flat Creek Watershed: Site 25-185 – Flat Creek Bridge and Site 25-333 – Russeldale Drain culvert; and
- Fish Creek Watershed: Site 25-332 – Fish Creek culvert.

Based on information provided by the UTRCA<sup>5</sup>, no Significant Natural Sites (provincial or locally significant wetlands, significant natural areas, areas of natural and scientific interest) occur within 500 metres of the individual sites.

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<sup>4</sup> Drinking Water Source Protection Act for Clean Water – Thames-Sydenham and Region, *Upper Thames River Source Protection Area Assessment Report*, Upper Thames River Conservation Authority, August, 2010.

<sup>5</sup> Upper Thames River Conservation Authority, *2007 Upper Thames River Watershed Report Cards*, 2007.

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### **3.0 SUBSURFACE CONDITIONS**

Between May 17 and June 8, 2011 and concurrent with the hydrogeological assessment, Golder conducted foundation field investigations for the reconstruction of the North Thames River Bridge and two culvert structures on Highway 23. Foundation investigation and design reports were provided to Delcan under separate cover. A summary of the results of the investigations is provided in the following sections.

#### **3.1 General**

The field work for the foundation investigation at the North Thames River Bridge (Site 25-128) was carried out between May 17 and June 8, 2011 and included a total of 10 boreholes; two drilled on the north side of the existing bridge and west of Highway 23, three drilled on the north side of the existing bridge and east of Highway 23, and five drilled on the south side of the existing bridge on the east side of Highway 23. The boreholes were terminated between 6.6 and 17.7 metres below the existing pavement or ground surface. Standpipe piezometers were installed in three of the boreholes. The locations of boreholes and associated Record of Borehole Sheets and grain size distribution curves for the foundation investigation carried out at the North Thames River Bridge are provided in Appendix A.

The field work for the foundation investigation at the Fish Creek Culvert (Site 25-332) was carried out between May 31 and June 6, 2011 and included a total of six boreholes surrounding the existing culvert beneath Highway 23 and Perth Line 10. The boreholes were terminated between 6.5 and 9.6 metres below the existing pavement or ground surface. Standpipe piezometers were installed in two of the boreholes. The locations of boreholes and associated Record of Borehole Sheets and grain size distribution curves for the foundation investigation carried out at the Fish Creek Culvert are provided in Appendix B.

The field work for the foundation investigation at the Russeldale Drain Culvert (Site 25-333) was carried out between May 31 and June 6, 2011 and included three boreholes on the north side of the existing culvert; one drilled on the west shoulder of Highway 23, one drilled on the east shoulder of Highway 23 and one in the east ditch of Highway 23. The boreholes were terminated between 10.4 and 14.2 metres below the existing pavement or ground surface. A standpipe piezometer was installed in one of the boreholes. The locations of boreholes and associated Record of Borehole Sheets and grain size distribution curves for the foundation investigation carried out at the Russeldale Drain Culvert are provided in Appendix C.

Borehole drilling at all locations was carried out using a track-mounted power auger supplied and operated by an independent drilling contractor which was supervised on a full-time basis by an experienced member of Golder's engineering staff.

No foundation investigation was carried out at the Flat Creek Bridge, Site 25-185.



### **3.1.1 Soil Conditions**

#### **North Thames River Bridge – Site 25-128 – Station 16+065**

Generally, boreholes drilled at the North Thames River Bridge site encountered the existing pavement structure and/or topsoil overlying fill materials or clayey silt till followed by sandy silt till and clayey silt till with occasional layers of silty clay till, silty fine sand, clayey silt and sandy silt.

The five boreholes drilled through the pavement on Highway 23 encountered variable fill materials consisting of a combination of sand and gravel to silt material averaging approximately 2.5 metres in thickness. Fill material consisting of sandy silt to sand and gravel was encountered beneath surficial topsoil in two holes drilled on the north side of the bridge, east of Highway 23 and averaged approximately 1.2 metres in thickness. The three boreholes drilled on the east side of Highway 23, south of the bridge did not intersect fill material but encountered either sandy silt or clayey silt till beneath surficial topsoil. Generally, clayey silt till was encountered beneath fill materials followed by alternating sandy silt till and clayey silt till to borehole termination. Cobbles and boulders were encountered within the sandy silt till and clayey silt till units.

Thin layers of silty sand to silty fine sand were encountered between till units in four of the boreholes drilled in the area. The material was described as compact to dense, brown to grey silty sand which ranged between 0.12 to 0.76 metres in thickness at elevations between 341.42 to 342.73 metres. A thin layer (0.75 metre) of very dense, grey sand was encountered beneath the silty fine sand in one of the boreholes at an elevation of approximately 341.42 metres. A layer of very dense sand and gravel was encountered beneath the silty clay till in one of the boreholes drilled south of the bridge on the east side of Highway 23. The material was encountered at an approximate elevation of 339.1 metres and was at least 0.2 metres in thickness. The borehole was terminated in the sand and gravel unit.

#### **Fish Creek Culvert – Site 25-332 – Station 20+023**

The boreholes drilled at this site generally encountered surficial topsoil or granular fill underlain by layers of sand and gravel or silts followed by sandy silt till. The sandy silt till was encountered between elevations of 305.6 and 306.7 metres and contained cobbles and boulders. All of the boreholes were terminated in the sandy silt till.

Granular fill material comprising sand and gravel was encountered at surface in boreholes drilled through the roadway shoulders and averaged approximately 1.4 metres in thickness. Silty sand and gravel to clayey silt fill material was encountered beneath the granular fill in these boreholes and beneath the surficial topsoil in adjacent boreholes drilled away from the roadway shoulders. The silty sand and gravel to clayey silt fill material was encountered between elevations of 307.7 and 308.5 metres and was between 0.3 and 1.1 metres in thickness.

Layers of clayey silt, loose silt and loose to compact sandy silt were locally encountered beneath the fill and topsoil in some of the boreholes drilled. The clayey silt and loose silt material was encountered at elevations between 306.3 and 307.4 metres and generally ranged in thickness between 0.3 and 0.9 metres. The loose to compact sandy silt layers were encountered at elevations between 307.1 and 306.7 metres and averaged approximately 0.8 metres in thickness.



Layers of compact sand and gravel were encountered in two boreholes, underlying the fill and clayey silt, at elevations of 307.1 and 306.5 metres, respectively. The sand and gravel layers were approximately 0.8 metres in thickness.

#### **Russeldale Drain Culvert – Site 25-333 – Station 13+030**

The boreholes drilled at this site generally encountered variable surficial fill materials underlain by layers of clayey silt, silts and sands followed by clayey silt till and sandy silt till.

All of the boreholes encountered fill material at the ground surface ranging between 1.5 and 3.4 metres in thickness. The fill was variable and consisted of sand and gravel to clayey silt. A layer of buried topsoil, approximately 0.9 metres thick, was encountered beneath the fill material in the borehole drilled on the west shoulder of the highway. Layers of silt, clayey silt and sandy silt were encountered beneath fill material in boreholes and ranged between 0.5 and 1.1 metres in thicknesses.

Layers of fine sand with trace silt were encountered in each of the boreholes at an average elevation of 325.5 metres and were between 0.8 and 1.7 metres in thickness. One of the boreholes encountered an additional 0.8 metre thick layer of sand at an elevation of approximately 324.0 metres underlying a 0.8 metre thick layer of silty sand at an elevation of approximately 324.8 metres.

Clayey silt till was encountered in all of the boreholes at elevations ranging between 317.2 and 324.1 metres and where fully penetrated, was between 2.3 and 4.6 metres thick. Sandy silt till was encountered in two of the boreholes at elevations ranging between 318.8 and 319.5 metres and where fully penetrated, was approximately 2.3 metres thick. Cobbles were encountered in both the clayey silt till and sandy silt till. Boreholes were terminated in either the clayey silt till or sandy silt till material.

### **3.1.2 Groundwater Conditions**

#### **North Thames River Bridge – Site 25-128 – Station 16+065**

Groundwater conditions were observed in the boreholes during drilling. Standpipes were installed in three of the boreholes and were located east of Highway 23; two south of the bridge (BH 105 and BH 106) and one north of the bridge (BH 101). The encountered and measured groundwater levels are presented on the Record of Borehole sheets in Appendix A.

Boreholes drilled through the existing pavement structure surrounding the existing bridge encountered groundwater at depths between 2.6 and 18.9 metres, corresponding to elevations of 344.2 and 331.0 metres. Boreholes drilled east of the existing bridge in the adjacent ditch encountered groundwater between 0.78 and 3.53 metres, corresponding to elevations of 344.3 and 341.9 metres. Two of the boreholes advanced in this area remained dry during drilling.

Groundwater elevations were subsequently measured in standpipes installed in BH 101, BH 105 and BH 106 on June 8, 2011 and ranged in elevations between 341.4 and 343.9 metres. Based on the measured and



encountered groundwater levels during the foundation investigations, the groundwater level in this area is inferred to be at an approximate elevation of 344 metres.

#### **Fish Creek Culvert – Site 25-332 – Station 20+023**

Groundwater conditions were observed in the boreholes during drilling. Standpipes were installed in two of the boreholes and were located on Highway 23, south of the intersection of Perth Line 10; one on the west shoulder of the highway (BH 201) and one in the east ditch of the highway (BH 205). The encountered and measured groundwater levels are presented on the Record of Borehole sheets in Appendix B.

Boreholes drilled in the area surrounding the existing culvert encountered groundwater at depths between 1.4 and 3.0 metres. Corresponding groundwater elevations ranged between 305.9 and 307.3 metres. All of the boreholes encountered groundwater during drilling.

Groundwater levels were subsequently measured in standpipes installed in BH 201 and BH 205 on June 8, 2011 and were at depths of approximately 2.1 and 1.7 metres, corresponding to elevations of 307.1 and 305.8 metres, respectively.

Based on the measured and encountered groundwater levels during the foundation investigations, the groundwater level in this area is inferred to be at an approximate elevation of 307 metres.

#### **Russeldale Drain Culvert – Site 25-333 – Station 13+030**

Groundwater conditions were observed in the boreholes during drilling. A standpipe was installed in the borehole located on the east shoulder of Highway 23 (BH 301). The encountered and measured groundwater levels are presented on the Record of Borehole sheets in Appendix C.

Boreholes drilled north of the existing culvert on the east and west shoulders of Highway 23 and in the east ditch encountered groundwater at depths between 2.3 and 4.6 metres, corresponding to elevations of 325.3 and 325.6 metres. All of the boreholes encountered groundwater during drilling.

A groundwater level was subsequently measured in the standpipe installed in BH 301 on June 8, 2011 at a depth of approximately 4 metres, corresponding to an elevation of 325.9 metres.

Based on the measured and encountered groundwater levels during the foundation investigations, the groundwater level in this area is inferred to be at an approximate elevation of 326 metres.





## 4.0 EXISTING WATER WELLS

### 4.1 MOE Database

Golder submitted a request to the MOE for water well record summaries for all wells located within 500 metres of each of the individual sites. In response, the MOE provided summaries of the water well records for a total of 12 wells located within approximately 500 metres of the proposed construction and the results of which are presented in Table I. The approximate locations of the wells within approximately 500 metres of the individual sites, as provided from the MOE water well record summaries, are shown on Figure 3. The following provides a summary of the results of the MOE database search at the individual sites.

#### **North Thames River Bridge – Site 25-128 – Station 16+065**

Based on the results of the MOE water well records summary, no active wells were identified within 500 metres of Site 25-128.

#### **Flat Creek Bridge – Site 25-185 – Station 12+828**

Three water well records were identified within 500 metres of Site 25-185, two of which were located within 250 metres of the proposed construction. All three wells identified were reportedly bedrock installations drilled to depths ranging from 58 to 80 metres. Fresh water was encountered in three of the wells at depths between 58 and 76 metres and was being used for domestic and livestock purposes. One of the active water supply wells encountered sulphur water at a depth of approximately 73 metres and was reportedly for public use.

#### **Fish Creek Culvert – Site 25-332 – Station 20+023**

Five water well records were identified within 500 metres of Site 25-332, none of which were located within 250 metres of the proposed construction. Of the five wells identified, four wells were reportedly bedrock installations and drilled to depths ranging from 61 to 76 metres. Fresh water, reportedly used for domestic and livestock purposes, was encountered at depths averaging 64 metres with static levels averaging 52 metres. One of the five wells identified was reportedly a shallow overburden installation to a depth of 7 metres (MOE well No. 5002257). Fresh water, reportedly used for domestic purposes, was encountered at a depth of 5.5 metres with a static level measured at 4.6 metres. The well is located approximately 350 metres south-southwest of the proposed construction and is inferred to correspond with the shallow well located at 2105 Highway 23.

#### **Russeldale Drain Culvert – Site 25-333 – Station 13+030**

Four water well records were identified within 500 metres of Site 25-333, three of which were located within 250 metres of the proposed construction. Three of the wells were identified as bedrock installations and were drilled to a depth of approximately 20 metres. Fresh water, reportedly used for domestic purposes, was encountered at



depths ranging between 16.5 and 21.5 metres. One of the four wells identified was reportedly a shallow overburden installation to a depth of 4.6 metres (MOE well No. 5001562). Fresh water, for domestic purposes, was encountered at 1.5 metres. Based on MOE coordinates, the well is located approximately 135 metres southwest of the proposed construction. It is inferred that the well corresponds with the shallow well located at 2729 Highway 23.

## **4.2 Field Survey**

The Municipality of West Perth and the Township of South Huron were contacted to determine if a municipal supply of piped water was available to residents located along the subject section of Highway 23. Based on a telephone conversation and email correspondence with personnel at the Public Works Departments of each municipality, no municipal supply of piped water is available to residents located within the individual sites.

Based on aerial photograph coverage of the project, provided by Delcan, and using a radius of 500 metres from the proposed replacement/rehabilitation of the individual structures at each site, a preliminary number of residents was estimated. Based on this information, 22 residences were included in the survey. On January 12, 2011, a notification letter was hand delivered to each of the 22 properties to request their participation in the well survey and to provide details regarding the date and approximate time of the survey. Based on field observations, a list of municipal addresses/911 emergency response numbers was created. The properties surveyed are summarized in Table II.

A representative from Golder attempted to contact each resident while canvassing the area on January 17, 2011, at which time a brief interview was conducted to obtain information regarding private water wells located on each property. A total of 19 interviews were successfully completed on January 17, 2011. Of the three remaining properties: the resident located at 4608 Highway 23 was subsequently contacted on July 26, 2011 and information regarding the drilled well on the property was obtained; the resident located at 6012 Line 16 was subsequently contacted on May 4, 2011 and details regarding a shallow overburden well on the property were obtained; and, the property located at 70619 Highway 23 was a commercial aggregate pit with no available contact information.

The door to door field survey identified an active well at each of the residences surveyed in the area surrounding each individual site of the subject section of Highway 23. The approximate locations of the wells located within approximately 500 metres of the proposed work at each site, as identified during the door to door survey, are shown on Figure 3. The results of the door to door survey are summarized as follows:

### **North Thames River Bridge – Site 25-128 – Station 16+065**

Eight wells were identified within approximately 500 metres of Site 25-128. Seven of the wells were drilled installations ranging in depths between 13.5 and 50 metres. Details regarding the remaining well, located at 5996 Line 42, were limited. The owner indicated that the well was reportedly greater than 30 metres deep but details regarding type of installation, casing type and diameter were unknown. The well was reportedly located in the ditch in close proximity to the east side of Highway 23 and covered by approximately 0.5 metres of soil.



The owner indicated that the well was no longer used for drinking purposes and only supplied water to the adjacent commercial enterprise for washroom facilities and washing purposes.

#### **Flat Creek Bridge – Site 25-185 – Station 12+828**

Three wells were located within 500 metres of Site 25-185. One of the wells (6004 Line 16) was a drilled installation within a former dug well to a depth of approximately 90 metres. The well casing was reportedly a narrow diameter PVC pipe but was not observed at the time of the door to door survey. The two remaining wells were shallow dug/bored installations. The well located at 6012 Line 16 was reportedly a dug, concrete cased well approximately 6 to 9 metres deep. The owner indicated that the bottom of the well contained approximately 0.5 to 0.75 metres of water last time it was checked. The well is located approximately 170 metres southwest of the proposed rehabilitation of the Flat Creek Bridge. The residents at 5975 Line 16 obtain domestic water sourced from a shallow well located on an adjoining property via underground piping. The well is located on the north side of Line 16 on the east side of Flat Creek, approximately 430 metres southeast of the proposed rehabilitation. Based on discussions with the well owner, the well is a wide diameter, concrete cased installation less than 3 metres deep. The well reportedly collects shallow groundwater migrating toward the adjacent creek.

#### **Fish Creek Culvert – Site 25-332 – Station 20+023**

Four wells were identified within 500 metres of Site 25-332, three of which were drilled to depths of greater than 60 metres. The remaining well (2105 Highway 23) was a shallow, bored, overburden installation to a depth of approximately 5.5 metres with a large diameter concrete casing. The well was used for domestic purposes and was located approximately 350 metres south-southwest of the proposed construction.

#### **Russeldale Drain Culvert – Site 25-333 – Station 13+030**

Six wells were identified within approximately 500 metres of Site 25-333. Four of the wells were drilled installations ranging in depths between 18 and 90 metres. The two remaining wells were shallow dug/bored overburden installations. The well located at 2729 Highway 23 was reportedly a dug well with stone sidewalls to an approximate depth of 5.2 metres. The owner indicated that the water level in the well the last time it was checked was approximately 0.3 metres from the ground surface and that previous testing indicated a yield of approximately 25 litres per minute. The well is located approximately 325 metres southwest of the proposed construction. The well located at 2835A Highway 23 was reportedly a dug well with stone sidewalls to an approximate depth of 4.6 metres. The well is located more than 500 metres northeast of the proposed construction.



## 5.0 PROPOSED CONSTRUCTION ACTIVITIES

Based on existing information and the preliminary design information provided, it is not anticipated that a Permit to Take Water (PTTW) will be required for the proposed construction activities associated with the replacement of the North Thames River Bridge or the Fish Creek Culvert. Finalized construction design details for the replacement of the Russeldale Drain culvert were provided by Delcan. Based on our understanding of the surficial geology and groundwater conditions in the vicinity of the culvert replacement, it is inferred that a PTTW will be required during the proposed construction. The following paragraphs detail the preliminary foundation recommendations based on available information provided by Delcan.

### North Thames River Bridge – Site 25-128 – Station 16+065

Based on the construction details provided by Delcan and the groundwater levels observed during the foundation investigations carried out at the site, it is not anticipated that construction dewatering requiring a PTTW will be necessary to complete the excavations associated with the construction of the new bridge or the temporary structure crossing the North Thames River.

According to the foundation investigation and design report for the site, the recommended bridge foundations would use driven steel H-piles at a cut-off elevation of 343.6 metres. Based on the measured and encountered groundwater levels during drilling and subsequent monitoring, the inferred groundwater level is at an approximate elevation of 344 metres. Since the base of the excavation is expected to extend below the inferred groundwater table, some minor basal seepage is anticipated.

For the purposes of calculating discharge rates, the base of the excavation was estimated at approximately 1.5 metres below the top of the cut-off elevation, corresponding to an approximate elevation of 342.6 metres. Dewatering would generally be employed to lower the water level to approximately 0.25 metres below the base of the excavation, corresponding to approximately 1.75 metres below the top of the cut-off elevation. Based on the available information and an estimated hydraulic conductivity of  $2 \times 10^{-8}$  metres per second (m/s) for a typical sandy silt till material encountered in nearby boreholes, up to 1.4 metres of initial drawdown may be required in the vicinity of the excavation. A maximum daily discharge of less than 50,000 litres was estimated for the dewatering system. Consequently, it is inferred that a PTTW will not be required during the proposed construction.

### Flat Creek Bridge – Site 25-185 – Station 12+828

Based on information provided by Delcan, no excavations are anticipated during the rehabilitation of the Flat Creek Bridge. Consequently, construction dewatering will not be required as part of the proposed work.

### Fish Creek Culvert – Site 25-332 – Station 20+023

Based on the construction details provided by Delcan and the groundwater levels observed during the geotechnical investigations carried out at the site, it is not anticipated that construction dewatering requiring a



PTTW will be necessary to complete the excavations associated with the replacement of the existing concrete culvert with the two proposed new culverts crossing beneath Highway 23 and Perth Line 10, respectively.

According to the foundation investigation and design report for the site, the replacement culvert may be founded at or below an elevation of 305 metres. Based on the measured and encountered groundwater levels during drilling and subsequent monitoring, the inferred groundwater level is at an approximate elevation of 307 metres. Since the base of the excavation is expected to extend below the inferred groundwater table, some minor basal seepage is anticipated.

The hydraulic conductivity of the granular material encountered in the vicinity of the construction activities was estimated from the grain size distribution for representative samples from nearby boreholes using the Hazen approximation (described in further detail in Section 6.1). Based on the available information, the hydraulic conductivity of the saturated granular material in the vicinity of the site was estimated to range between approximately  $9 \times 10^{-8}$  and  $8 \times 10^{-4}$  m/s. For the purposes of calculating discharge rates, a conservative hydraulic conductivity of  $8.4 \times 10^{-4}$  m/s was used. Dewatering would generally be employed to lower the water level to approximately 0.25 metres below the base of the excavation, corresponding to approximately 0.5 metres below the bottom of the culvert. Based on this information, up to 3 metres of initial drawdown may be required in the vicinity of the excavation for the proposed culvert replacement. A maximum daily discharge of less than 50,000 litres was estimated for the dewatering system. Consequently, it is inferred that a PTTW will not be required during the proposed construction.

#### **Russeldale Drain Culvert – Site 25-333 – Station 13+030**

Based on the construction details provided by Delcan and the groundwater levels observed during the foundation investigation carried out at the site, it appears that the excavation will not extend into the underlying saturated granular material at this location. However, due to the confined nature of the granular material and the planned excavation to remove most of the overlying clayey silt, basal seepage into the excavation is considered likely. Based on the limited available information, it is inferred that temporary construction dewatering requiring a PTTW will be necessary during construction activities.

Based on finalized construction design details for the replacement of the Russeldale Drain culvert provided by Delcan, the replacement culvert may be founded at or below an elevation of 325.8 metres. Based on the measured and encountered groundwater levels during drilling and subsequent monitoring, the inferred groundwater level is at an approximate elevation of 326 metres. Dewatering would generally be employed to lower the water level to approximately 0.25 metres below the base of the excavation, corresponding to approximately 0.5 metres below the bottom of the culvert. Based on the available information, as much as 0.6 metres of initial drawdown may be required in the vicinity of the excavation for the proposed culvert replacement.

Based on our understanding of the surficial geology and groundwater conditions in the vicinity of the culvert replacement, a typical daily discharge of approximately 56,700 litres is estimated, corresponding to a pumping rate of approximately 39 litres per minute (L/min) over a 24 hour period. To account for the subsurface heterogeneity, a maximum daily discharge of 89,500 litres is estimated, corresponding to a pumping rate of approximately 62 L/min over a 24 hour period. Consequently, it is inferred that a PTTW for temporary construction dewatering will be required during the proposed construction. The discharge calculations for the Russeldale Drain culvert replacement are provided in Appendix D.



## 6.0 IMPACT ASSESSMENT

### 6.1 Methodology

The following section presents an evaluation of the potential impact of the proposed temporary construction dewatering on local groundwater resources in the vicinity of the Russeldale Drain culvert replacement (Site 25-333) inferred to require a PTTW for construction purposes.

The hydraulic conductivity (K) of the granular material encountered in the vicinity of the area requiring active dewatering was estimated from the grain size distribution for representative samples from nearby boreholes using the Hazen approximation:

$$K = Cd_{10}^2 \quad (\text{in Freeze and Cherry, 1979})^6$$

Where:

C = empirical constant (for K in centimeters per second (cm/s) and  $d$  in millimeters (mm), C is equal to 1.0); and

$d_{10}$  = effective grain size at which 10 per cent by weight of the soil particles are finer.

Based on the above relationship, the hydraulic conductivity of the saturated granular material in the vicinity of the site was estimated to range between approximately  $3 \times 10^{-7}$  and  $4 \times 10^{-5}$  metres per second (m/s).

The lateral extent of the zone of influence was estimated using an empirical relationship developed by Sichart and Kryieleis. Using this method, the radius of influence is estimated as a function of drawdown and hydraulic conductivity as follows:

$$Ro = 3000 (H - h)\sqrt{K} \quad (\text{in Powers et al., 2007})^7$$

Where:

$R_o$  = radius of influence in metres;

H = aquifer thickness in metres;

h = dewatering height in metres; and

K = hydraulic conductivity in metres per second.

Using the above relationship, the theoretical radius of influence for the proposed dewatering program is approximately 12 metres.

<sup>6</sup> Freeze, R. Allan, Cherry, John A. *Groundwater*. Prentice-Hall Inc, 1979.

<sup>7</sup> Powers, J. P., Corwin, A.B., Schmall, P.C., Kaeck, W.E. *Construction Dewatering and Groundwater Control, New Methods and Applications*, Third Edition. p. 71. John Wiley and Sons Inc, 2007.



## **6.2 Findings**

Based on the results of the door to door well survey, no shallow wells were identified within 100 metres of the proposed construction works within individual sites along the subject section of Highway 23. No shallow wells were identified within, or in close proximity to, the theoretical radius of influence for the dewatering system in the vicinity of the Russeldale Drain culvert replacement (Site 25-333) inferred to require a PTTW for temporary construction dewatering purposes. Given the distance of nearby water wells from the proposed construction, initial construction dewatering at individual sites along the subject section of Highway 23 is not anticipated to interfere with water levels in surrounding wells.

Since associated water channels are within close proximity to the proposed construction activities at each site requiring excavation, it is anticipated that initial construction dewatering may have a limited, temporary impact on water levels in the adjacent channel. Any impact on the water levels in adjacent channels is anticipated to be transient due to the relatively short duration of initial dewatering and the nature of the surficial materials at each location.



## **7.0 CONCLUSIONS AND RECOMMENDATIONS**

Based on our assessment of the local hydrogeological conditions at individual sites along the subject section of Highway 23, it is considered unlikely that the proposed temporary construction dewatering program will have any significant permanent impacts on the availability of groundwater in the shallow wells or on water levels within the adjacent water channels. However, as discussed in Section 5.0 above, transient impacts on water levels in the adjacent channels may be observed during the initial construction dewatering. As a result, the following monitoring program and contingency plan is proposed.

Prior to construction activities at individual sites, a monitoring station should be established to facilitate surface water level measurements in the Thames River (Site 25-128), Fish Creek (Site 25-332) and Russeldale Drain (Site 25-333) in the vicinity of the proposed excavations. A minimum of one surface water level monitoring station should be established at each location and a monitoring program should be implemented at least three weeks prior to the start of construction activities to establish baseline conditions. Monitoring should be increased to daily during construction for potential impacts resulting from construction dewatering. The water level data should be reviewed by a qualified professional following each monitoring event for evidence of significant impacts on surface water levels that may be attributable to the dewatering activities.

Temporary construction dewatering requiring a PTTW is inferred to be necessary during construction activities associated with the replacement of the Russeldale Drain culvert (Site 25-333). The dewatering contractor and/or contract administrator should maintain a daily record of the pumping rate, discharge volume and groundwater levels within the dewatering area to ensure efficient operation of the dewatering system and compliance with the Permit. This information, as well as a daily log of which sections of the alignment were being dewatered, should be available for review by the qualified person should interference complaints be received. Well interference complaints, if any, will be assessed on a case by case basis.





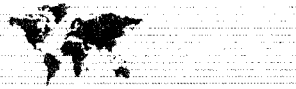
## **8.0 LIMITATIONS**

This report was prepared for Delcan Corporation on behalf of the Ministry of Transportation, Ontario to carry out a hydrogeological assessment to support a potential application to the Ontario Ministry of the Environment for a Permit to Take Water (PTTW), if required, for temporary construction dewatering in conjunction with the Preliminary Design Study and Class Environmental Assessment carried out for the design of the rehabilitation and reconstruction of bridge and culvert structures on Highway 23 as part of GWP 3043-06-00.

Information contained within this report is intended to support a PTTW application and is not intended to be used for the design of the dewatering system by the contractor. Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the sole responsibility of such third parties.

This report is based on data and information collected during geotechnical investigations conducted by Golder Associates Ltd. and is based solely on site conditions encountered at the time of the site visits supplemented by historical information and geological data obtained by Golder Associates Ltd., as described in this report.

In evaluating the site and potential dewatering impacts, Golder Associates Ltd. has relied in good faith on information provided by Delcan Corporation and others. We accept no responsibility for any deficiency, misstatements or inaccuracies contained in this report as a result of omission, misinterpretations or fraudulent acts of the persons interviewed. Golder Associates Ltd. accepts no responsibility for any reduction in property value, either real or perceived, as a result of the reporting of factual information herein.



## **9.0 CLOSURE**

We trust that this report provides all the information that you presently require. Should you have any questions, or require further information, please contact this office.

### **GOLDER ASSOCIATES LTD.**

Derek Mulligan, Hons.B.Sc.  
Environmental Scientist

Keith G. Lesarge, P.Geo.  
Principal, Senior Environmental Scientist

DM/KGL/PRB/sll

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TABLE I

## SUMMARY OF MOE WATER WELL RECORDS

Hydrogeological Assessment  
 Highway 23  
 Structure Rehabilitation and Replacements  
 GWP 3043-06-00  
 Ministry of Transportation, Ontario - West Region

MOE Well No.	UTM Coordinates		Year Drilled	Casing Diameter (millimetres)	Drilling Method	Water Quality	Well Status	Water Use	Depth			Test Pumping			Stratigraphy		Aquifer Type
	Easting (NAD 83)	Northing (NAD 83)							Water Found (metres)	Total Depth (metres)	Static Level (metres)	Level (metres)	Rate (L/min)	Duration (hours)	Material	Depth to Unit Base (metres)	
Site 25-333 RUSSEDALE DRAIN CULVERT																	
5001562	478254	4802873	1969	914	Cable Tool	Fresh	Water Supply	Domestic	1.5	4.6	1.5	4.0	9.1	1.0	Brown clay	1.5	Overburden
															Gravel	1.8	
															Blue clay	4.6	
5002998	478314	4802923	1980	127	Rotary (Air)	Fresh	Water Supply	Domestic	16.8	20.7	5.2	11.3	54.6	5.0	Clay	5.2	Bedrock
															Stones	6.1	
															Hardpan	16.8	
															Gravel	17.4	
															Clay	18.9	
															Stones limestone	20.7	
5003857	478312	4802902	1991	152	Rotary (Convent.)	Fresh	Water Supply	Domestic	21.6	21.6	9.8	17.7	27.3	1.0	Black topsoil	0.3	Bedrock
															Grey clay sand stones	3.7	
															Grey coarse gravel	9.8	
															Grey clay sand stones	21.0	
															Grey limestone	21.6	
5004391	478405	4803213	1996	152	Rotary (Air)	Fresh	Water Supply	Domestic	20.1	21.3	8.5	10.4	113.7	2.0	Black topsoil	0.6	Bedrock
															Yellow clay	1.8	
															Yellow clay stones	3.7	
															Grey clay stones	7.6	
															Grey hardpan packed	18.0	
															Grey limestone hard	21.3	
Site 25-185 FLAT CREEK BRIDGE																	
5000649	478014	4802131	1946	102	Cable Tool	Fresh	Water Supply	Domestic & Livestock	76.2	80.2	76.2	-	54.6	3.0	Clay boulders	41.1	Bedrock
															Gravel	42.7	
															Clay	68.6	
															Rock	80.2	
5000650	477814	4802170	1959	102	Cable Tool	Sulphur	Water Supply	Public	73.2	78.3	64.0	64.9	27.3	1.0	Clay stones	24.4	Bedrock
															Limestone	78.3	
5004265	477730	4802070	1995	178	Rotary (Air)	Fresh	Water Supply	Livestock & Domestic	57.9	57.9	22.6	48.8	45.5	2.0	Brown clay sandy	4.9	Bedrock
															Grey clay soft	10.1	
															Grey clay sandstone stones	24.4	
															Grey limestone	31.4	
															Brown limestone	57.9	

## SUMMARY OF MOE WATER WELL RECORDS

MOE Well No.	UTM Coordinates		Year Drilled	Casing Diameter (millimetres)	Drilling Method	Water Quality	Well Status	Water Use	Depth			Test Pumping			Stratigraphy		Aquifer Type
	Easting (NAD 83)	Northing (NAD 83)							Water Found (metres)	Total Depth (metres)	Static Level (metres)	Level (metres)	Rate (L/min)	Duration (hours)	Material	Depth to Unit Base (metres)	
Site 25-185 FLAT CREEK BRIDGE																	
3005838	475195	4798636	1995	127	Rotary (Convent.)	Fresh	Water Supply	Livestock & Domestic	61.0	61.0	48.8	51.8	36.4	1.0	Grey gravel sand clay Grey limestone layered	15.5 61.0	Bedrock
5002257	475664	4798323	1975	914	Boring	Fresh	Water Supply	Domestic	5.5	7.0	4.6	7.0	27.3	2.0	Brown clay boulders packed Blue clay boulders packed Gravel boulders loose	0.9 5.5 7.0	
5003620	476004	4798571	1989	152	Rotary (Convent.)	Fresh	Water Supply	Domestic	71.3	71.3	53.6	54.6	45.5	1.5	Topsoil Brown clay gravel stones Grey clay stones hard Brown limestone hard Brown limestone medium-grained soft	0.3 3.7 16.8 69.8 71.3	
5004182	475896	4798201	1994	127	Rotary (Convent.)	Fresh	Water Supply	Livestock & Domestic	68.9	70.4	50.9	50.9	45.5	12.0	Brown topsoil loose Black clay boulders hard Brown gravel sand boulders Brown gravel loose Black sand coarse gravel Blue granite boulders hard Brown sand gravel loose Brown limestone hard	0.3 1.2 7.0 7.9 9.4 9.8 14.0 70.4	Bedrock
5004395	476177	4798649	1996	152	Rotary (Convent.)	Fresh	Water Supply	Livestock	55.2	76.2	54.6	54.6	45.5	8.0	Black topsoil Brown clay Grey clay Brown sand Grey clay Brown rock Brown limestone Brown limestone Brown limestone rock hard	0.3 4.3 6.4 7.0 16.5 21.3 55.2 63.4 76.2	

NOTES: 1. Well records provided electronically by the Ontario Ministry of the Environment (MOE) on January 7, 2011.  
2. See Figure 3 for well locations.  
3. Table to be read in conjunction with accompanying text.

Prepared By: DM  
Checked By: ST

TABLE II

**SUMMARY OF PROPERTIES SURVEYED**

Hydrogeological Assessment  
Highway 23  
Structure Rehabilitation and Replacements  
GWP 3043-06-00  
Ministry of Transportation, Ontario - West Region

MN <sup>1</sup>	STREET	OWNER	OCCUPIED BY OWNER	OCCUPANT	TELEPHONE	RESPONSE DATE <sup>3,4</sup>	REPORTED NO. OF WELLS	COMMENTS
<b>Site 25-128 NORTH THAMES RIVER BRIDGE</b>								
5953	Perth Line 42	John and Mary McLagan	yes	-	519-348-8214	17-Jan-11	1	
5970	Perth Line 42	Dudley Burton	yes	-	519-348-9142	17-Jan-11	1	
5996	Perth Line 42	Shawn Snyder - Snyder Graphics	yes - commercial	-	519-348-0694	17-Jan-11	1	Well only used for washroom and cleaning. Drinking water brought from elsewhere.
6007	Perth Line 42	Mike Thomas	yes	-	519-801-8519 519-348-9775	12-Jan-11	1	
6104	Perth Line 42	Paul Dietz	yes	-	519-348-8319	17-Jan-11	1	
6105	Perth Line 42	James McLagan	yes	-	519-348-9136	17-Jan-11	1	
4609	Highway 23	Brent VanMoorsel	yes	-	519-348-4626	17-Jan-11	1	
4608	Highway 23	Paul and Rose Hill	yes	-	519-348-8666 519-272-6475	26-Jul-11	1	Contacted by telephone, observed well during January survey. Drilled well > than 50 metres
<b>Site 25-333 RUSSEDALE DRAIN CULVERT</b>								
2729	Highway 23	Dale and Coralee Foster	yes	-	519-229-8235	17-Jan-11	1	
2740	Highway 23	Niel Douglas Promotional Wood Products	yes - commercial	-	519-229-6331	17-Jan-11	1	
2756	Highway 23	Robert and Mildred Ulch	yes	-	519-229-8877	17-Jan-11	1	
2757	Highway 23	Dale Foster	no	tenant	-	17-Jan-11	1	Tenant not home during survey. Well details provided by owner at 519-229-8235
2835A	Highway 23	Larry and Janice Bertens	no	Roy Russell	519-229-6150	17-Jan-11	1	
6063	Perth Line 20	Larry and Janice Bertens	yes	-	519-229-6170	17-Jan-11	2	older dug well on property no longer used on daily basis but available in case of emergency
<b>Site 25-185 FLAT CREEK BRIDGE</b>								
5975	Perth Line 16	Keith and Liz Selves	yes	-	519-229-6490	17-Jan-11	0	Sources drinking water from spring (~3m deep) on adjacent land on north side of road.
6004	Perth Line 16	Linda Martyn	yes	-	519-229-8288	17-Jan-11	1	
6012	Perth Line 16	Elisha Martene/Steve Squibbs	yes	-	519-229-6327 519-301-3079	17-Jan-11 & 4-May-11	1	Dug concrete well approx 6m to 9m deep, approx 0.5 m water in well when last checked

## SUMMARY OF PROPERTIES SURVEYED

MN <sup>1</sup>	STREET	OWNER	OCCUPIED BY OWNER	OCCUPANT	TELEPHONE	RESPONSE DATE <sup>3,4</sup>	REPORTED NO. OF WELLS	COMMENTS
<b>Site 25-332 FISH CREEK CULVERT</b>								
5964	Perth Line 10	Bob Wallace	yes	-	519-229-6588	17-Jan-11	1	
2131	Highway 23	Alex Miko	yes	-	519-229-8807	17-Jan-11	1	
2105	Highway 23	William Bibby	yes	-	519-229-6865	17-Jan-11	1	
70719	Highway 23	Lisa Thomas	yes	-	519-229-6527	17-Jan-11	1	
70619	Highway 23	McCann Construction Pit #5	-	-	-	-	-	Seasonal pit operation - no access or contact information to send survey.

## NOTES:

1. MN refers to Municipal Number/Emergency Response Number.
2. "-" indicates information not available or not applicable.
3. Notification letter delivered on January 12, 2011; initial survey completed on January 17, 2011.
4. Table to be read in conjunction with accompanying report.

Prepared By: DM  
Checked By: KC

TABLE III

## SUMMARY OF WELL SURVEY RESULTS

Hydrogeological Assessment  
Highway 23  
Structure Rehabilitation and Replacements  
GWP 3043-06-00  
Ministry of Transportation, Ontario - West Region

MN <sup>1</sup>	STREET	NORTHING <sup>2</sup>	EASTING <sup>2</sup>	APPROXIMATE YEAR CONSTRUCTED	WELL TYPE	CASING TYPE	CASING DIAMETER (mm)	WELL DEPTH (m)	WATER QUALITY	WATER USE	COMMENTS
<b>Site 25-128 NORTH THAMES RIVER BRIDGE</b>											
5953	Perth Line 42	4817757	487580	1981	drilled	steel	102	>30	hard - good	domestic livestock	farm with ~ 35 head of cattle, new pump installed at 25m, water at 9m
5970	Perth Line 42	4817953	487530	~1995	drilled	steel	102	39.5	hard - good	domestic	well head not investigated due to snow cover, location approximate only
5996	Perth Line 42	4818097	487271	>50 years	unknown	unknown	unknown	>30	not used	commercial	commercial setting, well water used only for cleaning and bathroom
6007	Perth Line 42	4818090	487196	<20 years	drilled	steel	152	22.5	good	domestic	drilled well inside old dug well, water level at 12m when pump installed
6104	Perth Line 42	4818411	486817	1910	drilled	steel	102	19.5	good	domestic livestock	farm with ~ 100 head of sheep
6105	Perth Line 42	4818351	486754	1996	drilled	steel	152	38	hard - good	domestic	
4609	Highway 23	4818130	487321	1976	drilled	steel	152	13.5	good	domestic	water level at 9m when last measured
4608	Highway 23	4818190	487247	~ 1960s	drilled	steel	152	>50	good	domestic livestock	farm with ~ 450 sows
<b>Site 25-333 RUSSEDALE DRAIN CULVERT</b>											
2729	Highway 23	4802657	478219	>100 years	dug	stone	762	5.2	hard - good	domestic	owner indicated water level within 30cm of ground surface
2740	Highway 23	4802843	478215	~1988	drilled	steel	152	70	good	commercial	owner indicated well not used for drinking water, only bathrooms/cleaning
2756	Highway 23	4802871	478215	1975	drilled	steel	152	18.5	hard - good	domestic	
2757	Highway 23	4802897	478338	unknown	drilled	steel	152	24	good	domestic	
2835A	Highway 23	4803350	478713	>100 years	dug	stone	>1000	4.5	good	domestic	
6063	Perth Line 20	4803542	478348	>30 years	drilled	steel	152	60-90	hard - good	domestic livestock	farm with ~ 175 head of cattle, old dug well located on property but no longer used
<b>Site 25-185 FLAT CREEK BRIDGE</b>											
5975	Perth Line 16	4801938	478171	unknown	dug/bored	concrete	914	<3	hard - good	domestic	drinking water sourced from spring adjacent to creek on neighbouring property, spring less than 3m deep - no problems to date
6004	Perth Line 16	4802168	477804	1991	drilled	PVC	unknown	91	hard - sulphur	domestic	access restricted by concrete capping original dug well
6012	Perth Line 16	4802265	477791	>50 yrs	dug	concrete	unknown	6 to 9	unknown	domestic	owner indicated approx. 0.5 m of water in well when last checked

## SUMMARY OF WELL SURVEY RESULTS

MN <sup>1</sup>	STREET	NORTHING <sup>2</sup>	EASTING <sup>2</sup>	APPROXIMATE YEAR CONSTRUCTED	WELL TYPE	CASING TYPE	CASING DIAMETER (mm)	WELL DEPTH (m)	WATER QUALITY	WATER USE	COMMENTS
Site 25-332 FISH CREEK CULVERT											
5964	Perth Line 10	4798520	476014	unknown	drilled	steel	152	63	hard - good	domestic	owner indicated old dug well on property but no longer in use, water at 4.5m from surface when last checked
2131	Highway 23	4798421	475619	1996	drilled	steel	152	79.0	hard - good	domestic	
2105	Highway 23	4798272	475596	1975	bored	concrete	>1000	5.5	good	domestic	owner indicated another well on property but not in use, water approximately 60cm from surface when last checked
70719	Highway 23	4798356	475340	mid-1990s	drilled	steel	152	67	high in magnesium	domestic	owner indicated water high in Mg due to crack in bedrock below casing - had it cameraed and believes it happened during construction of new bridge in front of house

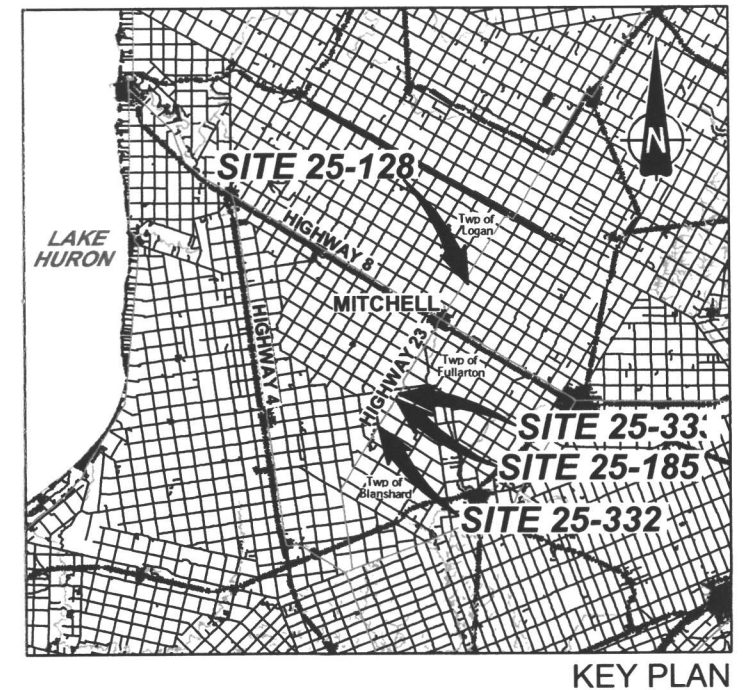
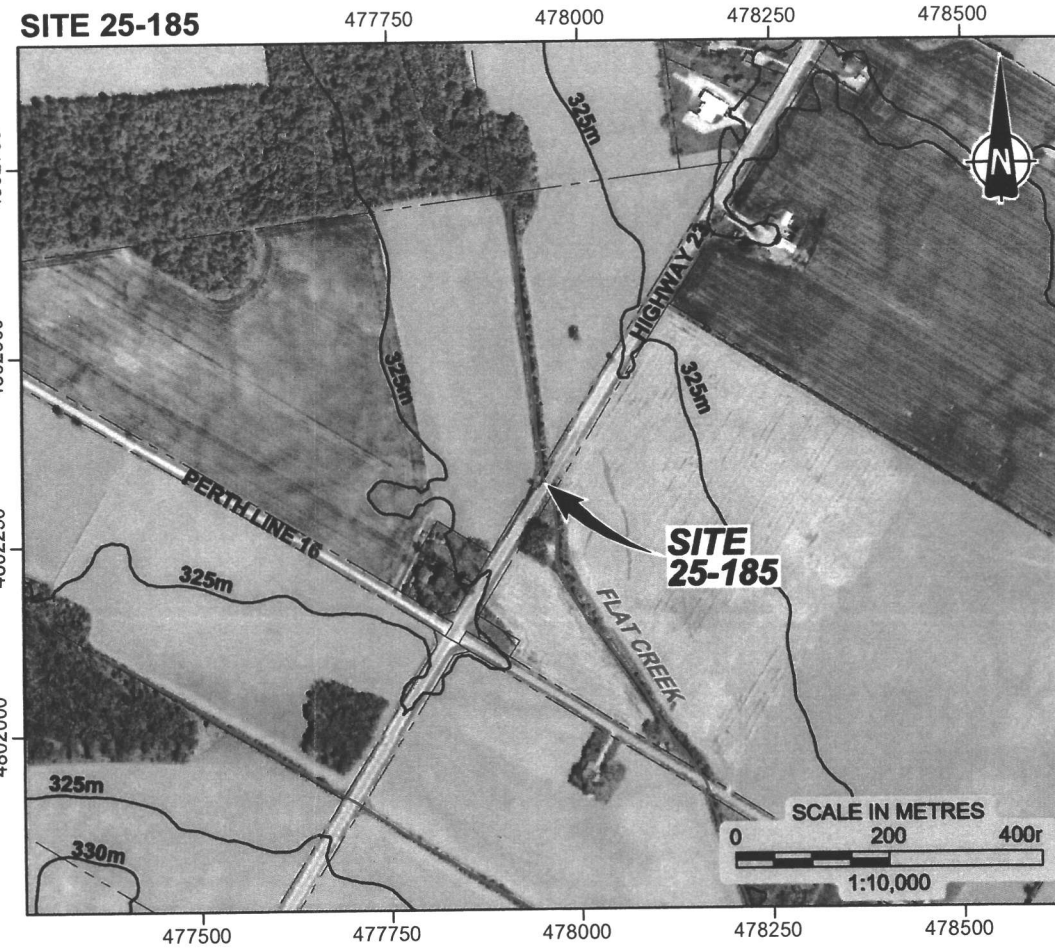
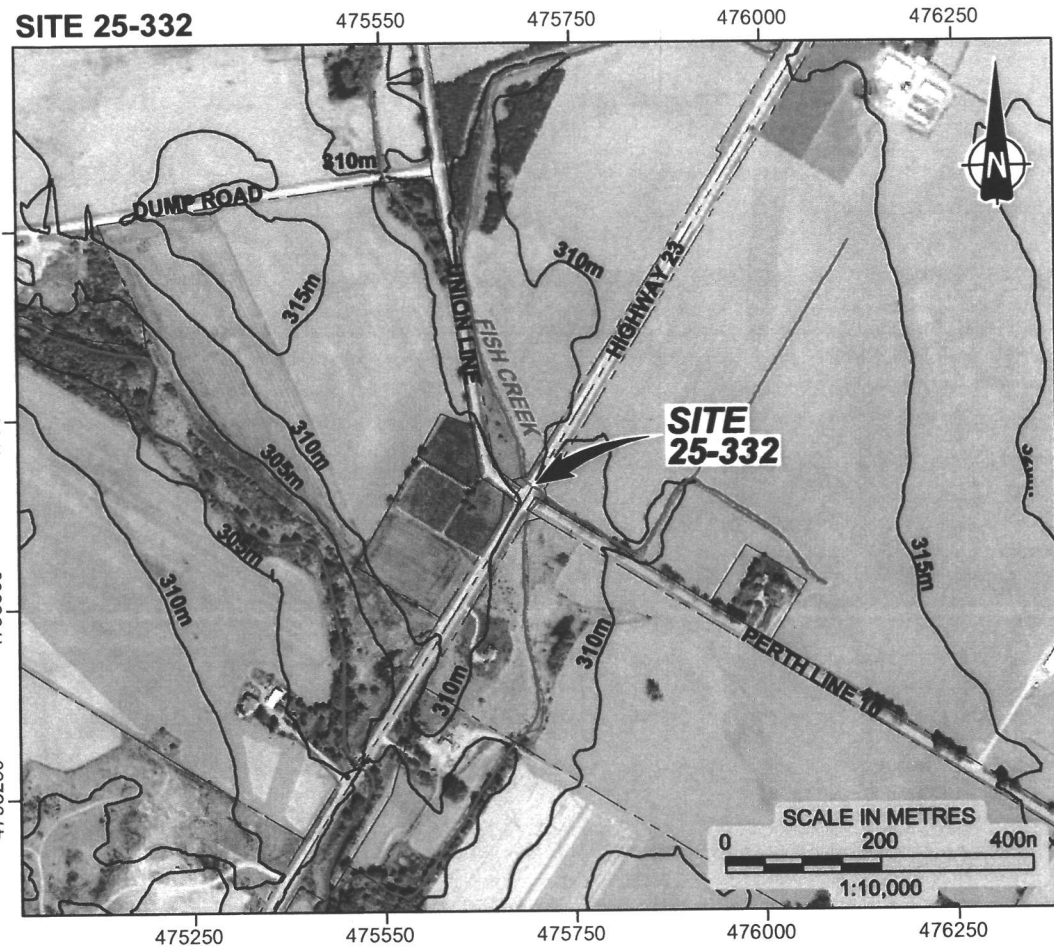
## NOTES:

1. MN refers to Municipal Number/Emergency Response Number.
2. Approximate UTM coordinates (NAD 83) determined from handheld GPS (+/- 10 metres), values in *italics* estimated from mapping (+/- 100 metres).
3. "-" indicates information not available or not applicable.
4. Table to be read in conjunction with accompanying report.

Prepared By: DM  
Checked By: KC



Drawing file: 1011320029-3000-R01001.dwg Jan 05, 2012 - 1:00pm



#### LEGEND

LINES:  
--- APPROXIMATE PROPERTY LIMITS  
— TOPOGRAPHIC CONTOUR (m)  
— DRAINAGE FEATURE

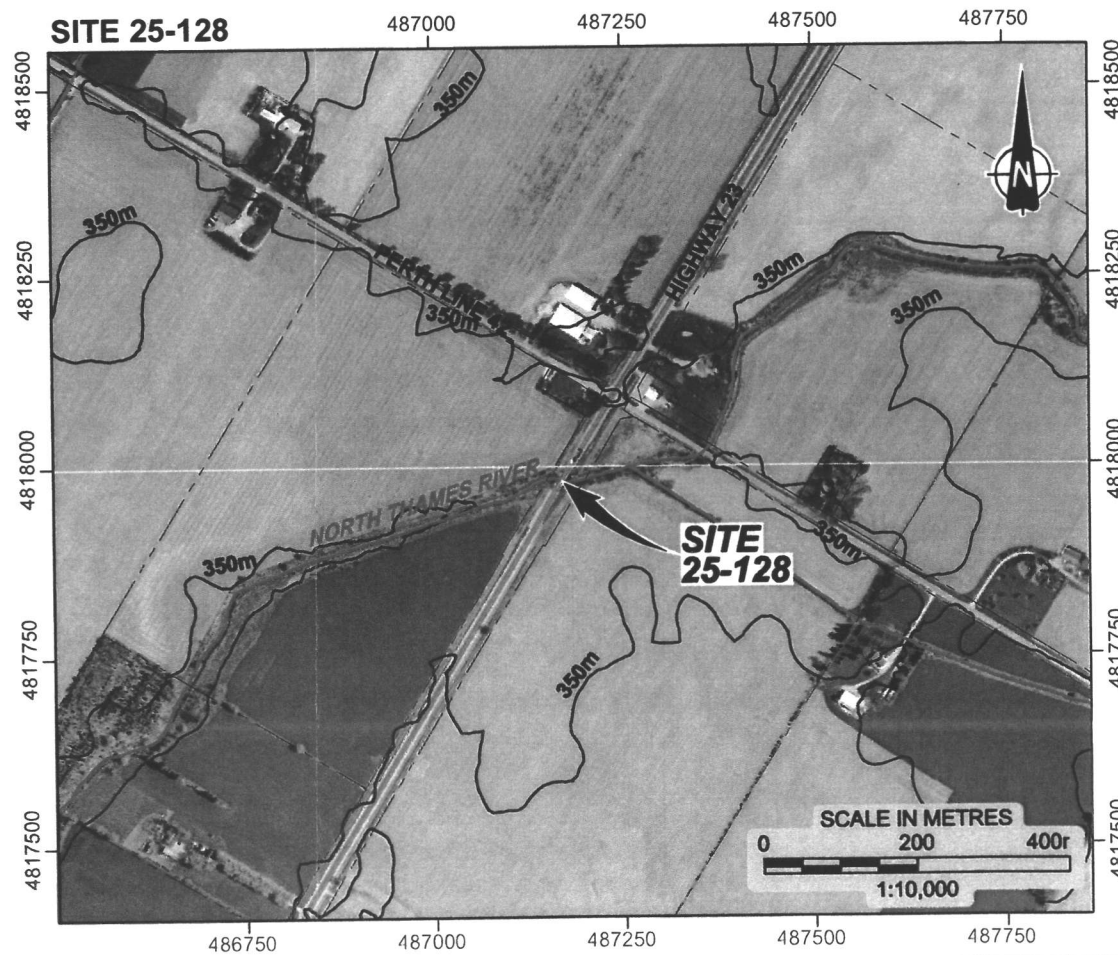
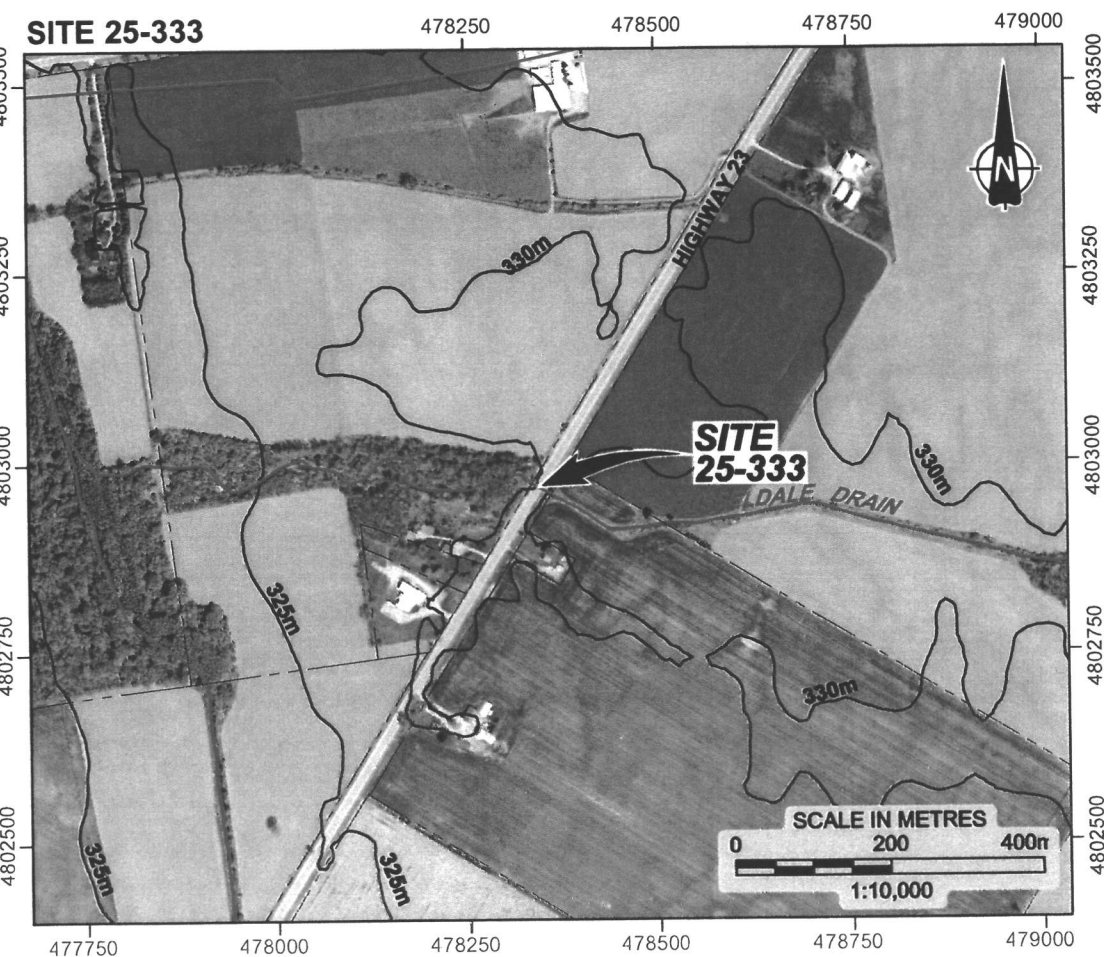
OTHER:  
487250 EASTING (NAD83, UTM Zone 17)  
4817500 NORTHING (NAD83, UTM Zone 17)


#### REFERENCE

PLAN BASED ON ORTHOGRAPHIC PHOTOGRAPHS PROVIDED BY CLIENT; ONTARIO BASE MAPPING PROVIDED BY THE GEOGRAPHYNETWORK ([www.geographynetwork.ca](http://www.geographynetwork.ca)) AS OF NOVEMBER 4, 2010; AND CANMAP STREETFILES V.2005.4

#### NOTES

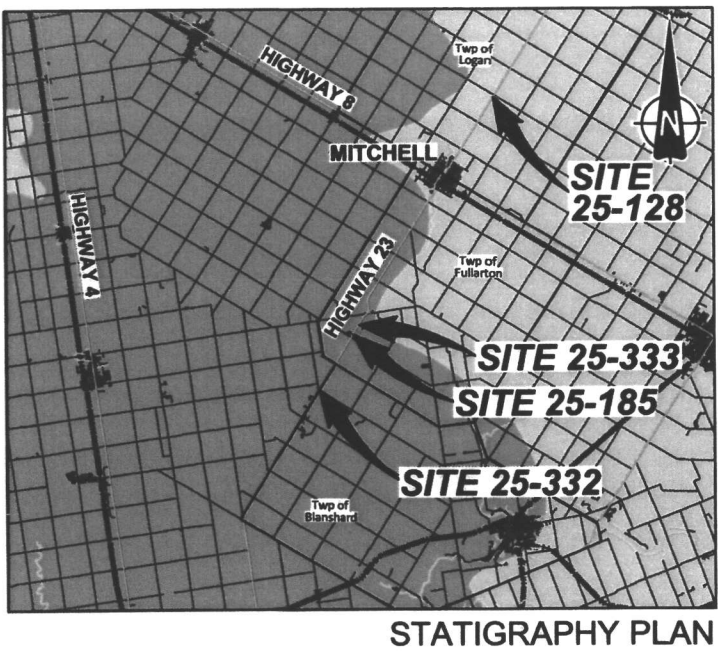
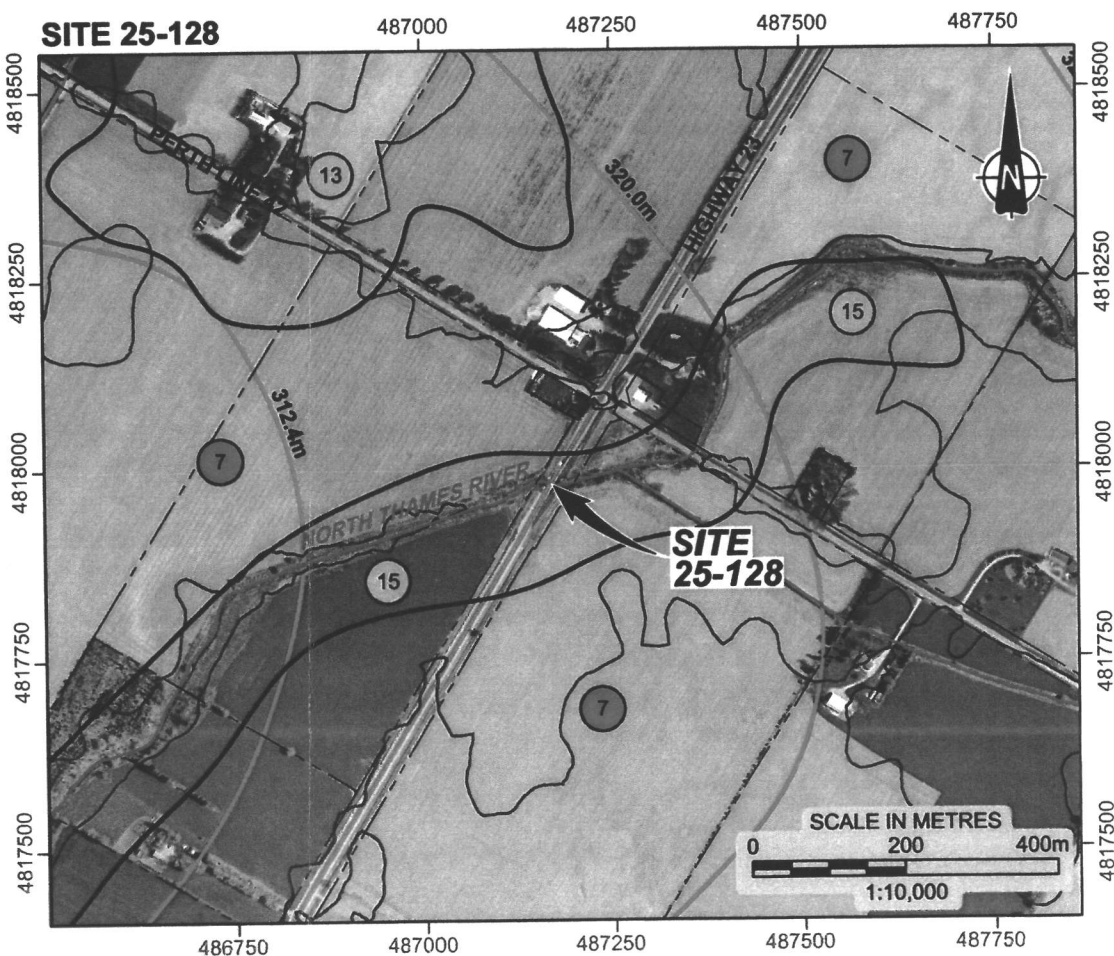
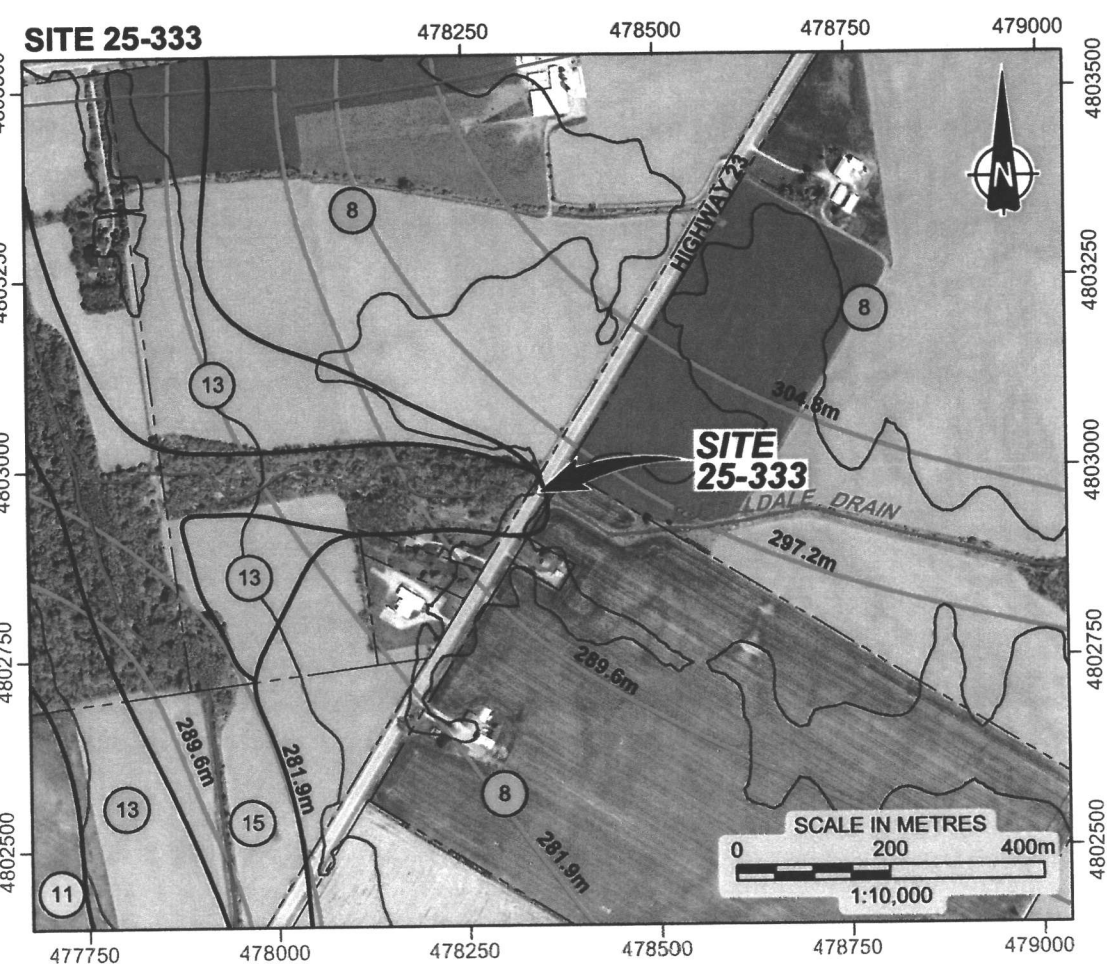
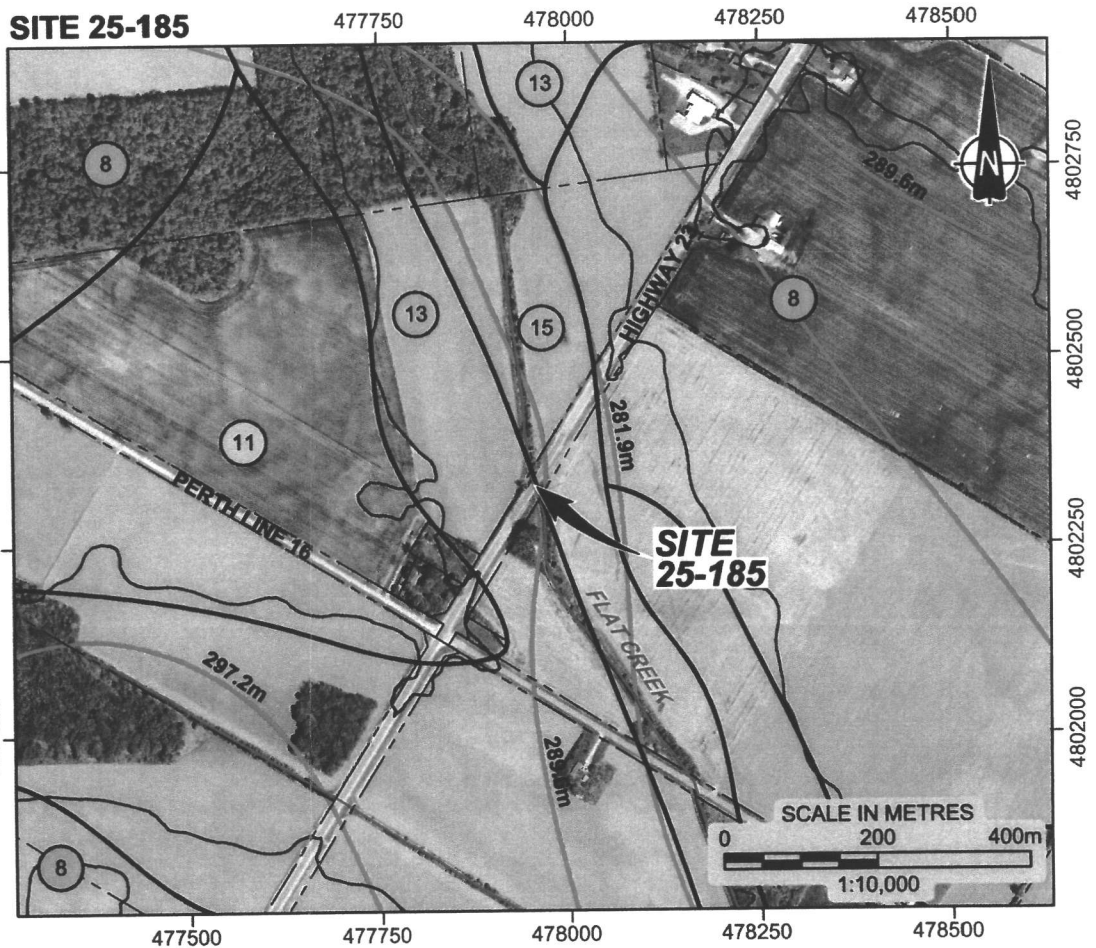
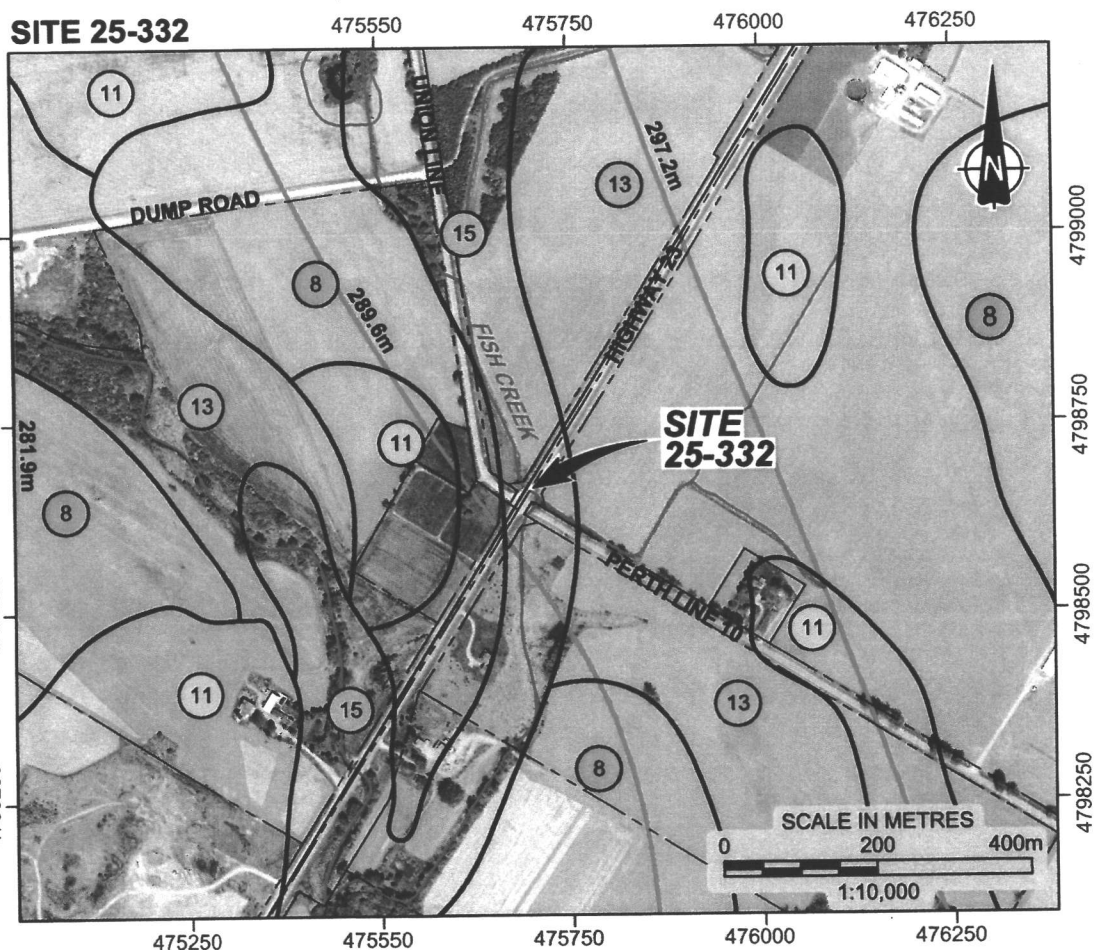
THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.  
ALL LOCATIONS ARE APPROXIMATE ONLY.



PROJECT		HIGHWAY 23 GWP 3043-06-00 MINISTRY OF TRANSPORTATION ONTARIO WEST REGION	
TITLE		STUDY AREA LOCATION PLAN	
 Golder Associates LONDON, ONTARIO	PROJECT No. 10-1132-0029		FILE No. 1011320029-3000-R01001
	CADD DBH/ANG SEPT. 29/11		SCALE AS SHOWN REV.
	CHECK [Signature] 5/12		FIGURE 1



Drawing file: 1011320029-3000-R01002.dwg Jan 05, 2012 - 1:03pm



#### LEGEND

##### LINES:

- APPROXIMATE PROPERTY LIMITS
- BEDROCK ELEVATION CONTOUR (m)
- DRAINAGE FEATURE

##### FORMATIONS:

- LUCAS
- DUNDEE

##### QUATERNARY GEOLOGY:

- 7 ELMA TILL: silt till
- 8 RANNOCH TILL: clayey to silty till
- 11 Outwash gravel
- 13 Lacustrine silt and clay, some outwash silt
- 15 Alluvium: young stream deposits of gravel, sand, and silt

##### OTHER:

- 487250 EASTING (NAD83, UTM Zone 17)
- 4817500 NORTHING (NAD83, UTM Zone 17)

#### REFERENCE

PLAN BASED ON ORTHOGRAPHIC PHOTOGRAPHS PROVIDED BY CLIENT; ONTARIO BASE MAPPING PROVIDED BY THE GEOGRAPHYNETWORK ([www.geographynetwork.ca](http://www.geographynetwork.ca)) AS OF NOVEMBER 4, 2010; QUATERNARY GEOLOGY MAP#2366, 1976 AND MAP#P.1233, 1977; BEDROCK GEOLOGY MAP#1263A, MAP #P.266, 1974, BEDROCK TOPOGRAPHY MAP#2366, 1976 AND MAP#P.1974; AND CANMAP STREETFILES V.2005.4.

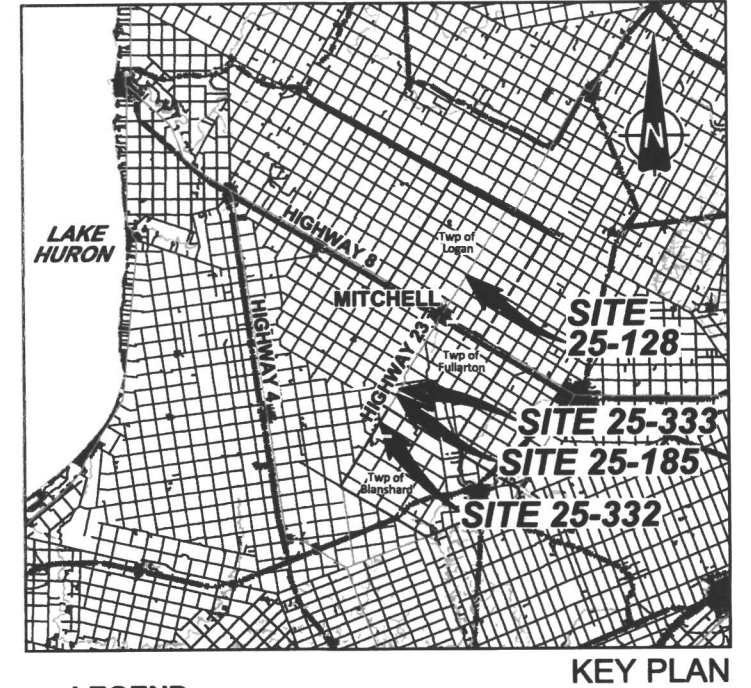
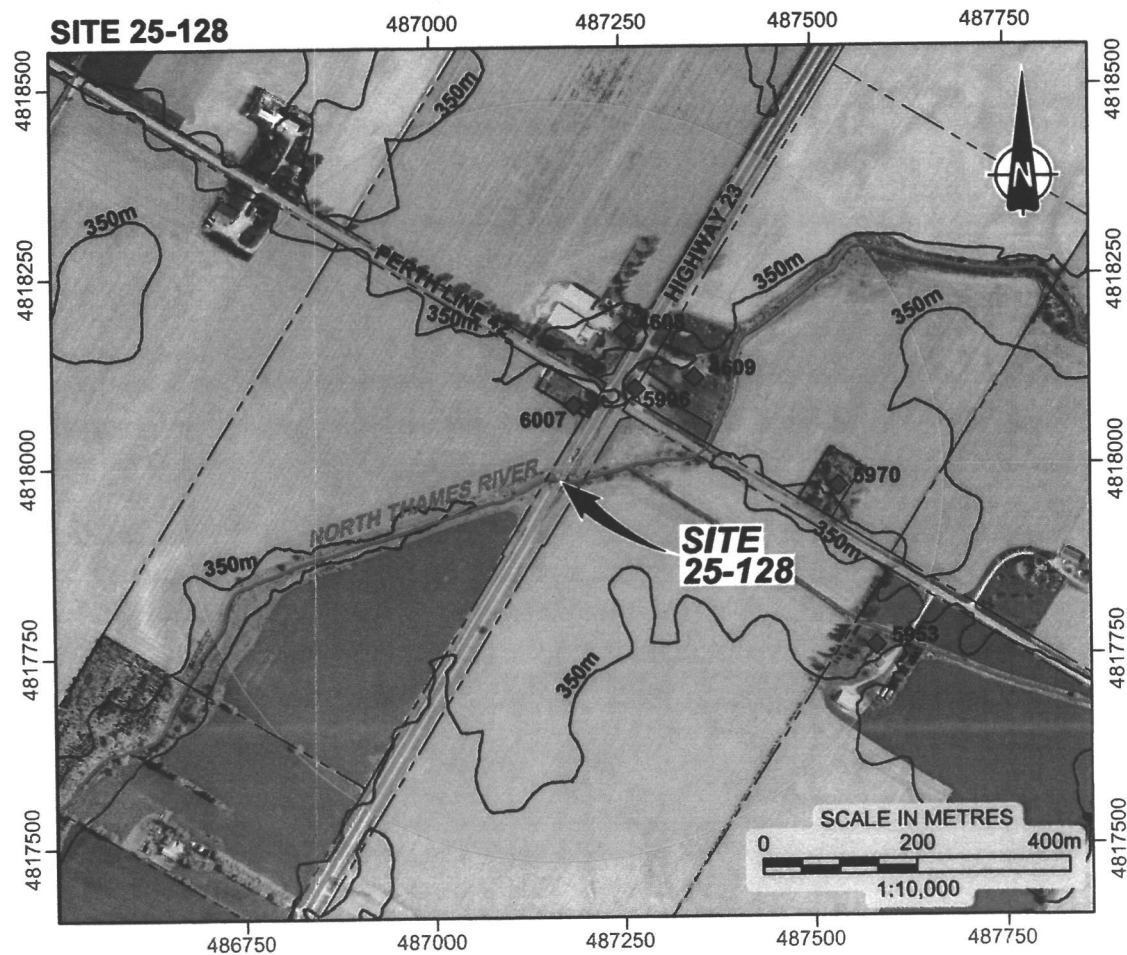
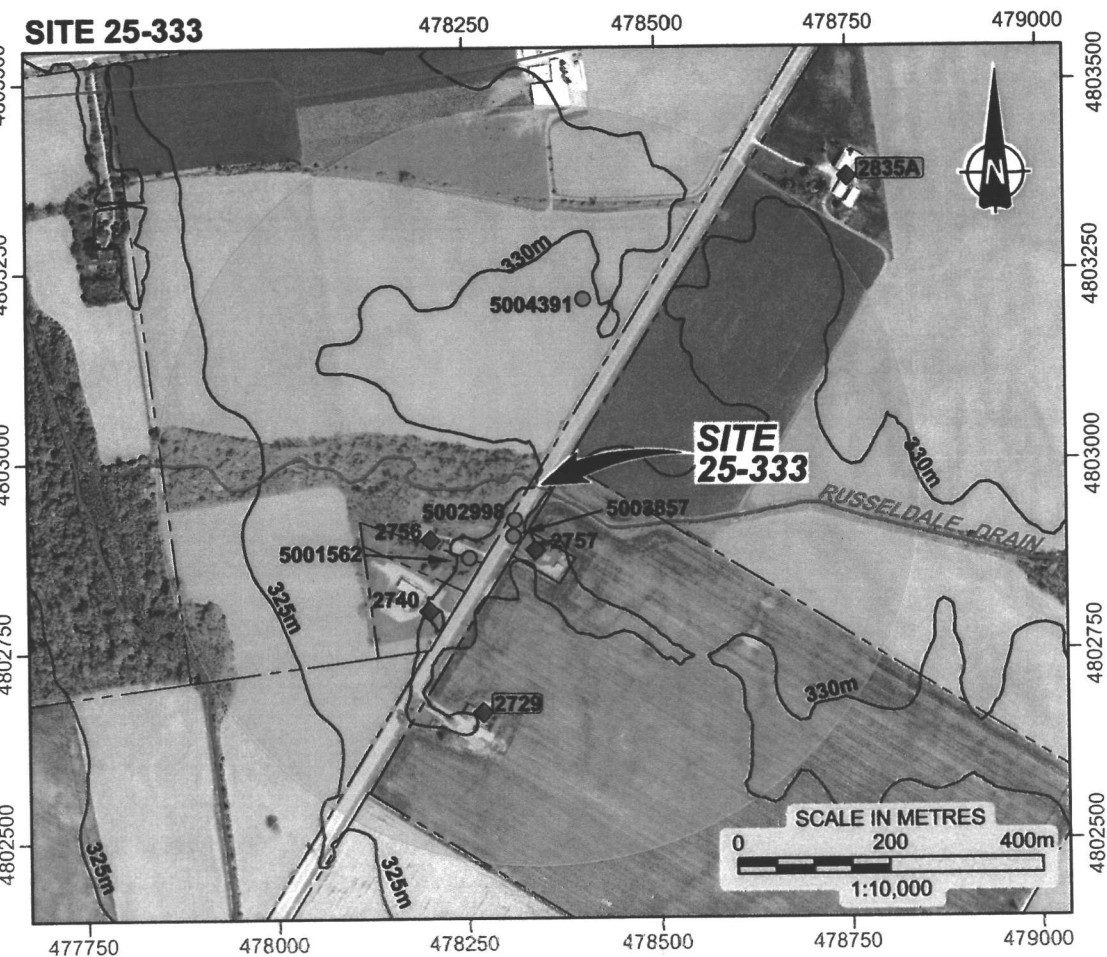
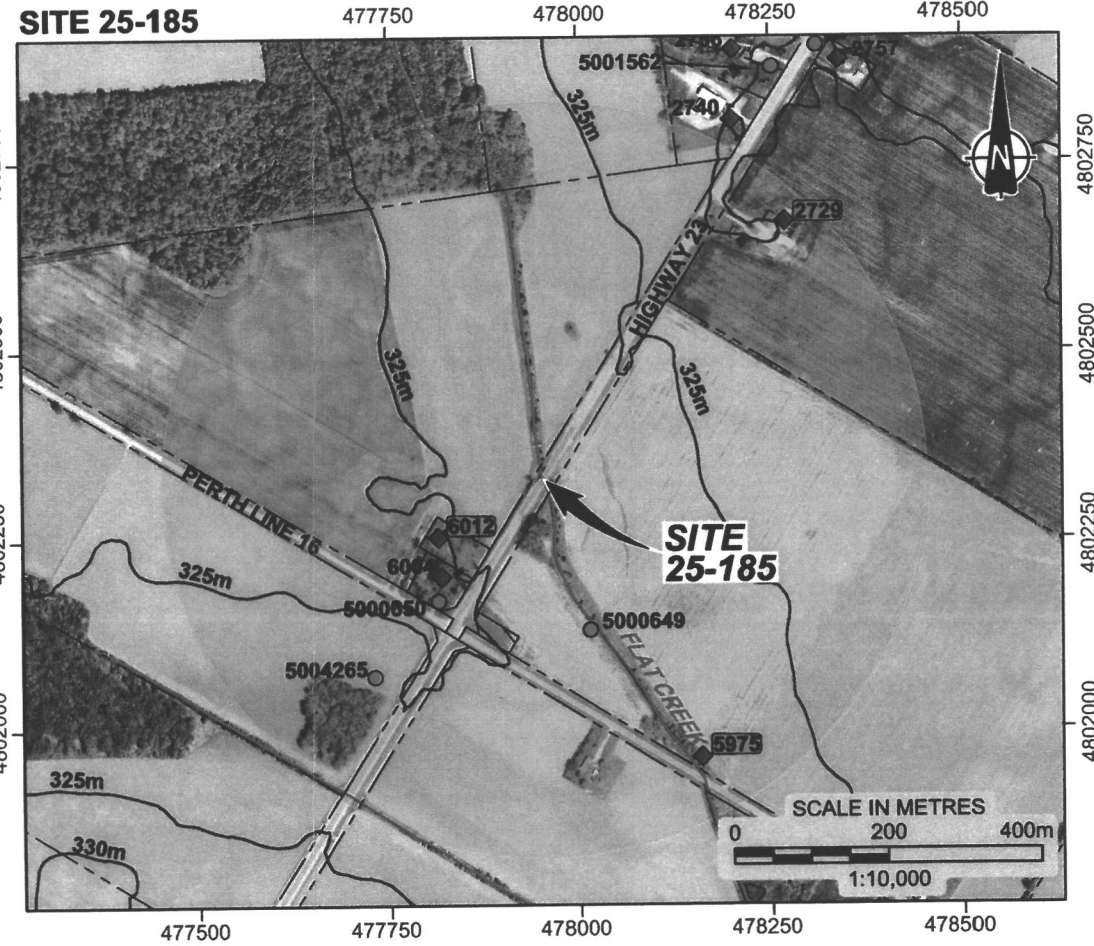
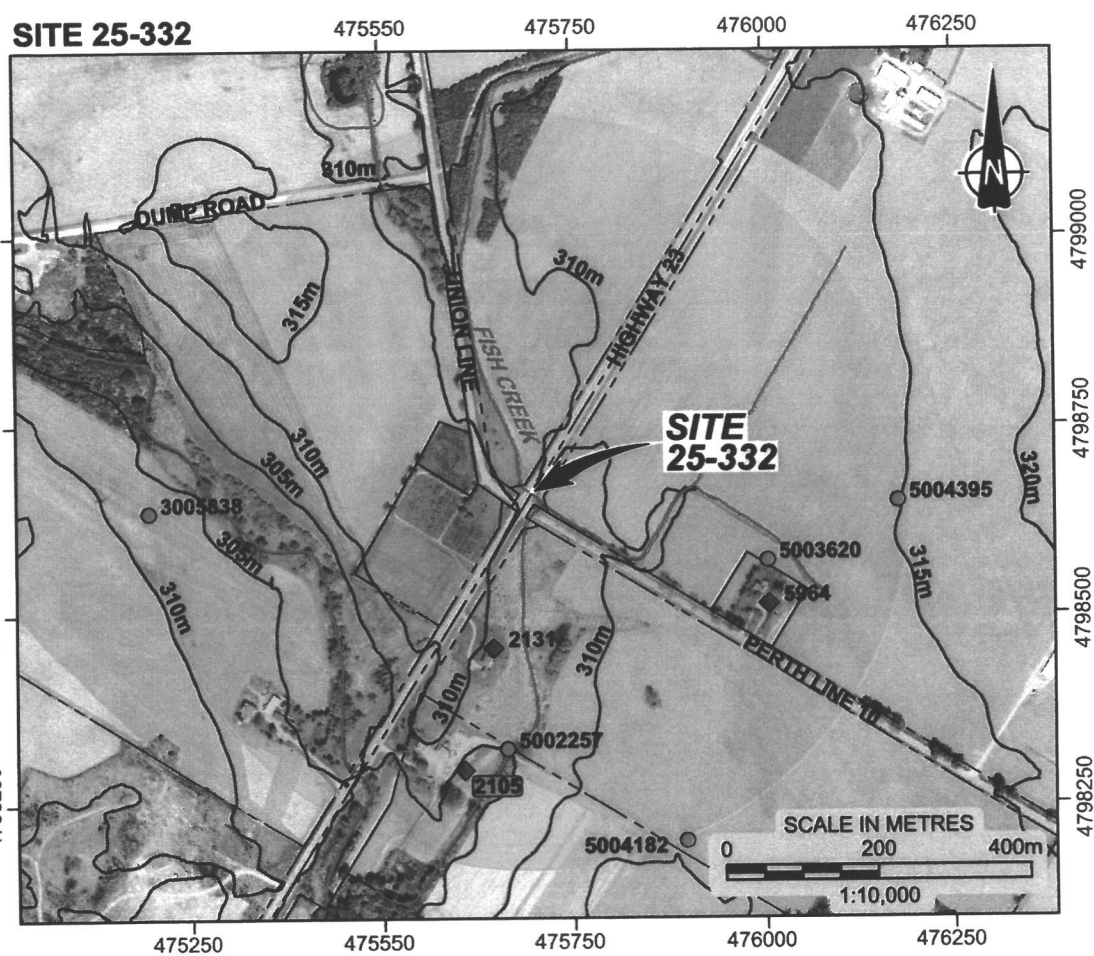
#### NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT. ALL LOCATIONS ARE APPROXIMATE ONLY.

PROJECT		HIGHWAY 23	
		GWP 3043-06-00	
		MINISTRY OF TRANSPORTATION ONTARIO	
		WEST REGION	
TITLE			
QUATERNARY AND BEDROCK GEOLOGY AND BEDROCK TOPOGRAPHY			
PROJECT No. 10-1132-0029		FILE No.1011320029-3000-R01002	
CADD	DCH/AMG	SEPT. 29/11	SCALE AS SHOWN
CHECK	DEL	8-5/12	REV.
Golder Associates LONDON, ONTARIO		FIGURE 2	



Drawing file: 1011320029-3000-R01003.dwg Jan 05, 2012 - 1:05pm



- LEGEND**
- SYMBOLS:**
- WATER WELL IDENTIFIED IN MOE RECORDS
  - ◆ ACTIVE WATER WELL IDENTIFIED DURING DOOR TO DOOR SURVEY
  - WELL REPORTED TO BE SHALLOW
- LINES:**
- - - APPROXIMATE PROPERTY LIMITS
  - TOPOGRAPHIC CONTOUR (m)
  - DRAINAGE FEATURE
- AREAS:**
- APPROXIMATELY 500m FROM SITE
- OTHER:**
- 487250 EASTING (NAD83, UTM Zone 17)  
4817500 NORTHING (NAD83, UTM Zone 17)

**REFERENCE**

PLAN BASED ON ORTHOGRAPHIC PHOTOGRAPHS PROVIDED BY CLIENT; ONTARIO BASE MAPPING PROVIDED BY THE GEOGRAPHYNETWORK ([www.geographynetwork.ca](http://www.geographynetwork.ca)) AS OF NOVEMBER 4, 2010; WATER WELL RECORDS AS OF JANUARY 7, 2011; AND CANMAP STREETFILES.V.2005.4

**NOTES**

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.  
ALL LOCATIONS ARE APPROXIMATE ONLY.

PROJECT		HIGHWAY 23 GWP 3043-06-00 MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION			
TITLE					
WATER WELL LOCATION PLAN					
 <b>Golder Associates</b> LONDON, ONTARIO	PROJECT No.		10-1132-0029		FILE No.1011320029-3000-R01003
					SCALE AS SHOWN REV.
	CADD	PCH/AMG	SEPT. 29/11		<b>FIGURE 3</b>
	CHECK	SKZ	J 5/17		



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**HYDROGEOLOGICAL ASSESSMENT**  
**GWP 3043-06-00 - HIGHWAY 23**

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# **APPENDIX A**

**Site 25-128 - Foundation Engineering Drawings, Record of  
Borehole Sheets and Laboratory Data  
Geocres No. 40P11-19**

**METRIC**  
 DIMENSIONS ARE IN METRES AND/OR  
 MILLIMETRES UNLESS OTHERWISE SHOWN.  
 STATIONS IN KILOMETRES + METRES.

CONT No.  
 WP No. 3043-06-00

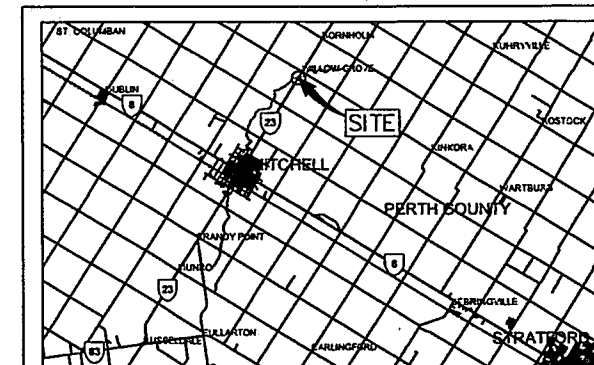


**NORTH THAMES RIVER BRIDGE**  
 HIGHWAY 23 STRUCTURE REPLACEMENTS  
 BOREHOLE LOCATIONS AND SOIL STRATA

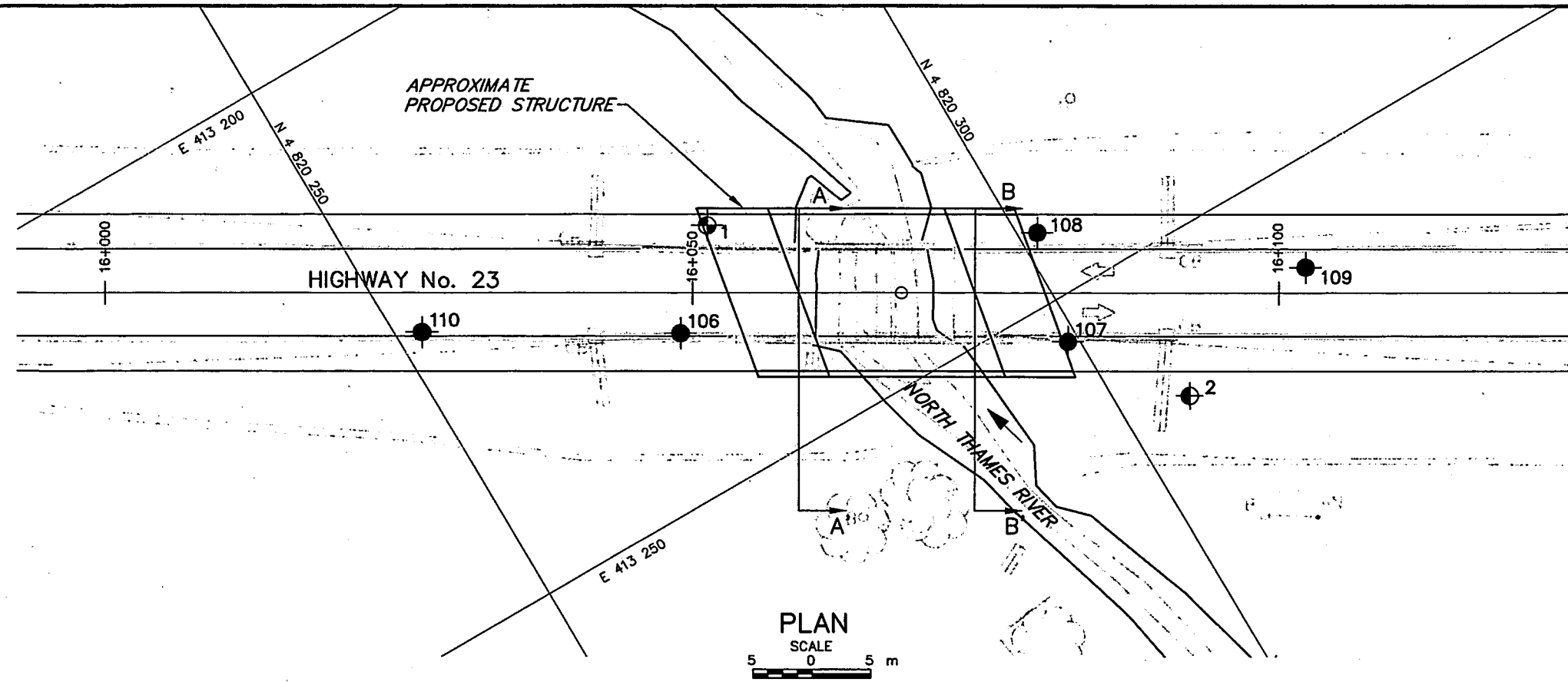
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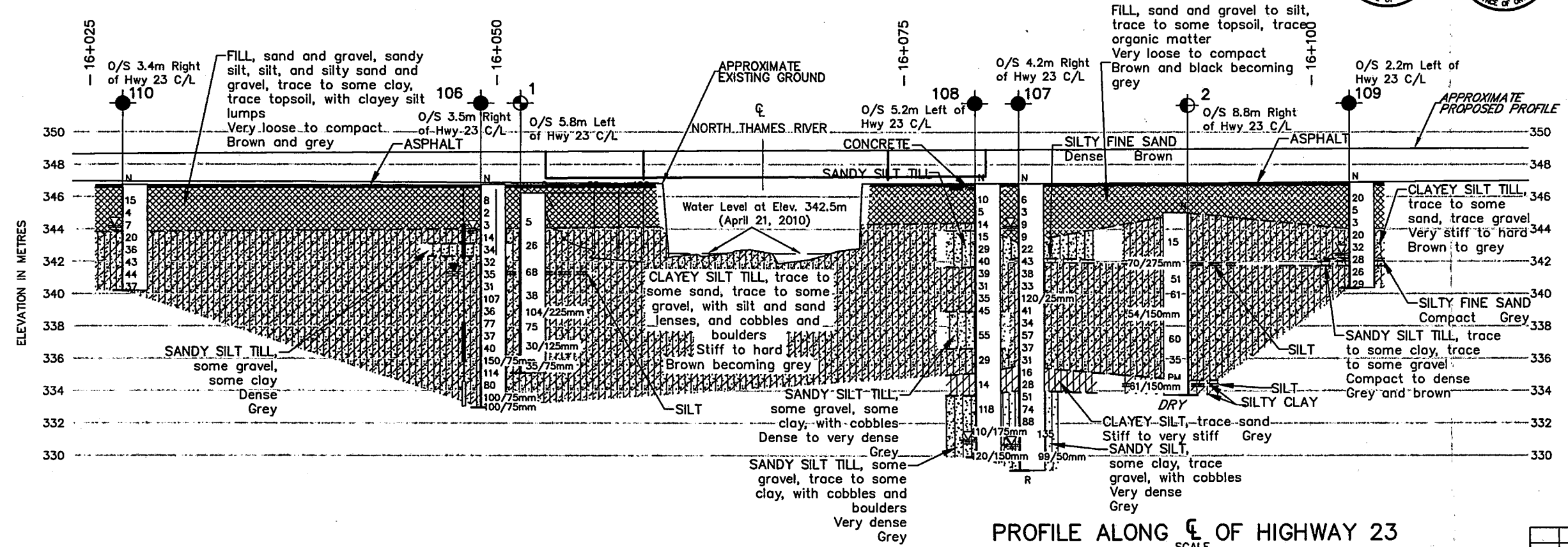
**Golder Associates Ltd.**  
 LONDON, ONTARIO, CANADA



SCALE IN KILOMETRES  
 0 1 2



**PLAN**  
 SCALE  
 5 0 5 m



**PROFILE ALONG C/L OF HIGHWAY 23**

SCALE  
 3 0 3 m

**LEGEND**

- Borehole (Current Investigation)
- Borehole and Cone (Geocres 40P11-7)
- Borehole (Geocres 40P11-7)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Encountered WL
- DRY Borehole dry during drilling
- Measured WL (June 8, 2011)
- R Refusal

CO-ORDINATES (MTM ZONE 11)			
No.	ELEVATION	NORTHING	EASTING
106	346.77	4 820 271.0	413 236.3
107	346.84	4 820 299.1	413 253.7
108	346.85	4 820 301.5	413 244.2
109	346.92	4 820 319.8	413 258.4
110	346.76	4 820 252.1	413 225.1
Geocres 40P11-7			
1	346.25	4 820 277.7	413 229.5
2	345.03	4 820 305.7	413 262.9

**NOTES**

This drawing is for subsurface information only. Surface details and features are for conceptual illustration. Subsurface information has been inferred from Geocres No. 40P11-7.

**REFERENCE**

Bore plans provided in digital format by Delcon.

NO.	DATE	BY	REVISION
Geocres No. 40P11-19			
HWY. 23			PROJECT NO. 10-1132-0029
SUBM'D. DUP	CHKD.	DATE: Sept. 12/11	SITE: 25-128
DRAWN: DCH/LMK	CHKD.	APPD.	DWG. 1



**METRIC**  
 DIMENSIONS ARE IN METRES AND/OR  
 MILLIMETRES UNLESS OTHERWISE SHOWN.  
 STATIONS IN KILOMETRES + METRES.

CONT No.  
 WP No. 3043-06-00

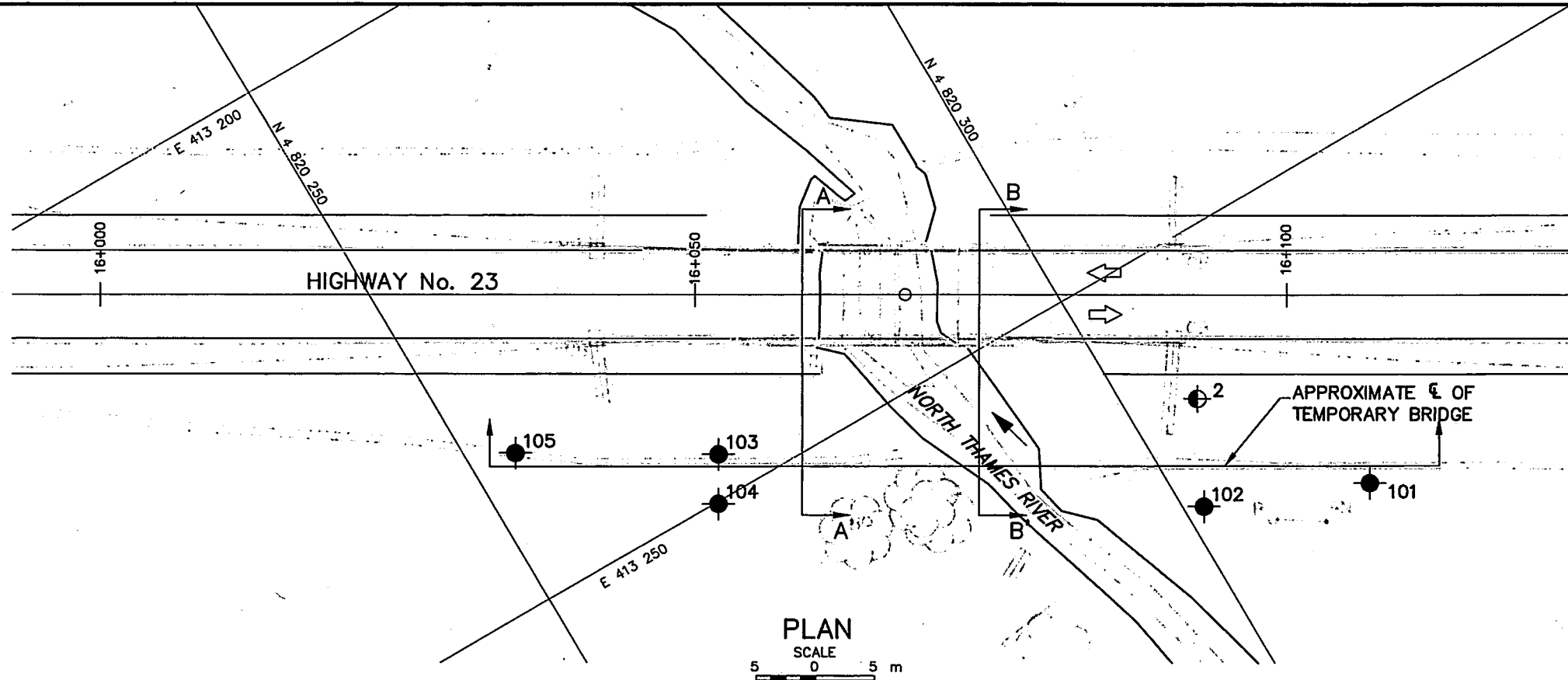
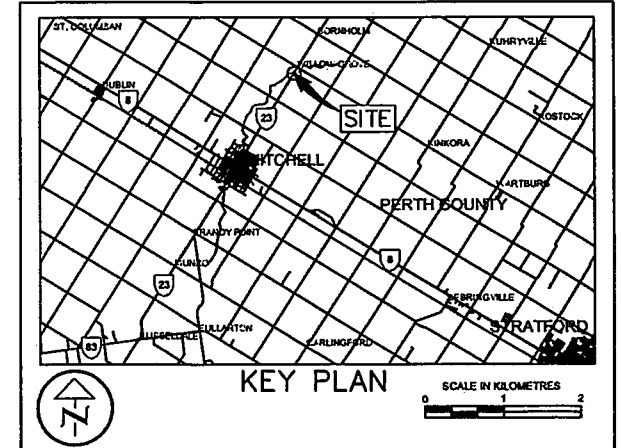








**NORTH THAMES RIVER BRIDGE**  
 HIGHWAY 23 STRUCTURE REPLACEMENTS  
 BOREHOLE LOCATIONS AND SOIL STRATA

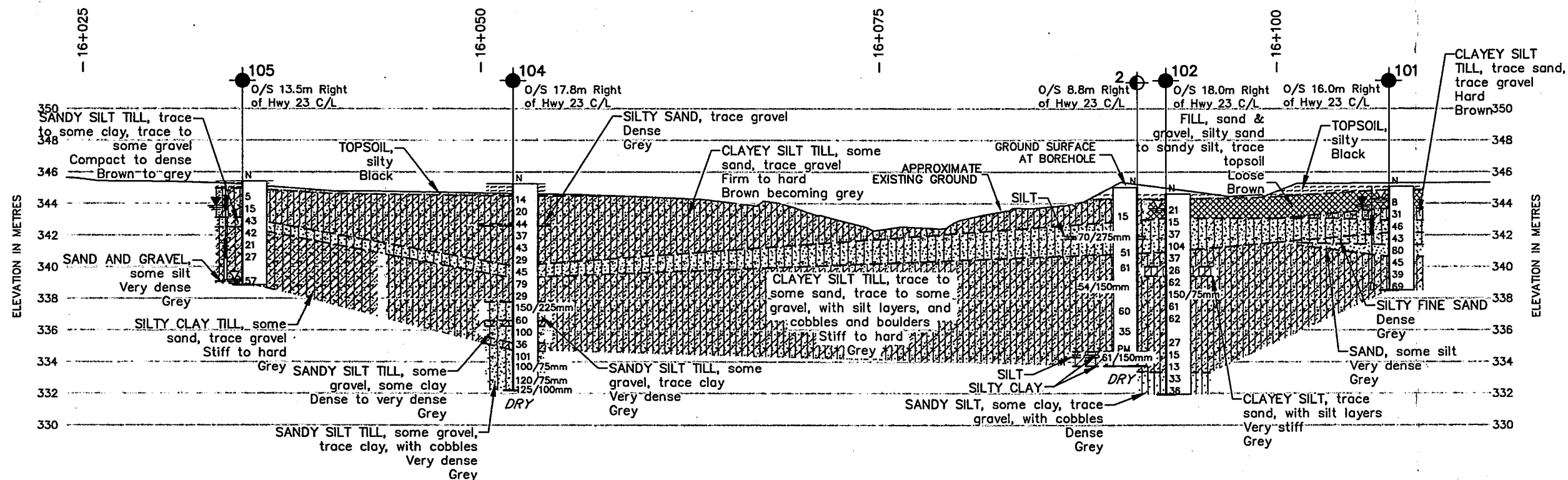
SHEET



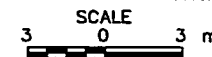
**Golder Associates Ltd.**  
 LONDON, ONTARIO, CANADA



LEGEND			
	Borehole (Current Investigation)		
	Borehole (Geocres 40P11-7)		
	Seal		
	Piezometer		
N	Standard Penetration Test Value		
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)		
	Encountered WL		
DRY	Borehole dry during drilling		
	Measured WL (June 8, 2011)		
		CO-ORDINATES (MTM ZONE 11)	
No.	ELEVATION	NORTHING	EASTING
101	345.08	4 820 314.7	413 276.5
102	344.61	4 820 301.6	413 271.1
103	344.95	4 820 268.5	413 246.6
104	345.26	4 820 266.3	413 250.2
105	345.43	4 820 253.9	413 237.9
Geocres 40P11-7			
2	345.03	4 820 305.7	413 262.9



PROFILE ALONG APPROXIMATE ALIGNMENT OF TEMPORARY BRIDGE



**NOTES**  
 This drawing is for subsurface information only. Surface details and features are for conceptual illustration. Subsurface information has been inferred from Geocres No. 40P11-7.

**REFERENCE**  
 Base plans provided in digital format by Delcan.

NO.	DATE	BY	REVISION
Geocres No. 40P11-19			
HWY.	23	PROJECT NO.	10-1132-0029
SUBM'D.	DUP	CHKD.	DATE: Aug. 24/11
DRAWN:	DCH/LMK	CHKD.	APPD.
		SITE:	25-128
		DWG.	2

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 101</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4820314.7 ; E 413276.5		<b>ORIGINATED BY</b> RA	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, SOLID STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> May 17, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
345.08	GROUND SURFACE													
0.00	TOPSOIL, silty Black													
0.20	FILL, sandy silt, some gravel Loose Brown		1	SS	8									
343.71														
1.37	CLAYEY SILT TILL, trace sand, trace gravel Hard Brown		2	SS	31									
342.95														
2.13	SANDY SILT TILL, some clay, trace gravel Dense Brown		3	SS	46								8 33 41 18	
342.18														
2.90	SILTY FINE SAND Dense Grey		4	SS	43									
341.42														
3.66	SAND, some silt Very dense Grey		5	SS	80									
340.66														
4.42	CLAYEY SILT TILL, some sand, some gravel, with cobbles Hard Grey		6	SS	45								14 21 32 33	
			7	SS	39									
			8	SS	69									
338.53	END OF BOREHOLE													
6.55	Groundwater encountered at about elev. 344.3m during drilling on May 17, 2011.  Water level measured at elev. 342.37m on May 18, 2011.  Water level measured at elev 343.91m on June 8, 2011.													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

PROJECT		10-1132-0029		RECORD OF BOREHOLE No 102		1 OF 1		METRIC						
W.P.		3043-08-00		LOCATION		N 4820301.6 E 413271.1		ORIGINATED BY RA						
DIST		HWY 23		BOREHOLE TYPE		POWER AUGER, HOLLOW STEM		COMPILED BY LMK						
DATUM		GEODETIC		DATE		May 17, 2011		CHECKED BY <i>TP</i>						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
344.61	GROUND SURFACE													
0.00	TOPSOIL, silty Black													
0.33	FILL, silty sand, trace gravel, trace topsoil													
0.61	Brown													
	FILL, sand and gravel, trace silt		1	SS	21									
	Compact Brown													
343.09														
1.52	SANDY SILT TILL, some clay, trace gravel, with cobbles		2	SS	15									
	Compact to very dense Brown													
			3	SS	37									4 29 49 18
			4	SS	104									
340.95														
3.66	CLAYEY SILT TILL, some sand, some gravel, with cobbles		5	SS	37									
	Hard Grey													
340.04														
4.57	CLAYEY SILT, trace sand, with silt layers		6	SS	26									
	Very stiff Grey													
339.43														
5.18	CLAYEY SILT TILL, some sand, trace to some gravel, with cobbles and boulders		7	SS	62									5 31 37 27
	Stiff to hard Grey		8	SS	150/75mm									
			9	SS	61									
			10	SS	62									
			11	SS	27									
			12	SS	15									1 17 35 47
			13	SS	13									
333.33														
11.28	SANDY SILT, some clay, trace gravel, with cobbles		14	SS	33									7 29 51 13
	Dense Grey													
			15	SS	36									
331.96														
12.65	END OF BOREHOLE													
	Groundwater encountered at about elev. 343.7m during drilling on May 17, 2011.													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11



**RECORD OF BOREHOLE No 103**

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820268.5, E 413246.6

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE May 18, 2011

CHECKED BY *TP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
344.95	GROUND SURFACE							20 40 60 80 100						
0.00	TOPSOIL, silty Black							20 40 60 80 100						
344.49														
0.46	SANDY SILT, trace rootlets Brown													
0.76	CLAYEY SILT TILL, trace to some sand, trace to some gravel, with cobbles Very stiff to hard Brown becoming grey at about elev 343.6m		1	SS	15		344							
			2	SS	18		343							
			3	SS	34		342							
			4	SS	41		341							5 25 44 26
			5	SS	38		340							
			6	SS	21		339							
			7	SS	38		338							
339.01			8	SS	66		337							
5.94	SILTY CLAY TILL, some sand, trace to some gravel, with cobbles Hard Grey		9	SS	41		336							8 27 37 28
337.48			10	SS	105		335							
7.47	SANDY SILT TILL, some gravel, trace to some clay, with cobbles and boulders, possible boulder from about elev. 335.0m to 334.6m Dense to very dense Grey		11	SS	39		334							
			12	SS	61		333							
			13	SS	100/ 25mm									
			14	SS	79									13 32 40 15
			15	SS	150/ 50mm									
			16	SS	150/ 50mm									
332.71														
12.24	END OF BOREHOLE  Borehole dry during drilling on May 18, 2011.													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO GDT 06/09/11

+ 3, x 3. Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No 105

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820253.9; E 413237.9

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE May 18, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
345.43	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30				
0.00	TOPSOIL, silty Black													
344.98														
0.45	CLAYEY SILT TILL, some sand, trace gravel Firm to very stiff Brown becoming grey at about elev 344.0m		1	SS	5									
			2	SS	15									2 23 52 23
343.14														
2.29	SANDY SILT TILL, some gravel, trace clay Dense Grey		3	SS	43									
342.53														
2.90	SILTY CLAY TILL, some sand, trace gravel Stiff to hard Grey		4	SS	42									
			5	SS	21									5 22 27 46
			6	SS	27									
339.09			7	SS	57									
6.34	SAND AND GRAVEL, some silt Very dense Grey													
6.55	END OF BOREHOLE													
	Groundwater encountered at about elev. 339.2m during drilling on May 18, 2011.  Water level measured at elev. 341.92m upon installation on May 18, 2011.  Water level measured at elev. 343.87m on June 8, 2011.													

# RECORD OF BOREHOLE No 106

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820271 0, E 413236.3

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE May 19, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
346.77	ROAD SURFACE							20 40 60 80 100							
0.00	ASPHALT														
0.20	FILL, sand and gravel, trace silt Brown														
346.01															
0.76	FILL, silt, some sand, trace to some gravel, trace to some clay, trace topsoil, with clayey silt lumps Very loose to loose Brown		1	SS	8		Cuttings								
			2	SS	2									11 12 60 17	
			3	SS	3										
344.03															
2.74	CLAYEY SILT TILL, trace sand, trace gravel Stiff Brown		4	SS	14										
343.11							Holeplug								
3.66	SANDY SILT TILL, some gravel, some clay Dense Grey		5	SS	34									12 32 39 17	
342.35															
4.42	CLAYEY SILT TILL, some sand, trace to some gravel, with cobbles and boulders Hard Grey		6	SS	32										
			7	SS	35										
			8	SS	31		Cuttings								
			9	SS	107									4 24 39 33	
			10	SS	36										
			11	SS	77										
			12	SS	37										
			13	SS	40		Holeplug								
			14	SS	150/ 75mm										
			15	SS	114		Filter sand							21 27 38 14	
			16	SS	80										
			17	SS	100/ 75mm		Standpipe								
			18	SS	100/ 75mm										
332.98 13.79	END OF BOREHOLE Groundwater encountered at about elev. 344.0m during drilling on May 19, 2011. Water level measured at elev. 334.73m on May 19, 2011.														

**RECORD OF BOREHOLE No 107**

1 OF 2

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820299.1 E 413253.7

ORIGINATED BY RA/MR

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM / TRI-CONE

COMPILED BY LMK

DATUM GEODETIC

DATE May 24, 2011 - June 08, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
346.84	ROAD SURFACE							20 40 60 80 100						
0.00	ASPHALT							○ UNCONFINED + FIELD VANE						
0.16	FILL, sand and gravel, trace silt Brown							● QUICK TRIAXIAL × LAB VANE						
346.08								20 40 60 80 100						
0.76	FILL, sandy silt, trace to some gravel, some clayey topsoil Very loose to loose Brown		1	SS	6		346							
			2	SS	3		345							4 19 59 18
344.71														
2.13	FILL, silt, some sand, trace organic matter Loose Black and grey		3	SS	9		344							
344.25														
2.59	FILL, sand and gravel, trace to some silt Loose Brown		4	SS	9		343							
343.18														
3.66	SANDY SILT TILL, some gravel, trace clay Compact Brown		5	SS	22		342							
342.27														
4.57	SILTY FINE SAND Dense Brown		6	SS	43		341							
4.79	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Hard Grey		7	SS	38		340							2 17 35 46
			8	SS	33		339							
			9	SS	120/ 25mm		338							
			10	SS	41		337							
			11	SS	34		336							
			12	SS	57		335							
			13	SS	37		334							8 25 36 31
			14	SS	31		333							
335.56														
11.28	CLAYEY SILT, trace sand Very stiff Grey		15	SS	16		332							
			16	SS	28									
334.04														
12.80	SANDY SILT, some clay, trace gravel, with cobbles Very dense Grey		17	SS	51									
			18	SS	74									
			19	SS	88									

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 107</b>		2 OF 2	<b>METRIC</b>
<b>W.P.</b> 3043-06-00	<b>LOCATION</b> N 4820289.1 E 413253.7	<b>ORIGINATED BY</b> RAMR			
<b>DIST</b> HWY 23	<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM / TRI-CONE	<b>COMPILED BY</b> LMK			
<b>DATUM</b> GEODETIC	<b>DATE</b> May 24, 2011 - June 08, 2011	<b>CHECKED BY</b> TP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
								20 40 60 80 100							
329.95	SANDY SILT, some clay, trace gravel, with cobbles Very dense Grey		20	SS	135	▽	331							3 20 63 14	
16.89	SANDY SILT TILL, some gravel, trace clay, with cobbles and boulders Very dense Grey		21	SS	99/ 50mm		330								
329.10															
17.74	END OF BOREHOLE Auger refusal on probable boulder at about elev. 329.1m  Groundwater encountered at about elev. 344.2m during drilling on May 24, 2011 and about elev. 330.7m on June 8, 2011.														

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

## METRIC

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820301.5 :E 413244.2

ORIGINATED BY MR

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE June 07, 2011

CHECKED BY *TP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa					
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT $w_p$ $w$ $w_l$ WATER CONTENT (%) 10 20 30					
346.85	ROAD SURFACE											
0.00	ASPHALT											
0.25	FILL, sand and gravel, trace silt											
0.38	Brown											
	CONCRETE											
	FILL, silty sand and gravel											
345.48	Compact Brown		1	SS	10							
1.37	FILL, sandy silt, trace gravel, some topsoil											
	Loose to compact		2	SS	5							
	Brown and black, becoming grey and black at about elev. 344.9m											
344.41												
2.44	CLAYEY SILT TILL, trace sand, trace gravel		3	SS	14							
343.95	Stiff Grey											
2.90	SANDY SILT TILL, some clay, trace to some gravel		4	SS	15							
	Compact to dense Grey											
			5	SS	29							
			6	SS	40							
341.67												
5.18	CLAYEY SILT TILL, some sand, trace gravel, with silt and sand lenses		7	SS	39							
	Hard Grey											
			8	SS	31							
			9	SS	35							
338.93			10	SS	45							
7.92	SANDY SILT TILL, some gravel, some clay, with cobbles											
	Dense to very dense Grey											
			11	SS	55							
336.64												
10.21	CLAYEY SILT TILL, some sand, trace gravel											
	Very stiff Grey		12	SS	29							
335.12												
11.73	CLAYEY SILT, trace sand											
	Stiff Grey		13	SS	14							
333.74												
13.11	SANDY SILT TILL, trace to some gravel, some clay, with cobbles											
	Very dense Grey		14	SS	118							

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 108</b>		2 OF 2	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4820301.5 ; E 413244.2		<b>ORIGINATED BY</b> MR	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> June 07, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100	20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
	SANDY SILT TILL, trace to some gravel, some clay, with cobbles Very dense Grey		15	SS	110/ 175mm	▽	331								
329.93 16.92	END OF BOREHOLE  Groundwater encountered at about elev. 331.0m during drilling on June 7, 2011		16	SS	120/ 150mm		330								

LDN\_MTO\_06 10-1132-0029-7000 GPJ LDN\_MTO\_GDT 06/09/11



# RECORD OF BOREHOLE No 109

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820319.8 : E 413258.4

ORIGINATED BY MR

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE June 07, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
346.92	ROAD SURFACE													
0.00	ASPHALT													
0.19	FILL, sand and gravel, trace silt													
346.33	Brown													
0.59	FILL, silty sand, some gravel, trace topsoil		1	SS	20		346							
345.55	Compact Brown													
1.37	FILL, silt, some clay, trace gravel, trace to some topsoil		2	SS	5		345							
344.79	Loose Brown													
2.13	FILL, silty sand and gravel		3	SS	3									
344.02	Very loose Brown						344							
2.90	CLAYEY SILT TILL, trace to some sand, trace gravel		4	SS	20									
	Very stiff to hard													
	Brown becoming grey at about elev 342.5m		5	SS	32		343							0 7 51 42
342.20														
4.72	SILTY FINE SAND		6	SS	28		342							
4.88	Compact Grey													
5.18	SANDY SILT TILL, some gravel, trace clay		7	SS	26									
	Compact Grey						341							
	CLAYEY SILT TILL, some sand, trace gravel		8	SS	29									8 30 34 28
340.37	Very stiff Grey													
6.55	END OF BOREHOLE													
	Groundwater encountered at about elev. 342.5m during drilling on June 7, 2011													

LDN\_MTO\_06 10-1132-0029-7000 GPJ LDN\_MTO\_GDT 06/09/11

# RECORD OF BOREHOLE No 110

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4820252.1, E 413225.1

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

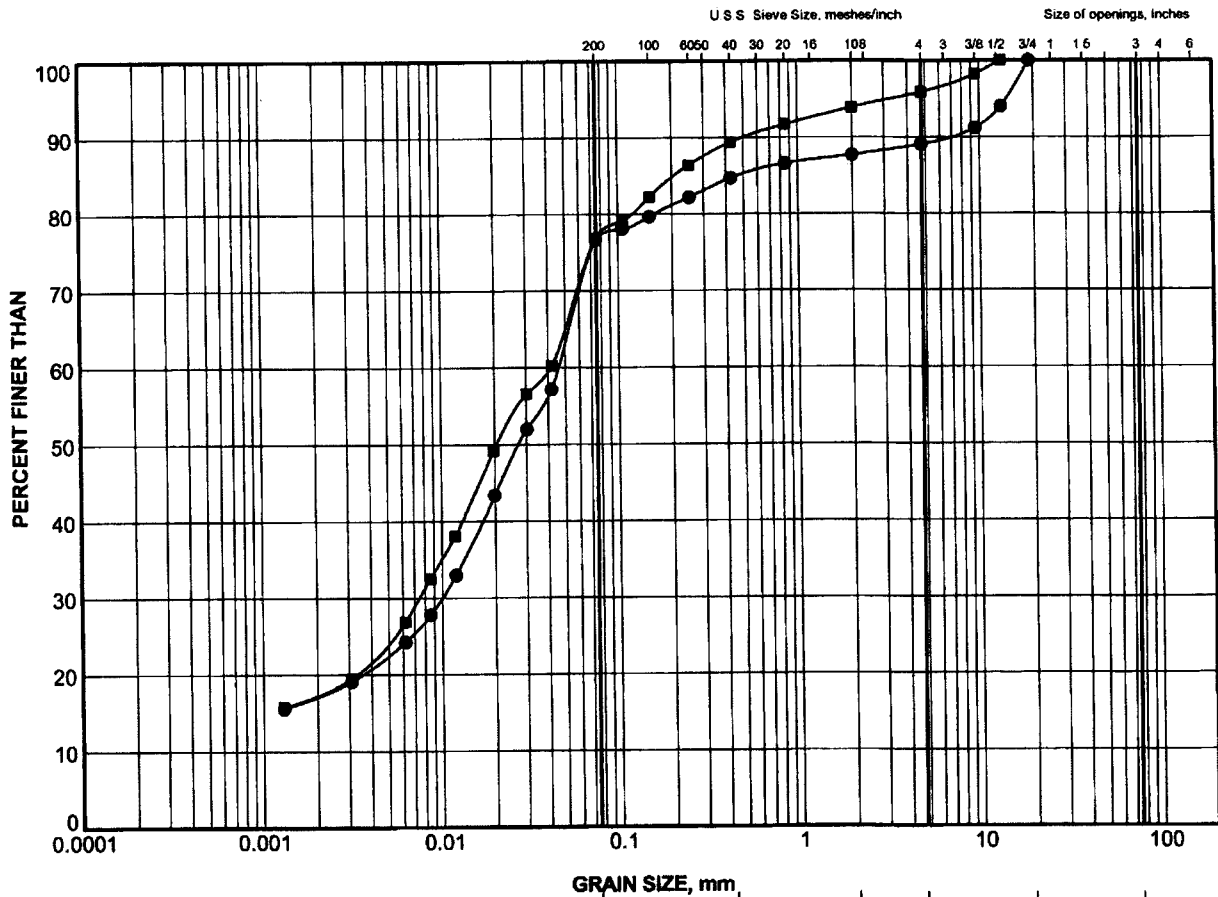
DATUM GEODETIC

DATE May 19, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× LAB VANE						
346.76	ROAD SURFACE						20 40 60 80 100		10 20 30						
0.00	ASPHALT														
0.19	FILL, sand and gravel, trace silt Brown														
346.16															
0.60	FILL, sandy silt, trace to some gravel, trace clay, topsoil, rootlets Loose to Compact Brown and grey		1	SS	15		346								
			2	SS	4		345								
344.17			3	SS	7		344								
2.59	FILL, silty sand and gravel Loose														
343.86															
2.90	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Very stiff to hard Brown becoming grey at about elev. 343.1m		4	SS	20		343						4 22 47 27		
			5	SS	36										
			6	SS	43		342								
			7	SS	44		341						1 17 58 24		
			8	SS	37										
340.21	END OF BOREHOLE														
6.55	Groundwater encountered at about elev. 344.2m during drilling on May 19, 2011.														

LDN\_MTO\_08 10-1132-0029-7000.GPJ LDN\_MTO GDT 06/09/11

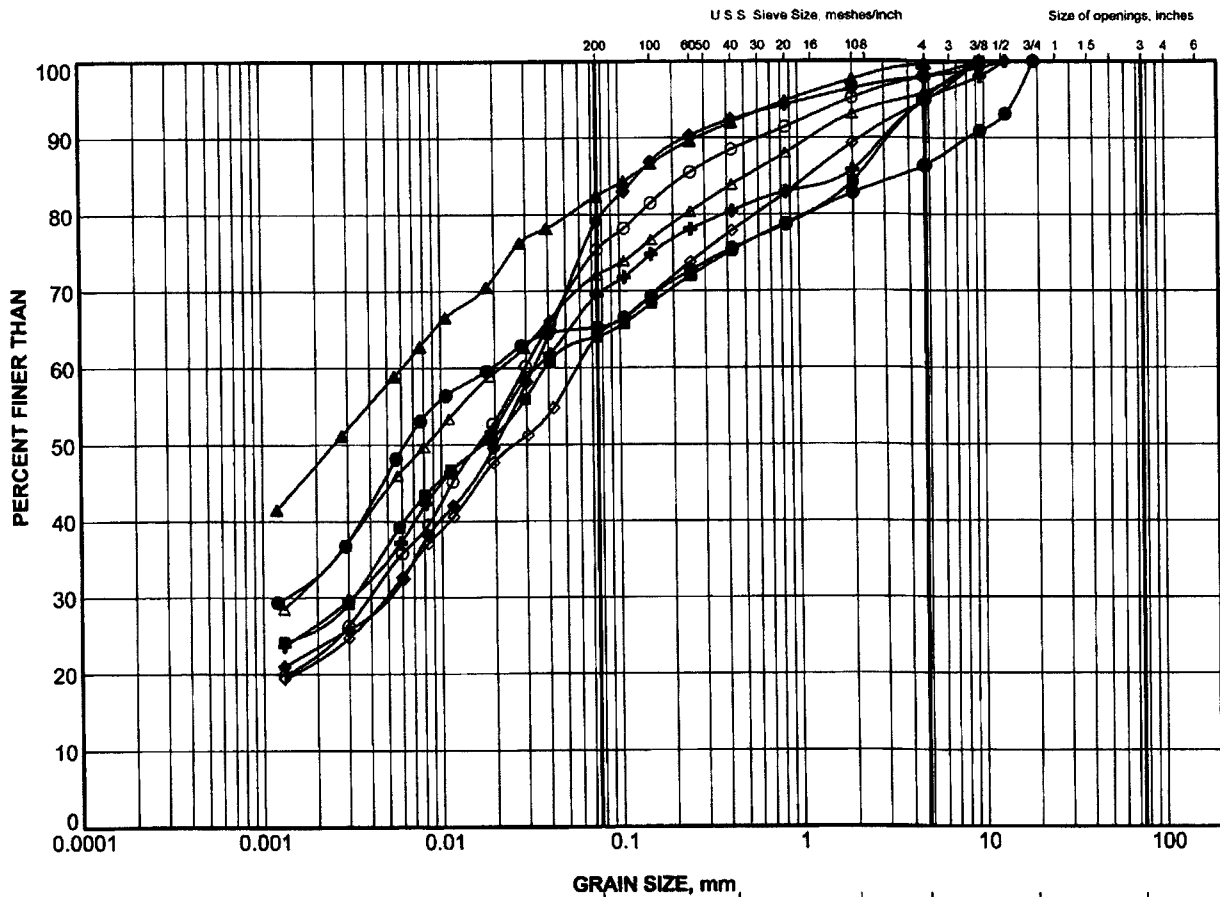


CLAY AND SILT	GRAIN SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	106	2	345.0
■	107	2	345.1

PROJECT				NORTH THAMES RIVER BRIDGE HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-128			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No		10-1132-0029		FILE No		10-1132-0029-7000-F010A1	
DRAWN		DCH/AMG		SCALE		N/A	
CHECK		TP		REV			
		SEPT. 12/11					
		FIGURE A-1					




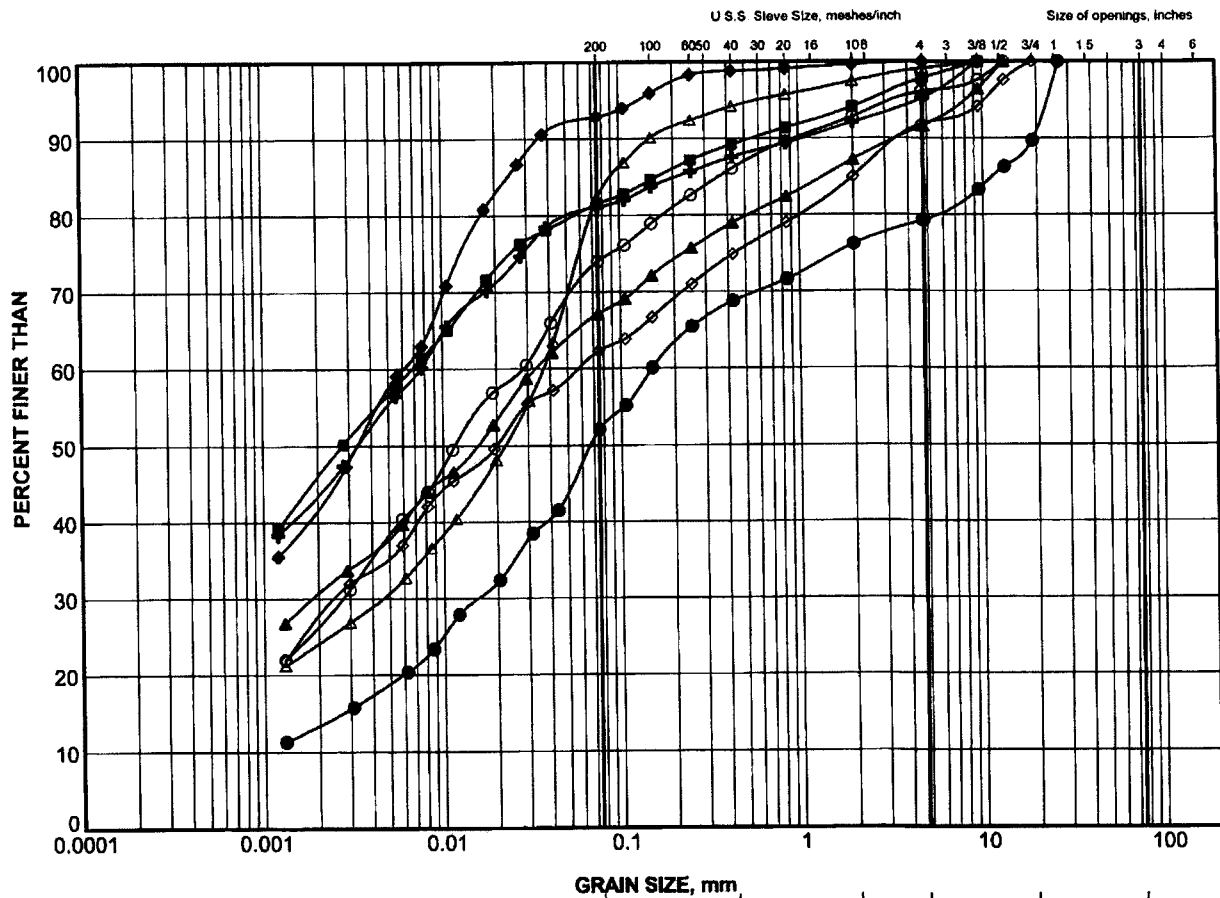


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	6	340.3
■	102	7	339.1
▲	102	12	334.5
◆	103	4	341.7
◆	104	5	341.2
◇	104	8	338.9
○	105	2	343.7
△	106	9	339.7

PROJECT				NORTH THAMES RIVER BRIDGE HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-128			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F010A2	
DRAWN		DCH/AMG		SCALE		N/A	
CHECK		TP		REV		12/11	
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-2</b>			



CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	106	15	335.1
■	107	8	340.5
▲	107	13	336.7
+	108	8	340.5
◆	109	4	343.6
◇	109	8	340.6
○	110	4	343.5
△	110	7	341.2

PROJECT

NORTH THAMES RIVER BRIDGE  
HIGHWAY 23 STRUCTURE REPLACEMENTS  
GWP 3043-06-00, SITE 25-128

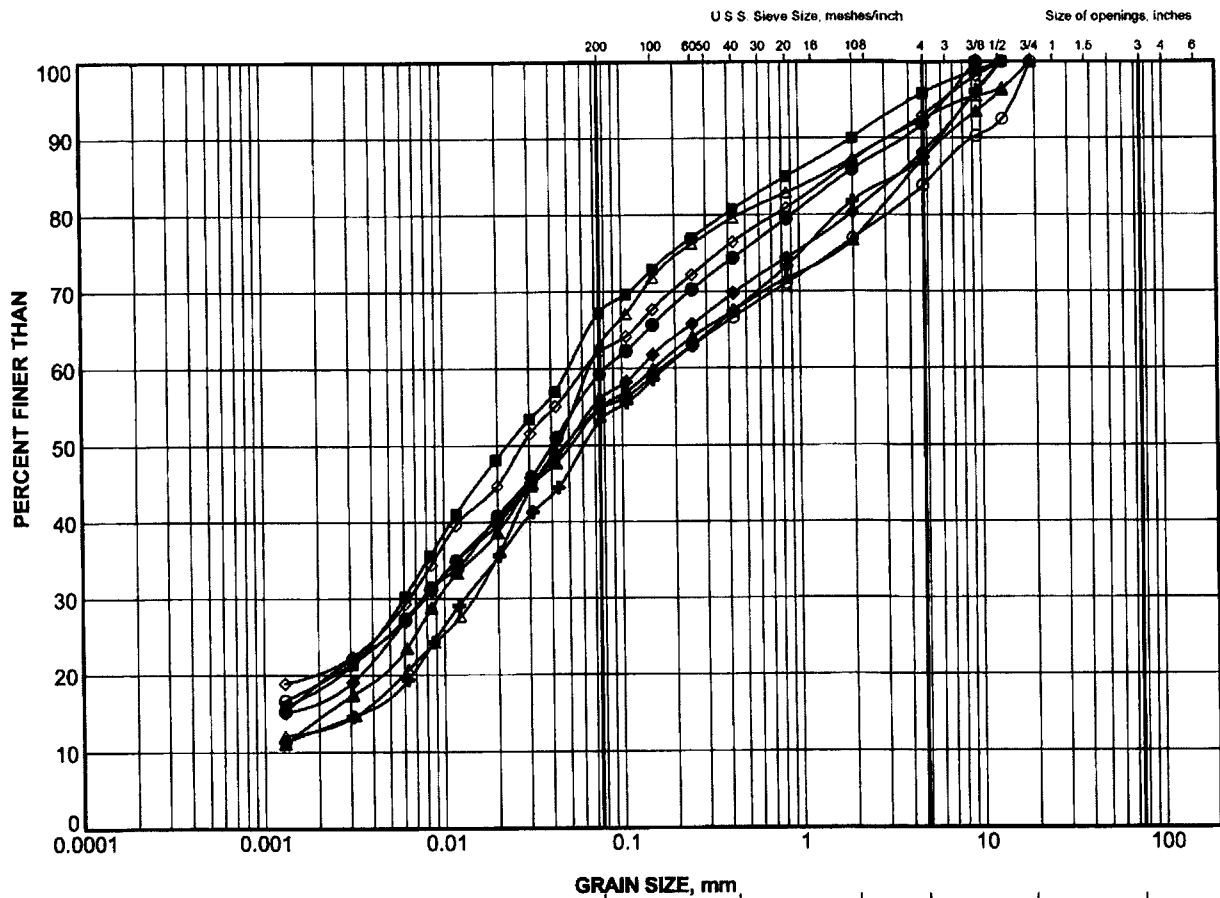
TITLE

## GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL



**Golder Associates**  
LONDON, ONTARIO

PROJECT No	10-1132-0029	FILE No	11320029-7000-F010A3
DRAWN	DCH/AMG	6EPT. 12/11	SCALE N/A REV
CHECK	TP	Sgt 12/11	FIGURE A-3



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	3	342.6
■	102	3	342.1
▲	103	14	334.1
◆	104	12	335.9
◆	106	5	342.7
◇	108	5	342.8
○	108	11	337.5
△	108	14	332.9

PROJECT

NORTH THAMES RIVER BRIDGE  
HIGHWAY 23 STRUCTURE REPLACEMENTS  
GWP 3043-06-00, SITE 25-128

TITLE

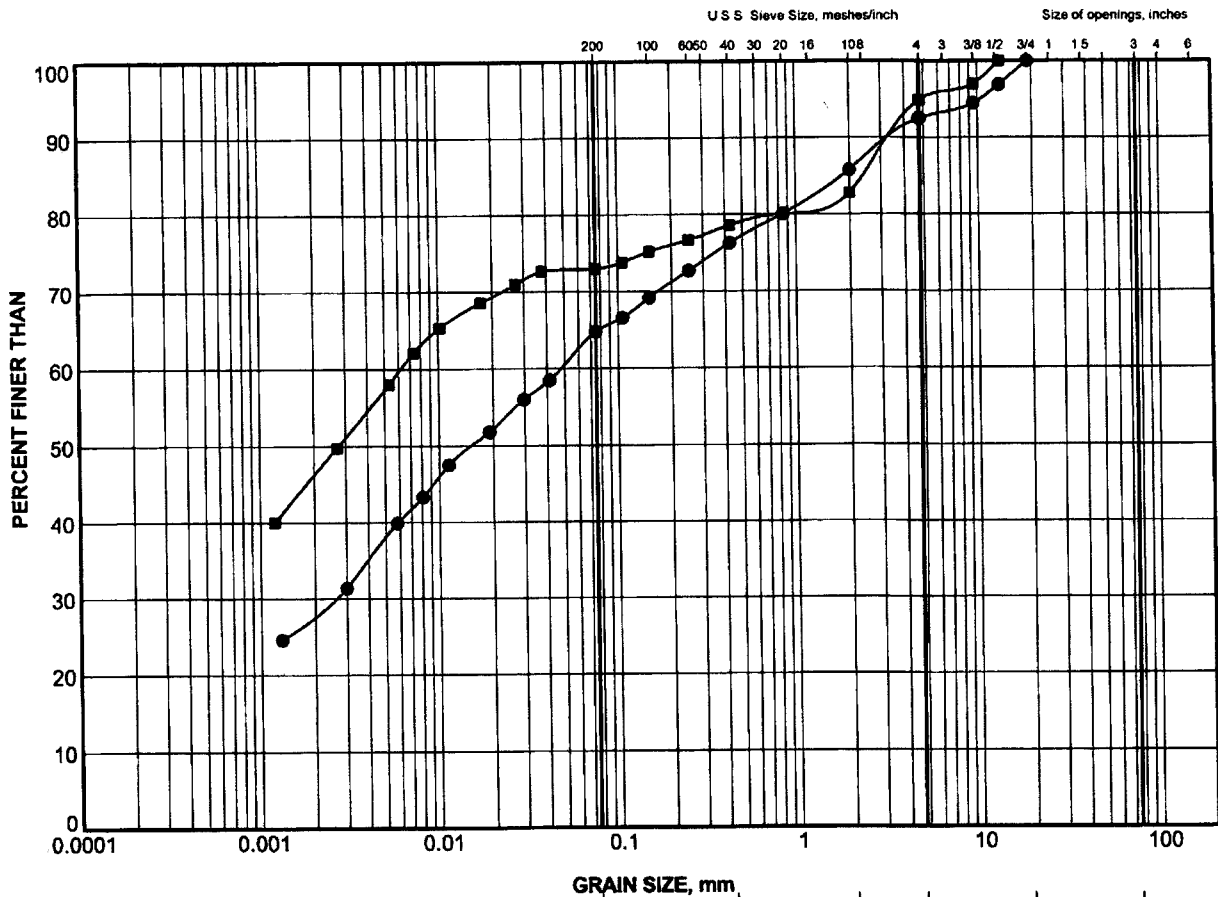
## GRAIN SIZE DISTRIBUTION SANDY SILT TILL



**Golder  
Associates**  
LONDON, ONTARIO

PROJECT No	10-1132-0020	FILE No	1011320020-7000-F010A4
SCALE	N/A	REV	
DRAWN	DCH/AMG	SEPT. 12/11	
CHECK	TP	SEP 12/11	


**FIGURE A-4**

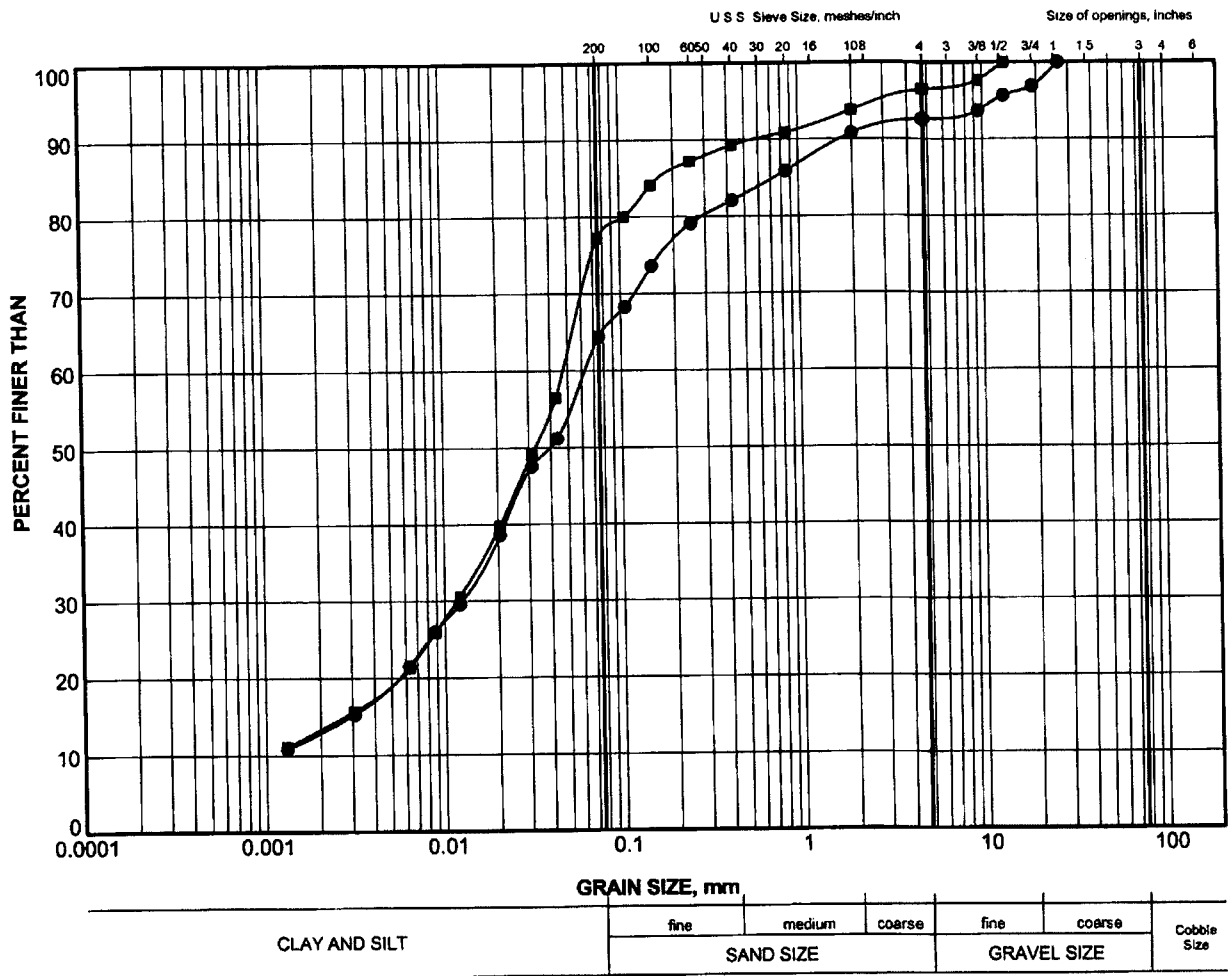


CLAY AND SILT						Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	103	9	337.9
■	105	5	341.4

PROJECT				NORTH THAMES RIVER BRIDGE HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-128			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F010A5	
DRAWN		DCH/AMG		SCALE		N/A	
CHECK		TP		SEPT 12/11		REV	
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-5</b>			



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	102	14	333.0
■	107	20	331.4

PROJECT				NORTH THAMES RIVER BRIDGE HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-128			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F010A6	
SCALE		N/A		REV			
DRAWN		DCH/AMG		SEPT. 12/11			
CHECK		TP		Sept 12/11		FIGURE A-6	







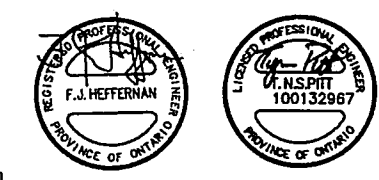
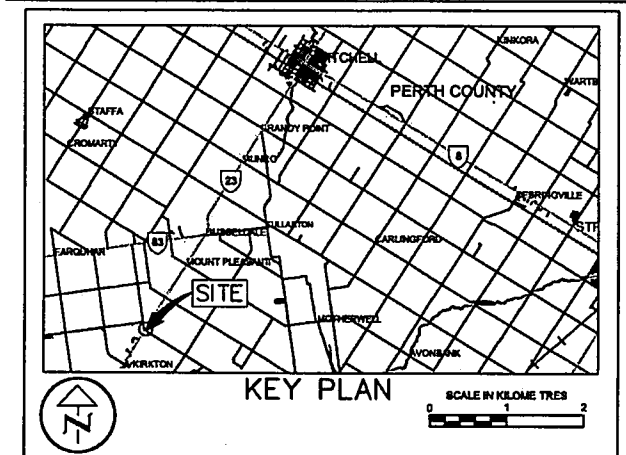
## **APPENDIX B**

**Site 25-332 - Foundation Engineering Drawings, Record of  
Borehole Sheets and Laboratory Data  
Geocres No. 40P6-24**



SHEET

**Golder Associates Ltd.**  
LONDON, ONTARIO, CANADA



**NOTES**

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

### REFERENCE

SCALE  
1.5 0 1.5 m

NO.	DATE	BY	REVISION		
Geocres No.    40P6-24					
HWY.     23		PROJECT NO. 10-1132-0029		DIST.	
SUBM'D.	CHKD.	DATE: Aug. 18/11		SITE: 25-322/C	
DRAWN: LMK/DCH	CHKD.	APPD.		DWG.       1	

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 201</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4800731.2 E 402089.3		<b>ORIGINATED BY</b> RA	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> May 31, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)									
								UNCONFINED								FIELD VANE		QUICK TRIAXIAL		LAB VANE				
							20	40	60	80	100	10	20	30										
309.21	GROUND SURFACE																							
0.00	FILL, sand and gravel, some silt, with sandy silt layers Loose Brown																							
307.84			1	SS	9																			
1.37	FILL, silt, some clay, trace sand, trace topsoil with silt seams Loose Brown		2	SS	6																			
307.08																								
2.13	SAND AND GRAVEL, some silt, trace clay Compact Brown		3	SS	25																			
306.31																								
2.90	SANDY SILT TILL, trace to some gravel, some clay, with cobbles Loose to very dense Brown becoming grey at about elev. 303.9m		4	SS	8																			
			5	SS	84																			
			6	SS	127																			
			7	SS	123																			
			8	SS	137/ 230mm																			
302.75																								
6.46	END OF BOREHOLE																							
	Groundwater encountered at about elev. 307.1m during drilling on May 31, 2011.																							
	Water level measured at 307.13m on June 8, 2011.																							

LDN\_MTO\_06 10-1132-0029-7000 GPJ LDN\_MTO GDT 06/09/11

**RECORD OF BOREHOLE No 202**

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4800759.8 E 402095.7

ORIGINATED BY MR

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE June 06, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
307.87	GROUND SURFACE													
0.00	TOPSOIL, silty													
0.20	Dark brown													
307.35	FILL, silty sand and gravel, trace													
0.52	topsoil													
	Brown													
306.50	CLAYEY SILT, trace sand, trace		1	SS	11		307							
	gravel													
1.37	Sluff													
	Brown													
305.74	SAND AND GRAVEL, trace silt		2	SS	19		306							
	Compact													
2.13	Brown													
	SANDY SILT TILL, some gravel,		3	SS	13		305							
	some clay, with cobbles													
	Compact to very dense													
	Brown becoming grey at about													
	elev. 303.6m													
			4	SS	27									
			5	SS	100/ 125mm		304							
			6	SS	56		303							25 31 32 12
			7	SS	53		302							
			8	SS	51		301							
			9	SS	95		300							9 33 40 18
299.79	END OF BOREHOLE													
8.08	Groundwater encountered at about elev. 306.5m during drilling on June 6, 2011													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 203</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4800754.5 E 402102.0		<b>ORIGINATED BY</b> RA	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> June 01, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
309.22	GROUND SURFACE							20 40 60 80 100	10 20 30					GR SA SI CL	
0.00	FILL, sand and gravel, some silt, trace topsoil Compact Brown		1	SS	27	▽	309								
307.85							308								
1.37	FILL, sandy silt, some clay, trace topsoil, trace gravel Loose Brown and grey		2	SS	5									5 21 58 16	
306.72			3	SS	5		307								
2.50	SILT, trace clay Loose Brown														
306.32			4	SS	8		306							0 0 70 30	
2.90	CLAYEY SILT, with silt seams Firm Brown														
305.56			5	SS	51		305								
3.66	SANDY SILT TILL, some gravel, some clay, with cobbles Dense to very dense Brown becoming grey at about elev 304.0m		6	SS	121									14 26 45 15	
			7	SS	35		304								
			8	SS	78		303								
			9	SS	78		302								
			10	SS	66	301									
			11	SS	107								11 33 39 17		
			12	SS	135	300									
289.62	END OF BOREHOLE														
9.60	Groundwater encountered at about elev 306.6m during drilling on June 1, 2011														

DN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 204</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4800728.3, E 402127.5		<b>ORIGINATED BY</b> MR	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> June 06, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
306.85	GROUND SURFACE													
0.00	TOPSOIL, silty													
308.51	Dark brown													
0.34	FILL, silty sand and gravel, trace topsoil													
0.61	Brown													
307.48	FILL, silt, some clay, trace sand, trace gravel, trace topsoil, with clayey silt layers		1	SS	4									
1.37	Loose Brown		2	SS	5									
306.72	SILT, some clay, trace sand, with roots													
2.13	Loose Brown		3	SS	12									
	SANDY SILT TILL, some gravel, some clay, with cobbles													
	Compact to very dense													
	Brown becoming grey at about elev. 303.7m		4	SS	19									
			5	SS	100/175mm									
			6	SS	97									
			7	SS	88									
			8	SS	100/200mm									
			9	SS	100/275mm									
300.01			10	SS	82									
8.84	END OF BOREHOLE													
	Groundwater encountered at about elev. 305.9m during drilling on June 6, 2011.													

PROJECT 10-1132-0029

# RECORD OF BOREHOLE No 205

1 OF 1

METRIC

W.P. 3043-06-00

LOCATION N 4800719.7 ; E 402113.9

ORIGINATED BY RA/MR

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE June 01, 2011 - June 06, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100								
307.50	GROUND SURFACE															
0.00	TOPSOIL, silty, some clay Dark brown															
307.04																
0.46	CLAYEY SILT Brown															
0.76	SANDY SILT, trace gravel, trace clay Compact Brown		1	SS	11											
305.98																
1.52	SANDY SILT TILL, some clay, trace to some gravel, with cobbles Dense to very dense Brown to grey at about elev. 303.8m		2	SS	30											
			3	SS	42											6 29 48 17
			4	SS	78											
			5	SS	114											12 33 42 13
			6	SS	100/ 150mm											
			7	SS	100/ 250mm											
			8	SS	67											
			9	SS	66											
			10	SS	73											
299.42	END OF BOREHOLE															
8.08	Groundwater encountered at about elev. 306.0m during drilling on June 1 & 6, 2011.  Water level measured at 302.17m on June 6, 2011.  Water level measured at 305.77m on June 8, 2011.															

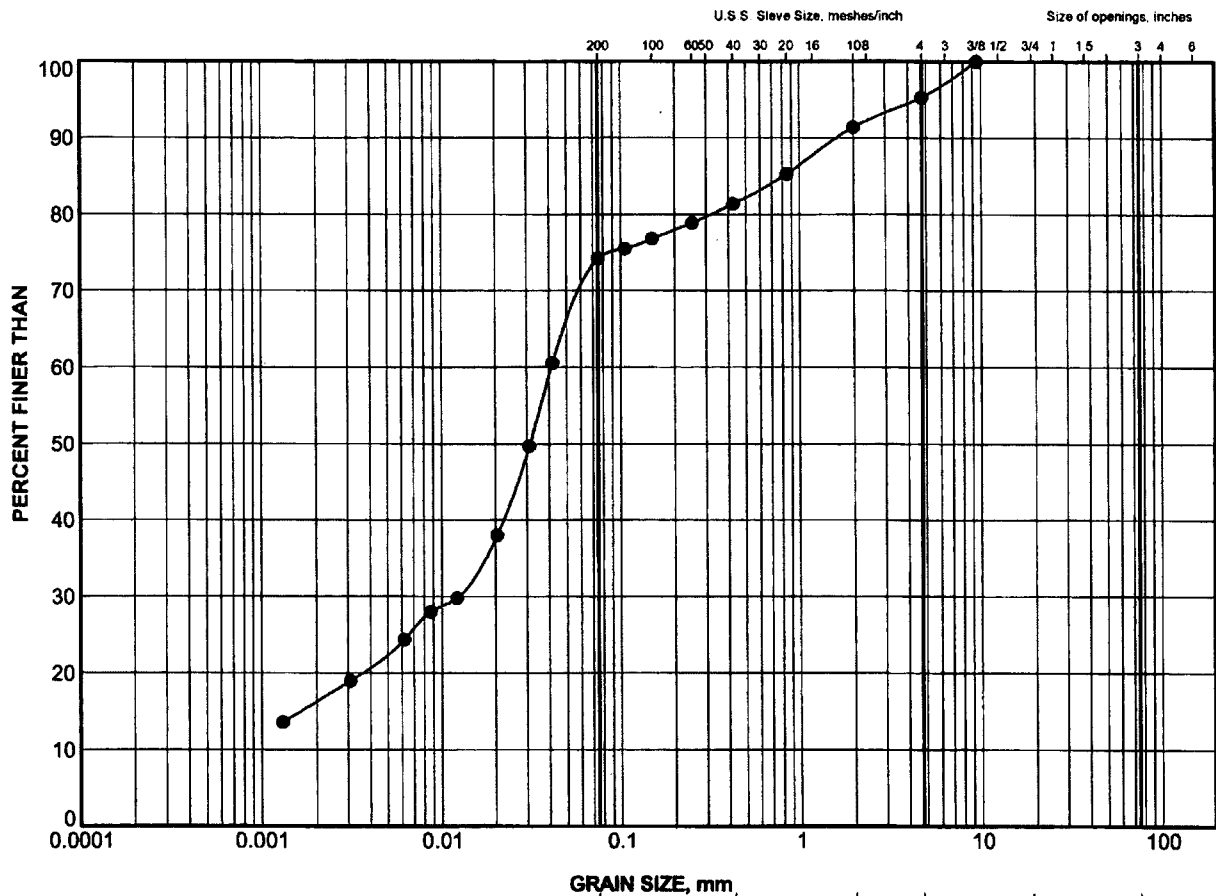
LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 206</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4800723.0 ; E 402098.4		<b>ORIGINATED BY</b> RA	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> June 01, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100	20 40 60 80 100						
309.26	GROUND SURFACE													
0.00	FILL, sand and gravel, trace silt Compact Brown		1	SS	17									
307.89	FILL, clayey silt, some topsoil, some sand, trace gravel Soft Brown		2	SS	4									
307.13	SANDY SILT, trace clay, some gravel Loose Brown		3	SS	7									
306.36	SANDY SILT TILL, trace to some gravel, some clay, with cobbles and boulders Compact to very dense Brown becoming grey at about elev. 303.9m		4	SS	12									
2.90			5	SS	34									
			6	SS	106									
			7	SS	154									
			8	SS	166									
			9	SS	105/50mm									
			10	SS	114									
301.18	END OF BOREHOLE													
8.08	Groundwater encountered at about elev. 307.3m during drilling on June 1, 2011.													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 08/09/11




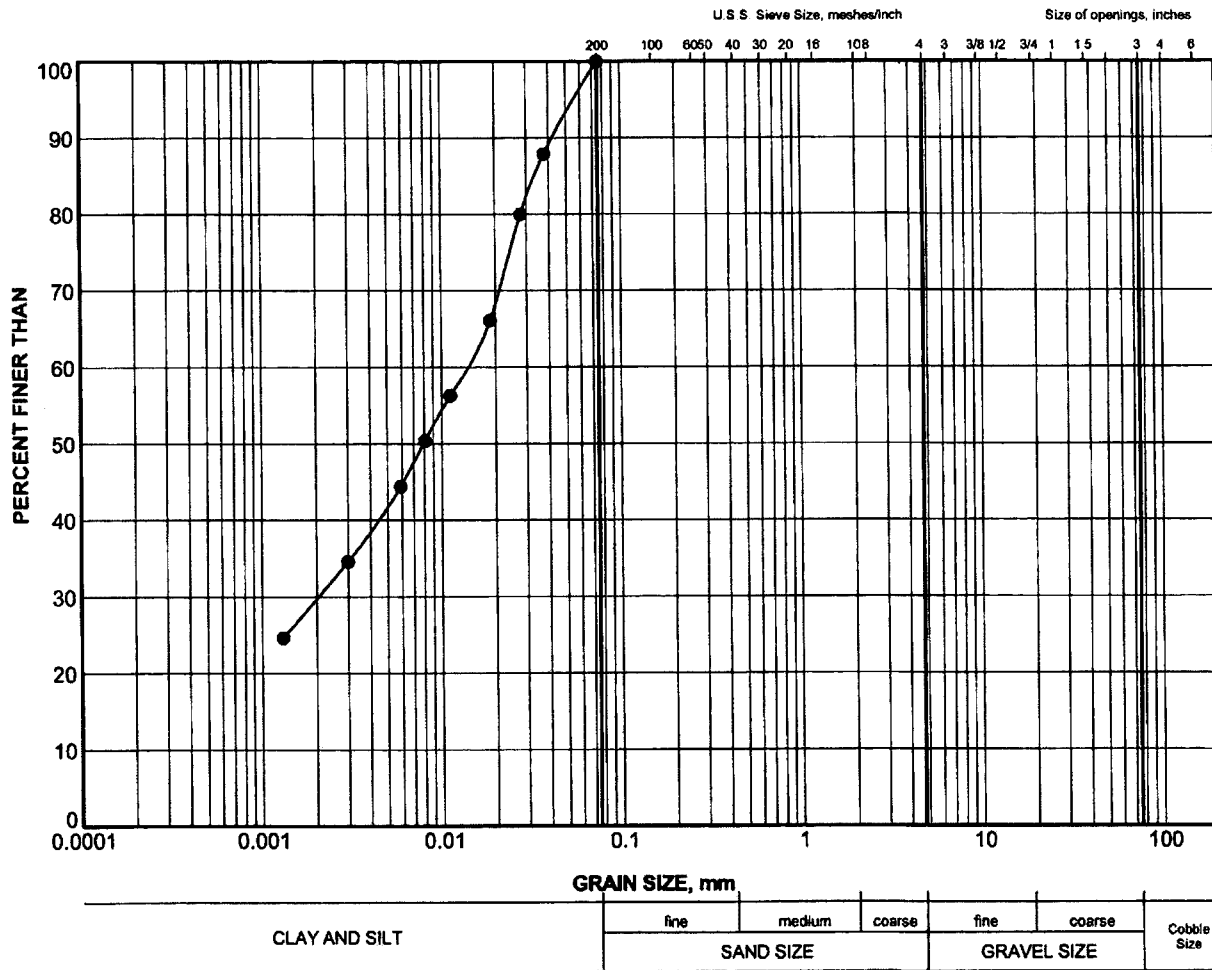


CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		


### LEGEND

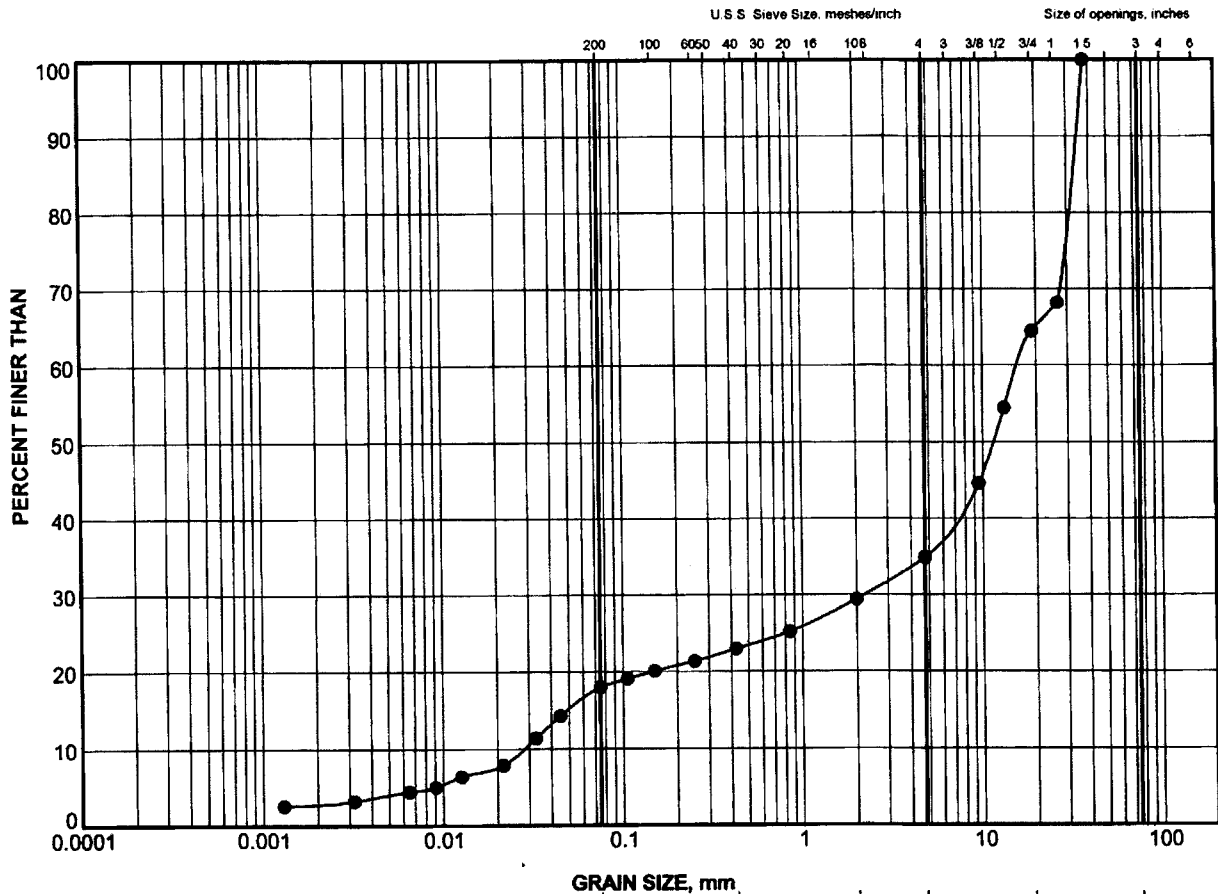
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	203	2	307.5

PROJECT				FISH CREEK CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-332/C			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No		10-1132-0029		FILE No.		1011320029-7000-F020A1	
DRAWN		LMK/AMG		SCALE		N/A	
CHECK		TP		REV		REV	
 <b>Golder Associates</b> LONDON, ONTARIO				SEP. 14/11 FIGURE A-1			



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	203	4	305.9

PROJECT				FISH CREEK CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-332/C			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F020A2	
DRAWN		LMK/AMG		SCALE		N/A	
CHECK		TP		REV			
		SEPT. 14/11					
		Sep 19/11					
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-2</b>			



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

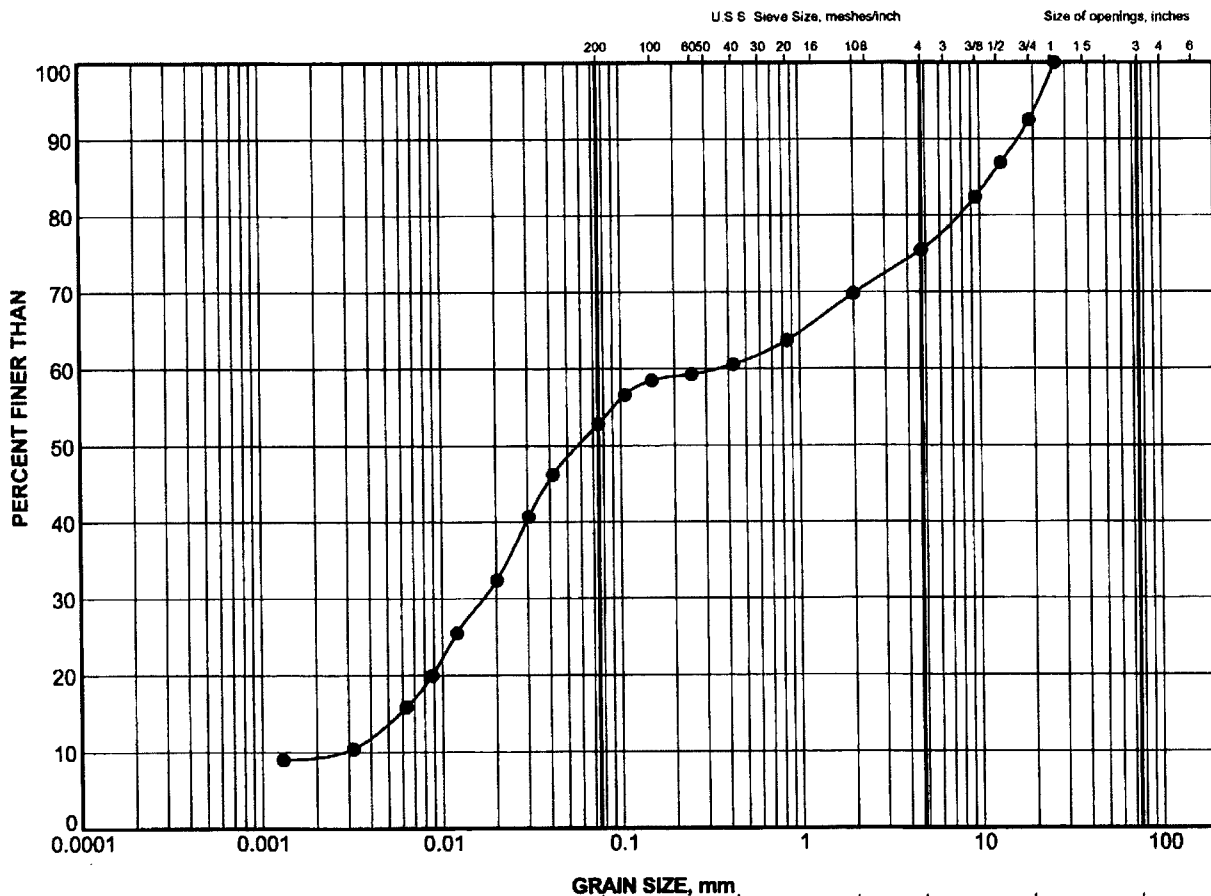
#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	3	306.7

PROJECT				FISH CREEK CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-332/C			
TITLE				GRAIN SIZE DISTRIBUTION SAND AND GRAVEL			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F020A3	
DRAWN		JMK/AMC		SCALE		N/A	
CHECK		TP		REV		REV	
DATE		SEPT. 14/11		FIGURE		A-3	



**Golder Associates**  
LONDON, ONTARIO



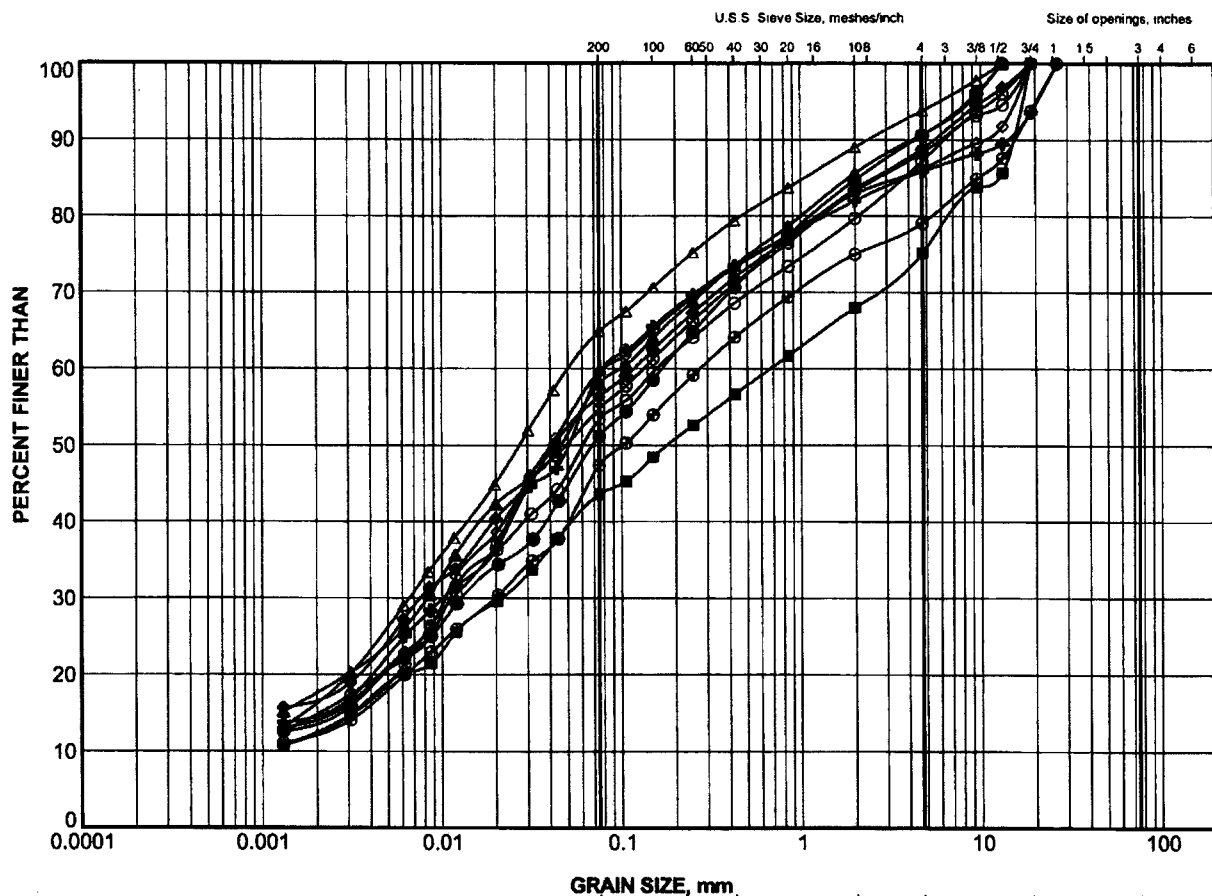
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	206	3	306.7

PROJECT				FISH CREEK CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-332/C			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F020A4	
DRAWN		LMK/AMG		SCALE		N/A	
CHECK		TP		REV			
DATE		SEPT. 14/11		FIGURE		A-4	





CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	201	7	303.6
■	202	6	303.1
▲	202	9	300.0
+	203	6	304.4
◆	203	11	300.6
◇	204	3	306.3
○	204	6	304.0
△	205	3	305.0
⊗	205	5	303.5
⊕	206	7	303.7

PROJECT

FISH CREEK CULVERT  
HIGHWAY 23 STRUCTURE REPLACEMENTS  
GWP 3043-06-00, SITE 25-332/C

TITLE

GRAIN SIZE DISTRIBUTION  
SANDY SILT TILL



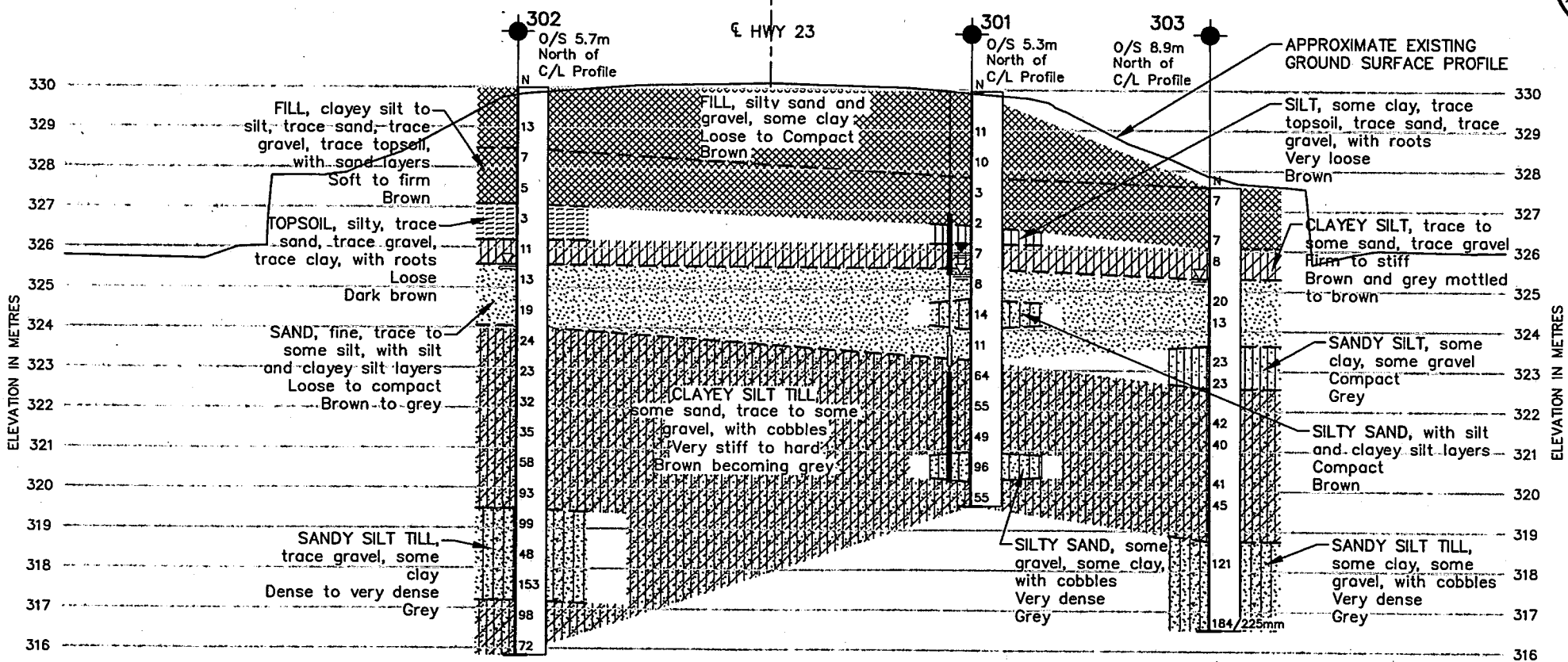
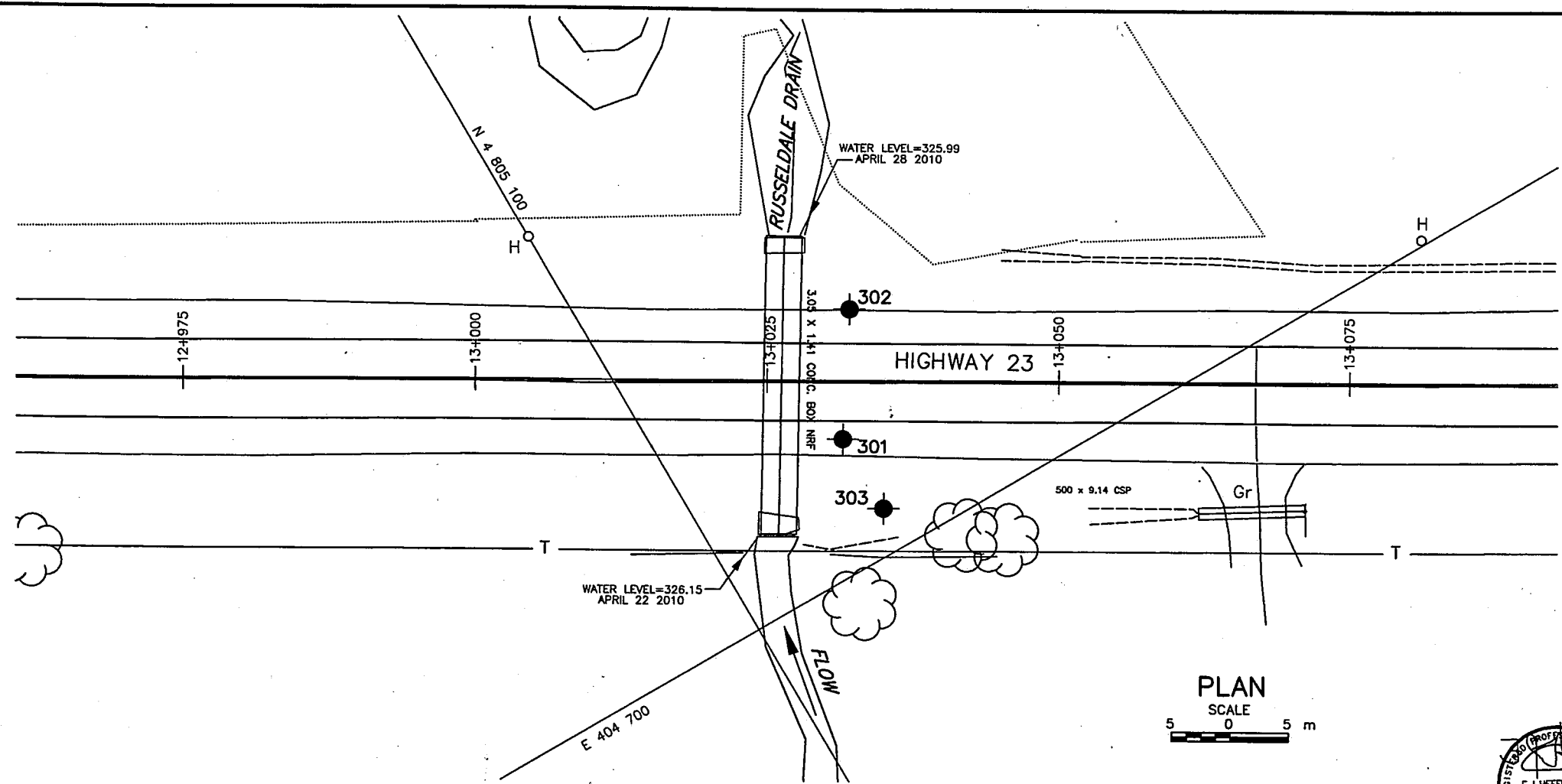
PROJECT No	10-1132-0029	FILE No	1011320029-7000-F020A5
DRAWN	LMK/AMG	SEPT. 14/11	SCALE N/A
CHECK	TP	SEP 14/11	REV

FIGURE A-5



## **APPENDIX C**

**Site 25-333 - Foundation Engineering Drawings, Record of  
Borehole Sheets and Laboratory Data  
Geocres No. 40P6-25**



PROFILE ALONG C/L OF CULVERT

**METRIC**  
 DIMENSIONS ARE IN METRES AND/OR  
 MILLIMETRES UNLESS OTHERWISE SHOWN.  
 STATIONS IN KILOMETRES + METRES.

CONT No.  
 WP No. 3043-06-00

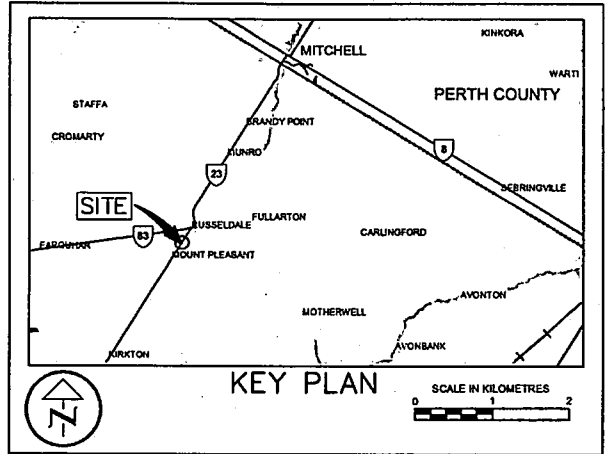
RUSSELDAL DRAIN CULVERT  
 HIGHWAY 23 STRUCTURE REPLACEMENTS  
 BOREHOLE LOCATIONS AND SOILS STRATA



SHEET



**Golder Associates Ltd.**  
 LONDON, ONTARIO, CANADA



**LEGEND**

- Borehole
- Seal
- Standpipe
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated  
 (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling
- ≡ Measured WL June 8, 2011.

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
301	329.97	4 805 144.5	404 689.4
302	330.01	4 805 120.6	404 679.9
303	327.60	4 805 114.4	404 696.3

**NOTES**

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.  
 The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

**REFERENCE**

Base plans provided in digital format by Delcan.

NO.	DATE	BY	REVISION
Geocres No. 40P6-25			
HWY. 23			PROJECT NO. 10-1132-0029
SUBM'D.	CHKD.	DATE: Nov. 17/11	SITE: 25-333/C
DRAWN: LMK/DCH	CHKD.	APPD.	DWG. 1

# RECORD OF BOREHOLE No 301

1 OF 1

**METRIC**

PROJECT 10-1132-0029

W.P. 3043-06-00

LOCATION N 4805144.5, E 404689.4

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE May 30, 2011

CHECKED BY TP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
329.97	GROUND SURFACE							20 40 60 80 100	10 20 30						
0.00	FILL, sand and gravel, trace silt Compact Brown		1	SS	11										
328.60															
1.37	FILL, silty sand and gravel, some clay Compact Brown		2	SS	10		Cuttings								
327.84															
2.13	FILL, clayey silt, trace gravel, some sand, trace topsoil Soft Brown		3	SS	3								5 26 47 22		
326.62			4	SS	2										
3.35	SILT, some clay, trace topsoil, trace sand, trace gravel, with roots Very loose Brown														
326.16							Bentonite								
3.81	CLAYEY SILT, trace sand, trace gravel Firm Brown		5	SS	7										
325.55															
4.42	SAND, fine, trace silt, trace clay Loose Brown		6	SS	8								0 88 8 4		
324.79															
5.18	SILTY SAND, with silt and clayey silt layers Compact Brown		7	SS	14		Cuttings								
324.03															
5.94	SAND, trace silt, with silt and clayey silt layers Compact Grey		8	SS	11		Standpipe								
323.26							Sand								
6.71	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Hard Grey		9	SS	64										
			10	SS	55								2 26 41 31		
			11	SS	49		Bentonite								
320.98															
8.99	SILTY SAND, some gravel, some clay, with cobbles Very dense Grey		12	SS	96								28 23 29 20		
320.22															
9.75	CLAYEY SILT TILL, some gravel, some sand, with cobbles Hard Grey		13	SS	55										
319.61							Cuttings								
10.36	END OF BOREHOLE														
	Groundwater encountered at about elev. 325.4m during drilling on May 30, 2011.														
	Water level measured at elev. 325.93m on June 8, 2011.														

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11



PROJECT 10-1132-0029

# RECORD OF BOREHOLE No 302

1 OF 1

METRIC

W.P. 3043-06-00

LOCATION N 4805120.6, E 404679.9

ORIGINATED BY RA

DIST HWY 23

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE May 30, 2011

CHECKED BY TP

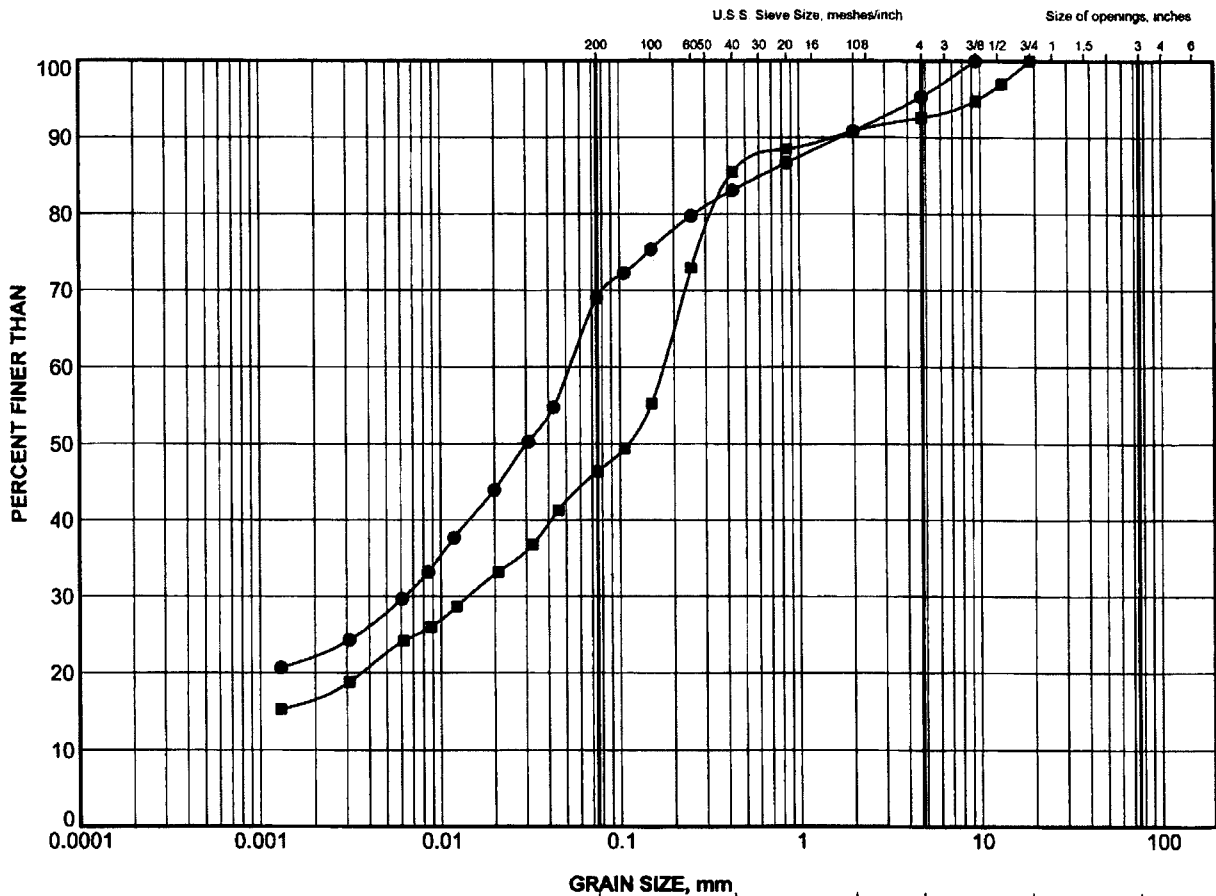
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							
330.01	GROUND SURFACE						330								GR SA SI CL
0.00	FILL, sand and gravel, trace silt Compact Brown		1	SS	13		329								
328.49							328								
1.52	FILL, clayey silt, trace sand, trace gravel, trace loess, with sand layers Firm Brown		2	SS	7		327								7 47 29 17
			3	SS	5		326								
327.11							325								
2.90	TOPSOIL, silty, trace sand, trace gravel, trace clay, with roots Loose Dark brown		4	SS	3		324								
326.20							323								
3.81	CLAYEY SILT, trace sand, trace gravel Stiff Brown and grey mottled		5	SS	11		322								
325.59							321								
4.42	SAND, fine, trace to some silt, trace clay, with silt layers Compact Brown		6	SS	13		320								2 78 11 9
			7	SS	19		319								
324.07							318								
5.94	CLAYEY SILT TILL, some sand, some gravel, with cobbles Very stiff to hard Brown becoming grey at about elev. 323.1m		8	SS	24		317								
			9	SS	23		316								
			10	SS	32										3 23 37 37
			11	SS	35										
			12	SS	58										
			13	SS	93										
319.50															
10.51	SANDY SILT TILL, trace gravel, some clay, with cobbles, gravelly below about elev. 318.0m Dense to very dense Grey		14	SS	99										8 34 35 23
			15	SS	48										
			16	SS	153										
317.21															34 21 28 17
12.80	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Hard Grey		17	SS	98										
			18	SS	72										
315.84															
14.17	END OF BOREHOLE Groundwater encountered at about elev. 325.6m during drilling on May 30, 2011														

LDN\_MTO\_06 10-1132-0029-7000 GPJ LDN\_MTO.GDT 06/09/11

<b>PROJECT</b> 10-1132-0029		<b>RECORD OF BOREHOLE No 303</b>		1 OF 1	<b>METRIC</b>
<b>W.P.</b> 3043-06-00		<b>LOCATION</b> N 4805114.4 , E 404696.3		<b>ORIGINATED BY</b> RA	
<b>DIST</b> HWY 23		<b>BOREHOLE TYPE</b> POWER AUGER, HOLLOW STEM		<b>COMPILED BY</b> LMK	
<b>DATUM</b> GEODETIC		<b>DATE</b> May 31, 2011		<b>CHECKED BY</b> TP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100	20 40 60 80 100						
327.60	GROUND SURFACE		1	SS	7									
0.00	FILL, silt, some clay, trace sand, trace gravel, some topsoil Loose Brown		2	SS	7									
326.08			3	SS	8									
1.52	CLAYEY SILT, trace to some sand, trace gravel Stiff Brown		4	SS	20									
325.31			5	SS	13									
2.29	SAND, fine, trace silt, with silt layers Compact Grey		6	SS	23									
323.64			7	SS	23									
3.96	SANDY SILT, some clay, some gravel Compact Grey		8	SS	42									
322.57			9	SS	40									
5.03	CLAYEY SILT TILL, some sand, trace gravel, with cobbles Hard Grey		10	SS	41									
			11	SS	45									
318.76			12	SS	121									
8.84	SANDY SILT TILL, some clay, some gravel, with cobbles Very dense Grey		13	SS	184/225mm									
316.54														
11.06	END OF BOREHOLE													
	Groundwater encountered at about elev. 325.3m during drilling on May 31, 2011.													

LDN\_MTO\_06 10-1132-0029-7000.GPJ LDN\_MTO.GDT 06/09/11

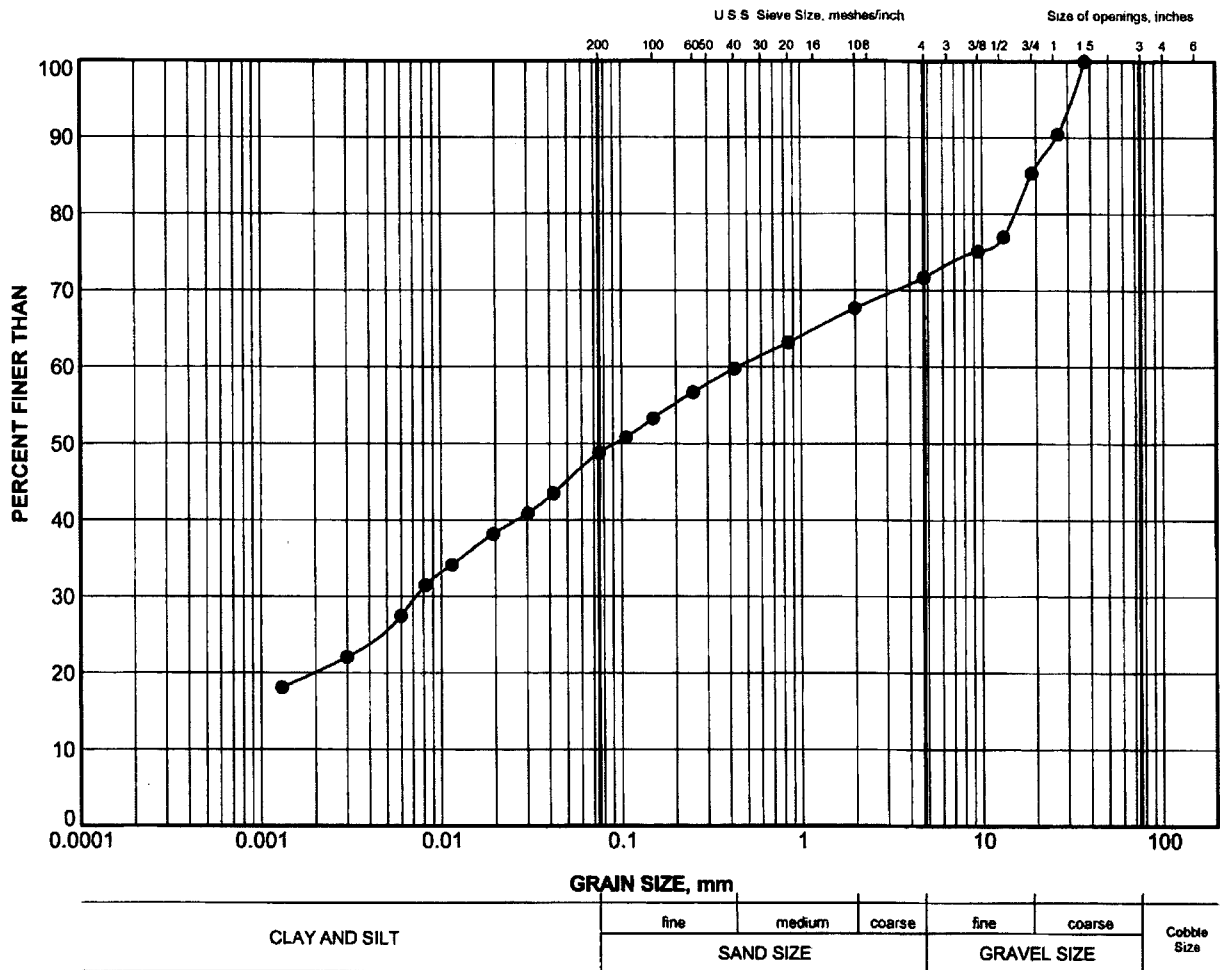


CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	301	3	327.4
■	302	3	327.5

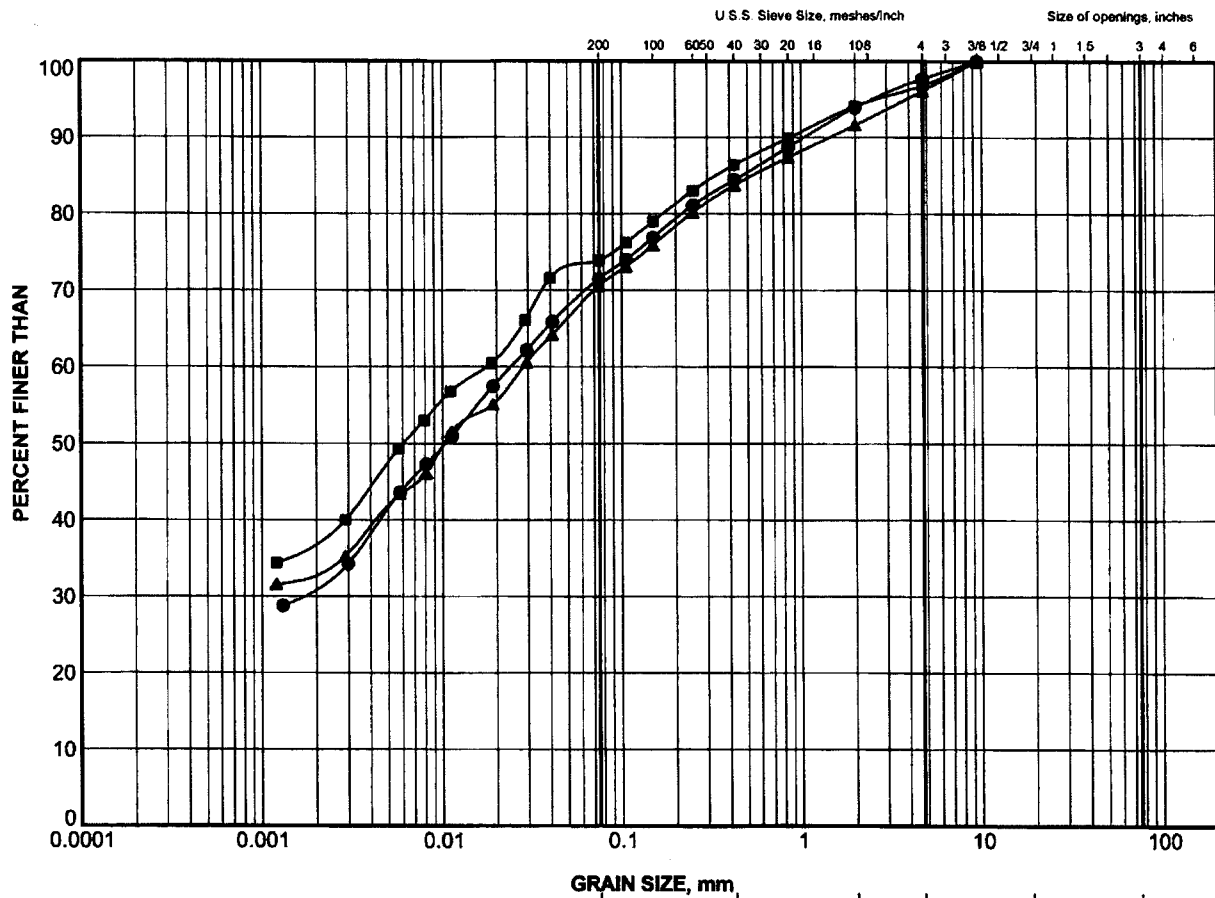
PROJECT				RUSSEDALE DRAIN CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-333/C			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F030A1	
DRAWN		DCH/AMG		SCALE		N/A	
CHECK		TP		REV			
		SEPT. 14/11					
		SEP 19/11					
Golder Associates LONDON, ONTARIO				FIGURE A-1			



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	301	12	320.6

PROJECT		RUSSEDALE DRAIN CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-333/C	
TITLE		GRAIN SIZE DISTRIBUTION SILTY SAND	
PROJECT No		10-1132-0020	
FILE No		1011320020-7000-F030A3	
SCALE		N/A	
REV			
DRAWN		DCH/AMG	
CHECK		TP	
DATE		SEPT. 14/11	
FIGURE		A-3	



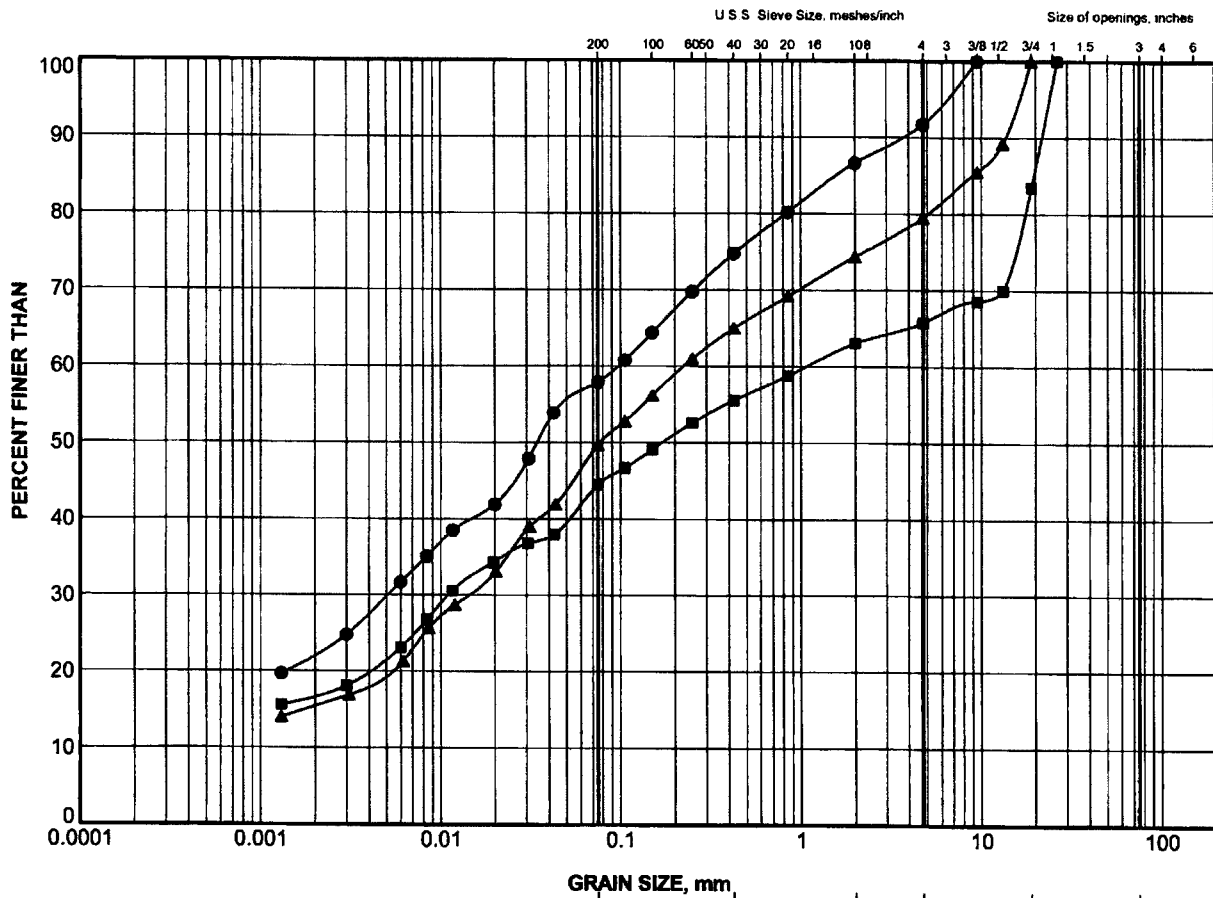


CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	301	10	322.1
■	302	10	322.2
▲	303	10	320.2

PROJECT		RUSSEDALE DRAIN CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-333/C			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> <b>CLAYEY SILT TILL</b>			
<b>Golder Associates</b> LONDON, ONTARIO	PROJECT No	10-1132-0029		FILE No	1011320029-7000-F030A4
	DRAWN	DCH/AMG	SEPT. 14/11	SCALE	N/A
	CHECK	TP	SEP 14/11	REV	
<b>FIGURE A-4</b>					


LDN MTO GSD-15 GLDR LDN GDT



CLAY AND SILT	GRAIN SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
SAND SIZE			GRAVEL SIZE			

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	302	14	319.1
■	302	16	317.6
▲	303	13	316.7

PROJECT				RUSSEDALE DRAIN CULVERT HIGHWAY 23 STRUCTURE REPLACEMENTS GWP 3043-06-00, SITE 25-333/C			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT TILL			
PROJECT No		10-1132-0029		FILE No		1011320029-7000-F030A5	
DRAWN		DCH/AMG		SEPT. 14/11		SCALE N/A	
CHECK		TP		SEP 14/11		REV	
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-5</b>			



# APPENDIX D

## Site 25-333 – Dewatering Calculations

Hydrogeological Assessment  
 Site 25-333  
 Russeldale Drain Culvert Replacement

$$Q = \pi K(H^2 - h^2) / (\ln(R_o/r_w)) + 2(xK(H^2 - h^2)/2L)$$

Typical Discharge			
Conductivity (K) =	2.1	m/d	
Saturated Thickness of Aquifer (H) =	2.7	m	
Dewatering height (h) =	2.1	m	
Line Source Distance (L) =	4.4	m	
Slot Radius (r <sub>w</sub> ) =	5	m	
Trench length (x) =	17	m	
Radius of Influence (R <sub>o</sub> ) =	9	m	
From Sichart equation:			
		R <sub>o</sub> =	9
Discharge (Q) =	56.7	m <sup>3</sup> /d	
=	39.3	L/min	

The excavation will be in two phases so the road will not have to be closed. The full excavation length of 34 m will therefore be completed sequentially as two 17 m long sections.

**Notes:**

1. Reference: *Construction Dewatering* (Powers, 1992)



Hydrogeological Assessment  
Site 25-333  
Russeldale Drain Culvert Replacement

$$Q = \pi K(H^2 - h^2) / (\ln(R_o/r_w)) + 2(xK(H^2 - h^2)/2L)$$

Maximum Discharge				
Conductivity (K) =	3.7	m/d	length (m) a =	17
Saturated Thickness of Aquifer (H) =	3.4	m	width (m) b =	5
Dewatering height (h) =	2.8	m	r <sub>s</sub> =	5
Line Source Distance (L) =	5.9	m		
Slot Radius (r <sub>w</sub> ) =	5	m	From Sichart equation:	
Trench length (x) =	17	m	R <sub>o</sub> =	12
Radius of Influence (R <sub>o</sub> ) =	12	m		
Discharge (Q) =	89.6	m <sup>3</sup> /d		
=	62.3	L/min		

The excavation will be in two phases so the road will not have to be closed. The full excavation length of 34 m will therefore be completed sequentially as two 17 m long sections.

**Notes:**

1. Reference: *Construction Dewatering* (Powers, 1992)

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Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**309 Exeter Road, Unit #1**  
**London, Ontario, N6L 1C1**  
**Canada**  
**T: +1 (519) 652 0099**

