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DESKTOP STUDY OF

WP 05-20012

**HYDROGEOLOGIC CONDITIONS IN THE 427
TRANSPORTATION CORRIDOR STUDY AREA**

GEOCRES No: 30M13-165

Submitted to:

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1.0 INTRODUCTION

The Ontario Ministry of Transportation (MTO) is conducting an Environmental Assessment (EA) for the proposed extension of the Highway 427 Transportation Corridor in Vaughan, Ontario. As shown on Figure 1, the study area for the proposed extension is bounded by Highway No. 7 to the south, Highway No. 27 to the east, Highway No. 50 to the west and Kirby Sideroad to the north. The prime consultant, McCormick Rankin Corporation (MRC), has retained Golder Associates Ltd. (Golder) to assess hydrogeological conditions in the proposed study area.

The first stage of the EA is the collection of information on existing conditions to assist in generating potential route alternatives. This technical memorandum provides a general discussion of hydrostratigraphic conditions and groundwater users within the proposed study area. This information will assist in generating route alternatives.

1.1 Work Scope

At this stage of the EA, Golder's work scope consists of completing a desktop study of available hydrogeological information in the study area. This information will be validated with field investigations as the study progresses to assist in the evaluation of route alternatives, identify potential impacts of the preferred alternative and develop appropriate mitigation measures to minimize potential effects to groundwater features.

Golder has obtained information from the regional groundwater flow model associated with the York Peel Durham Toronto (YPDT) Groundwater Management Study (Kassenaar and Wexler, 2006). The regional groundwater flow model represents a compilation of data from several sources (e.g., 135,000 MOE water well records, 13,000 geotechnical and monitoring wells, 200 municipal supply wells) that have been incorporated into a database format that supported the development of a hydrostratigraphic model of the York-Peel-Durham-Toronto area. Within the confines of the study area, the model has considered approximately 250 borehole locations. Regulatory agencies that contributed to the development of this regional model include the Toronto and Region Conservation Authority (TRCA) and the Regional Municipality of York (York Region).

2.0 HYDROSTRATIGRAPHY

Geological conditions underlying the study area are summarized on Figures 2 through 7. Figure 2 identifies near surface deposits, as reported by the Ontario Geological Survey (OGS, 2003). Figures 3 through 7 represent hydrostratigraphic cross sections through the study area, as modeled in the municipal groundwater study (Kassenaar and Wexler, 2006). These sections were provided in a finished state from York Region through Earthfx. The locations of these cross-sections are shown on Figure 1.

According to the municipal groundwater study (Kassenaar and Wexler, 2006) regionally extensive hydrostratigraphic units underlying the study area may be organized as follows:

1. Glaciolacustrine deposits (sand, silt and clay);
2. Halton Till Aquitard;
3. Oak Ridges Aquifer Complex (ORAC);
4. Newmarket Till Aquitard;
5. Thorncliffe Aquifer Complex (TAC);
6. Sunnybrook Diamict Aquitard (or equivalent);
7. Scarborough Aquifer Complex (SAC); and
8. Bedrock (aquifer or aquitard).

This section discusses the characteristics of the geological units identified above and their significance on regional hydrogeology and groundwater use.

2.1 Bedrock

The study area is underlain by Ordovician shales of the Georgian Bay Formation. Within the study area, the bedrock surface generally exhibits a gentle regional dip towards the southeast at a grade of approximately 0.5 to 1.5 percent (White, 1975). Based on the mapping shown on Figure 2, bedrock does not outcrop in the study area. As shown on Figure 3, the interpreted bedrock surface along Highway 50 ranges from approximately 190 masl at Nashville Road to 165 masl at Highway No. 7. Buried bedrock valleys are common in this region. A major buried bedrock valley runs along the west side of the Humber River from Bolton through to Lake Ontario (shown on Figures 3 and 5).

The permeability of the shale bedrock is relatively low, generally considered to be less than 10^{-5} cm/s. As such, the bedrock is not typically utilized as a groundwater supply source. Groundwater quality in the shale bedrock is typically brackish to saline.

2.2 Aquifers

Three aquifer zones are identified in the regional groundwater model, an upper (ORAC), intermediate (TAC) and lower aquifer (SAC). These aquifers are generally comprised of medium to coarse grained granular material (e.g., sands and gravels) and are characteristic of high hydraulic conductivity (e.g., greater than 10^{-3} cm/s). Water wells completed in these aquifers typically report moderate to high well yields. Groundwater quality in these aquifers is normally fresh but hard.

Aquifer zones are well confined in the vicinity of the study area and are generally encountered at depths of 10 m below ground surface. At depth, aquifers tend to be separated by low permeability zones (e.g., aquitards). As a result, groundwater flow in the regionally extensive aquifers is generally not considered to have a direct hydraulic connection with surface water drainage or surface activities.

2.3 Aquitards

Three aquitard zones (Halton, Newmarket and Sunnybrook) are generally observed at depth within the study area. These deposits comprise of silty sand to silty clay till and have characteristically low values of hydraulic conductivity (e.g., less than 10^{-5} cm/s). As such, these aquitards limit groundwater flow and do not reflect water bearing deposits.

As shown on Figure 2, the Halton Till is exposed along the main water courses of the study area (e.g., Humber River, Rainbow Creek). At these locations, surface water flow has eroded into the Halton Till deposits.

The upper (Halton) and intermediate (Newmarket) aquitards confine the regional aquifers. The thickness of the confining layers generally range from 5 to 25 m. These confining layers provide a degree of protection for groundwater in the aquifers from surface activities.

2.4 Glaciolacustrine Deposits

As shown on Figure 2, the vast majority of the study area is blanketed by glaciolacustrine deposits. These deposits are generally encountered to depths of 10 m below ground surface and can be characterized as:

1. Fine-textured glaciolacustrine deposits (shown in blue on Figure 2); and
2. Coarse-textured glaciolacustrine deposits (shown in yellow on Figure 2).

In the valleylands of Rainbow Creek and the Humber River, watercourses have eroded through glaciolacustrine deposits into the underlying Halton Till (shown in green on Figure 2). Modern alluvial deposition from the water courses are shown in brown on Figure 2.

Fine Textured Glaciolacustrine Deposits

Fine textured glaciolacustrine deposits (silt and clay) are prominent in the western and southern sections of the study area. These deposits reflect lake bed deposition from ancient glacial Lake Peel. Due to the fine grained nature, the hydraulic conductivity of these deposits is low (e.g., less than 10^{-5} cm/s). As such, the majority of precipitation in this area becomes overland runoff or evapotranspiration as opposed to groundwater recharge. Private wells completed in these

deposits typically reflect shallow dug or bored wells characteristic of low well yields (e.g., less than 25 m³/day).

Coarse Textured Glaciolacustrine Deposits

Coarse textured glaciolacustrine deposits (sands, some silts and gravels) are identified in the upland areas bordering the Humber River. These deposits reflect flood plain deposition from the ancestral Humber River. As a result of their coarse grained nature, the hydraulic conductivity of these deposits is moderate to high (e.g., greater than 10⁻⁴ cm/s) which results in greater groundwater recharge potential.

These coarse grained deposits are generally encountered in elevated areas, therefore the saturated thickness of these deposits is generally low. As such private wells completed within these deposits (most notably in the Nashville area) provide only modest well yields.

3.0 AREAS OF GROUNDWATER RECHARGE / DISCHARGE

Regional topography and drainage in the study area are shown on Figure 7. The study area is located on the south slope of the Oak Ridges Moraine (ORM). The ORM is a major depositional feature in this region forming a height of land between 15th and 17th Sideroad, approximately 9 km north of the study area. Within the study area, the topography gently slopes southward towards Lake Ontario at a gradient of approximately 0.004 m/m.

Figures 3 through 7 show the water table elevation reported in available MOE water well records. The water table generally represents a subdued reflection of ground surface topography, typically encountered from 3 to 7 m below ground surface. There are no reports of flowing wells within the study area. Based on these results and gently sloping topography, the study area is generally considered to be an area of groundwater recharge. It is to be noted, however, that groundwater recharge in the study area is limited due to the low hydraulic conductivity of the near surface deposits. As such, most of the water surplus in the study area becomes surface water runoff as opposed to groundwater recharge. The principal recharge area for groundwater flow in the regional aquifers is the crest of the ORM, where coarse grained deposits are prominent at ground surface.

Areas of groundwater discharge are generally limited to the main watercourses (e.g., Humber River, Rainbow Creek). The main channels of these watercourses have eroded into the overburden and have likely intersected the water table. Based on the thickness of the regional aquitards, however, it is expected that groundwater discharge to these watercourses is moderate to low. Surface water flow in tributary watercourses is predominantly expected to be above the water table and reflect overland drainage.

As shown on Figure 7, the Natural Resources Values Information System (NRVIS) database identifies only one (1) wetland in the study area. The wetland is relatively small (less than 1 ha.) and located on elevated terrain near Nashville. No hydrogeological assessment of this wetland is available, however, it is expected that this wetland area reflects surface water ponding as opposed to groundwater discharge.

4.0 GROUNDWATER USE

The majority of the study area is not serviced by municipal water or sewer services. Private well locations on-file in the Ontario Ministry of Environment database are shown on Figure 8. Most of these private wells were installed in the 1950's and 1960's prior to the installation of municipal services within the study area. As such, most of these private well locations, most notably in the Nashville area are no longer in service.

Municipal services (e.g., water and sewer) extend along Highway 27 and Islington Avenue to service the urban areas of Woodbridge, Kleinburg and Nashville. Other municipally serviced areas within the study area, as provided by the City of Vaughan, are also shown on Figure 8. It is noted that new development is occurring at the south end of the study area. These new development areas will also be municipally serviced.

A municipal production well (MOE well no. 69-21118) is located on Whisper Lane in Nashville (shown on Figure 9). This production well is completed in the Thorncliffe aquifer which is well confined in this area. The wellhead protection zone for the municipal production well, as provided by York Region, is shown on Figure 9. York Region and the MOE are continuing to review the assumptions made in delineating these zones and to determine the appropriate policies required for groundwater protection within these zones. York Region staff anticipates that further direction regarding requirements for wellhead protection will come from the Province in conjunction with the Clean Water Act. Given the well confined nature of the Thorncliffe aquifer in this area, potential impact to groundwater quality as a result of surface activity is expected to be low. As a result, precluding highway development within the 2 year capture zone for the municipal production well is considered to be a reasonable precaution.

The west end of the study area is sparsely populated. Private wells in this area are typically completed in fine grained, near surface deposits which provides a degree of protection from surface activities.

5.0 POTENTIAL CONTAMINATION SOURCE INVENTORY

An inventory of potential contamination sources in the study area, as provided by York Region, is shown on Figure 9. These sources were identified as part of York Region's Water Use

Assessment, Potential Contaminant Source Inventory and Initial Threat Assessment (MMM and Golder, 2006).

As shown on Figure 9, few (approximately 12 locations) potential contaminant sources exist within the study area. These locations predominantly exist along the main roads (e.g., Rutherford Road and Nashville Road) in the study.

6.0 SUMMARY

Based on the available data collected, Golder has assessed regional hydrogeological conditions in the study area of the proposed 427 extension corridor. Our conclusions are as follows:

1. Near surface deposits in the study area are predominantly comprised of fine grained glaciolacustrine sediments (shown in blue on Figure 2) and Halton Till (shown in green in Figure 2). The hydraulic conductivity of these sediments is low (e.g., 10^{-5} cm/s). These conditions limit groundwater recharge and provide a degree of protection for groundwater in lower aquifer deposits from surface activities. Therefore, there is a low potential for groundwater impacts as a result of roadway development.
2. Coarse grained lacustrine deposits are located on elevated areas adjacent to the Humber River valley (shown in yellow on Figure 2). The hydraulic conductivity of these deposits are expected to be moderate (e.g., on the order of 10^{-3} cm/s). The quality and quantity of groundwater in private wells completed in these deposits are more likely to be affected by surface activities. As such, highway construction in this area should not be undertaken without additional studies or mitigation measures to limit the infiltration of highway runoff into the shallow coarse grained lacustrine deposits.
3. The study area is underlain by three water supply aquifers and confining aquitards. The water supply aquifers are well confined by the aquitards which are comprised of till deposits ranging in thickness from 5 to 25 m. As such, highway construction is not expected to significantly affect groundwater quantity or quality in the confined aquifers. The principal area of recharge for groundwater flow in these confined aquifers is the crest of the Oak Ridges Moraine, which is located approximately 9 km north of the study area.
4. Within the study area one (1) municipal water supply production well is currently in operation in the community of Nashville. This production well is completed in an aquifer that is confined by a 25 m silty clay aquitard. As such, the quality and quantity of groundwater produced by this production well is not expected to be

affected by surface activities or highway construction. As a precautionary measure, highway construction should not be located within the 2 year capture area of the production well without additional studies.

5. Groundwater users (e.g., private wells) are predominantly located in unserved areas west of Huntington Road. These wells are typically shallow and completed in fine grained deposits which provide a degree of protection from surface activities.
6. Potential groundwater contamination sources (approximately 12 locations) are located along the regional roads within the study area. Further studies should be undertaken if construction is planned to occur in the vicinity of these locations.

7.0 LIMITATIONS

This desktop hydrogeological study was prepared for McCormick Rankin Corporation in support of a Ontario Ministry of Transportation led Environmental Assessment for the proposed extension of the Highway 427 Transportation Corridor in Vaughan, Ontario. This report is based on data and information collected by the Regional Municipality of York, Toronto and Region Conservation Authority, Ontario Geological Survey, Ontario Ministry of the Environment and Earthfx Inc. Golder has relied in good faith on this information and has carried out no independent field investigations to confirm this information. Golder has assumed that the information provided was factual and accurate. Golder accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations or fraudulent acts of persons interviewed or contacted.

8.0 CLOSURE

We trust this report provides the information required to satisfy hydrogeological concerns regarding the proposed Highway 427 Transportation Corridor Study Area in Vaughan, Ontario. Should you have any questions or comments, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.



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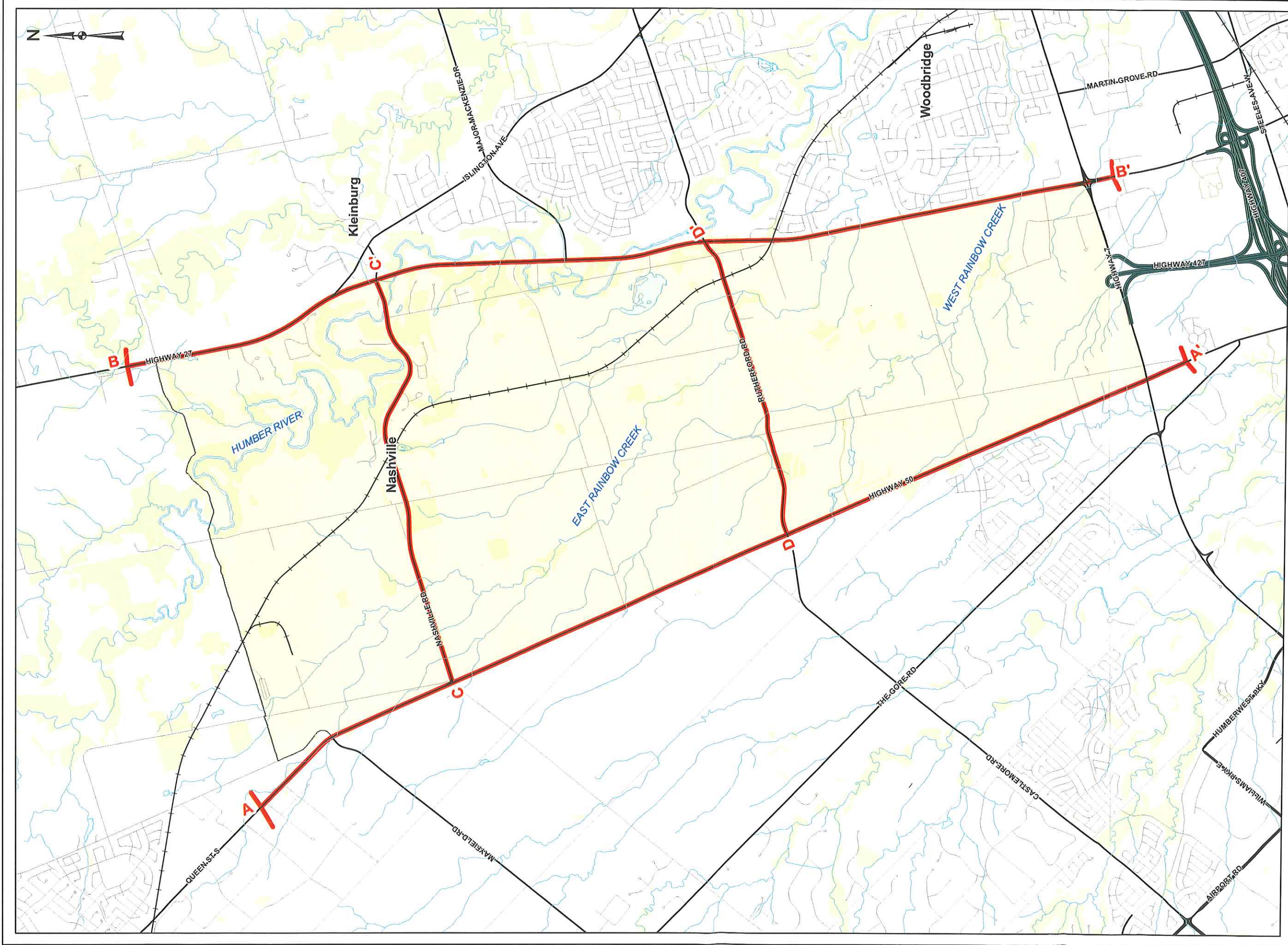
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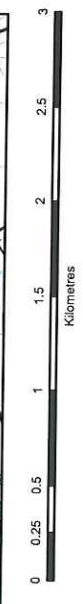
REFERENCES

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- Marshall Macklin Monaghan and Golder Associates Ltd. 2006. Water Use Assessment, Potential Contaminant Source Inventory and Initial Threat Assessment.
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- White, O.L., 1975. Quaternary Geology of the Bolton Area, Southern Ontario. Ontario Ministry of Natural Resources. Geological Report 117.

FIGURES



- LEGEND**
- Cross-Section Location
 - Watercourse
 - Study Area



TITLE

427 TRANSPORTATION CORRIDOR
ENVIRONMENTAL ASSESSMENT

PROJECT

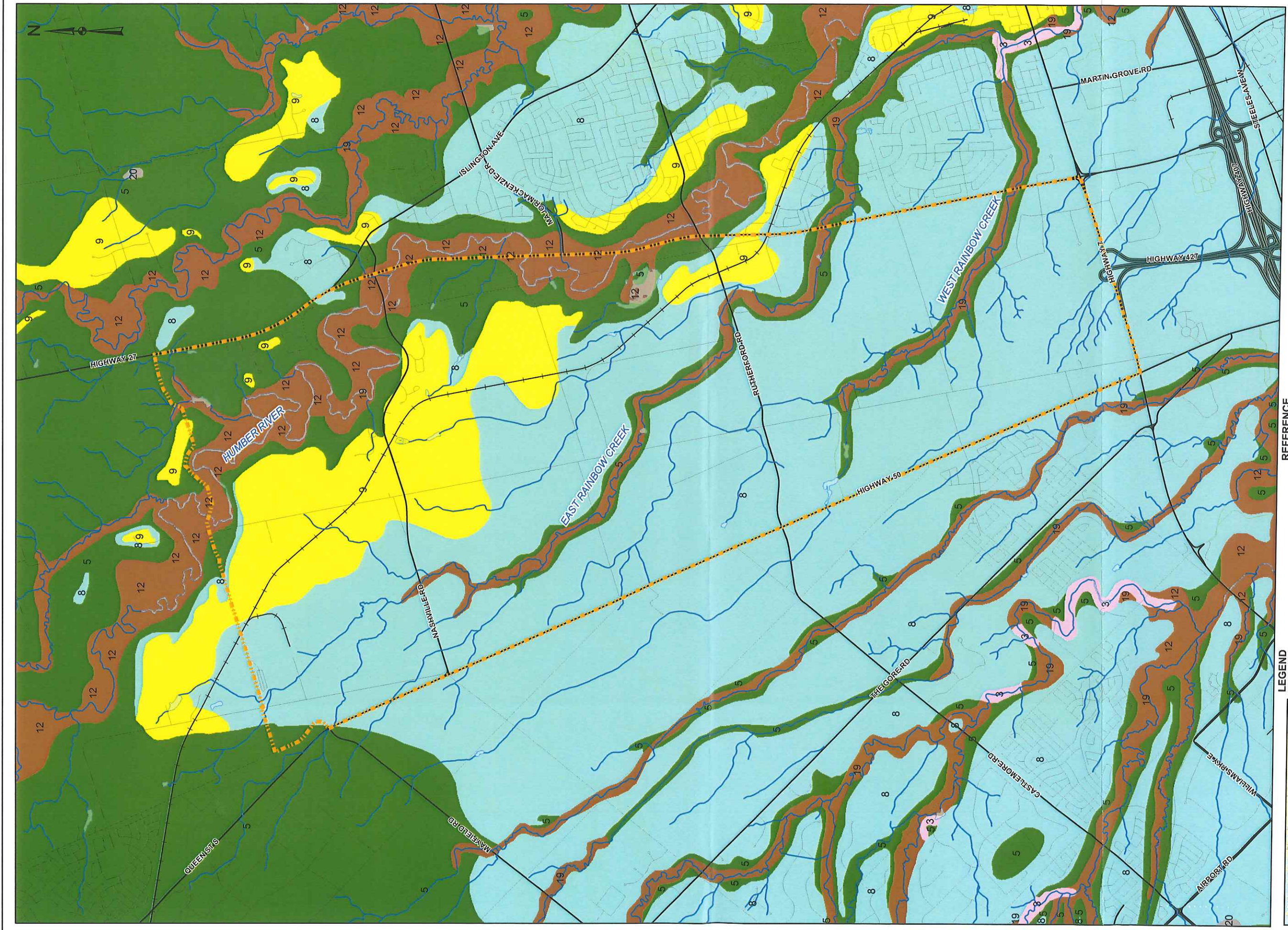
STUDY AREA & SECTION LOCATIONS

PROJECT No. 06-111-012 SCALE 1:40 000 REV. 0

DESIGN	ASS	10 Oct. 2006
GIS	NO	06 Feb. 2007
CHECK	SND	06 Feb. 2007
REVIEW	RB	06 Feb. 2007

FIGURE: 1

REFERENCE
Base Data - Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2006
Datum: NAD 83 Projection: UTM Zone 17



LEGEND

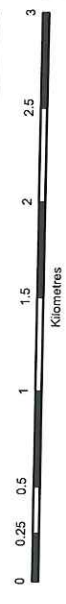
- Watercourse
- Study Area
- 3: Paleozoic bedrock
- 5: Undifferentiated till
- 8: Fine-textured glaciolacustrine deposits
- 9: Coarse-textured glaciolacustrine deposits
- 12: Older alluvial deposits
- 19: Modern alluvial deposits
- 20: Organic deposits

REFERENCE

Base Data - Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2006. OGS - Digital Quaternary Geology of Southern Ontario, 2003. Datum: NAD 83 Projection: UTM Zone 17



Index Map



TITLE

427 TRANSPORTATION CORRIDOR
ENVIRONMENTAL ASSESSMENT

PROJECT

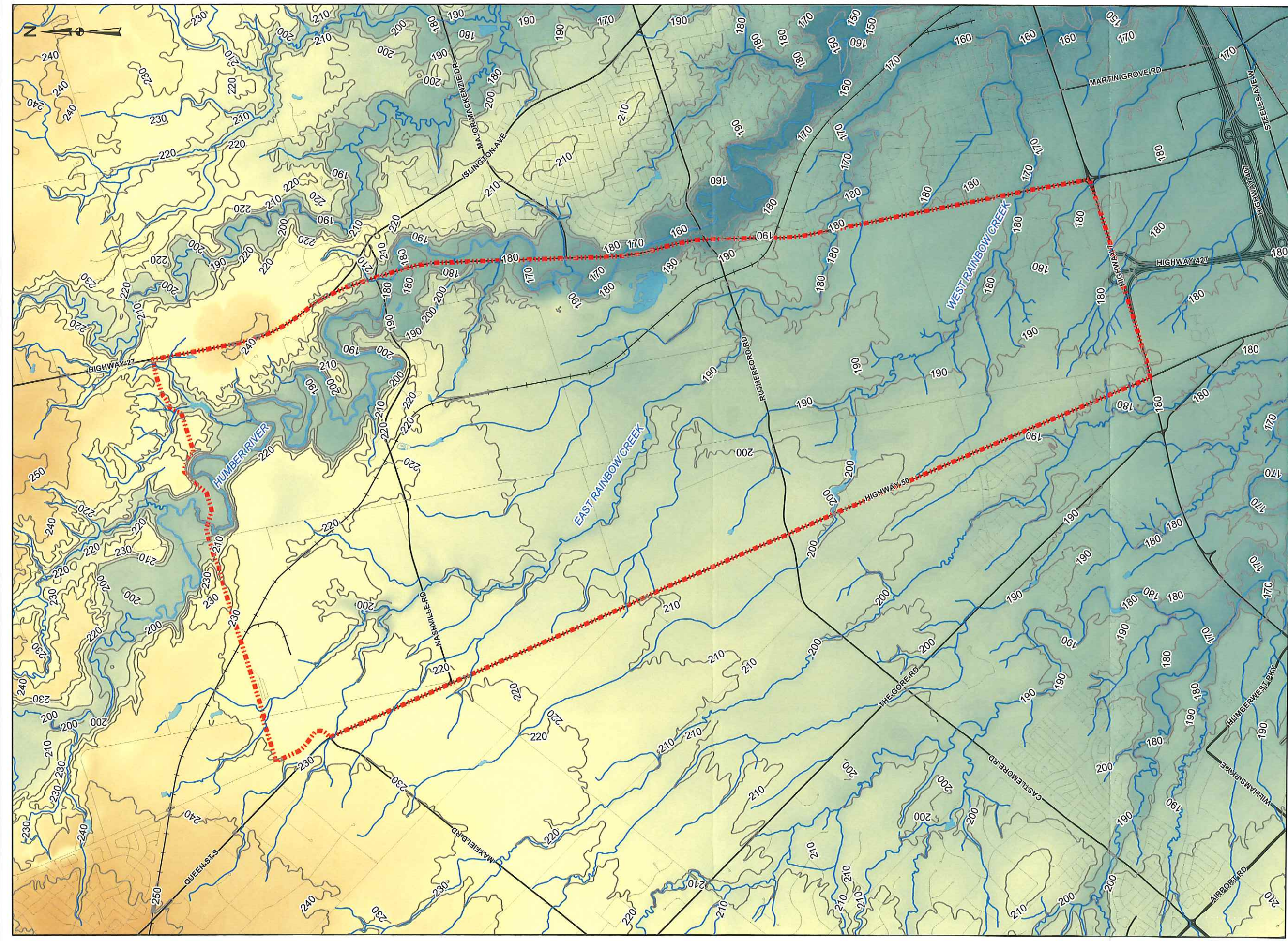
QUATERNARY GEOLOGY

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DESIGN	ASE	10 Oct. 2006
GIS	KD	08 Feb. 2007
CHECK	SMD	08 Feb. 2007
REVIEW	RB	08 Feb. 2007

Golder Associates
Mississauga, Ontario

FIGURE: 2



LEGEND

- High : 310
- Low : 120
- Watercourse
- Contours
- Study Area



TITLE
427 TRANSPORTATION CORRIDOR
ENVIRONMENTAL ASSESSMENT

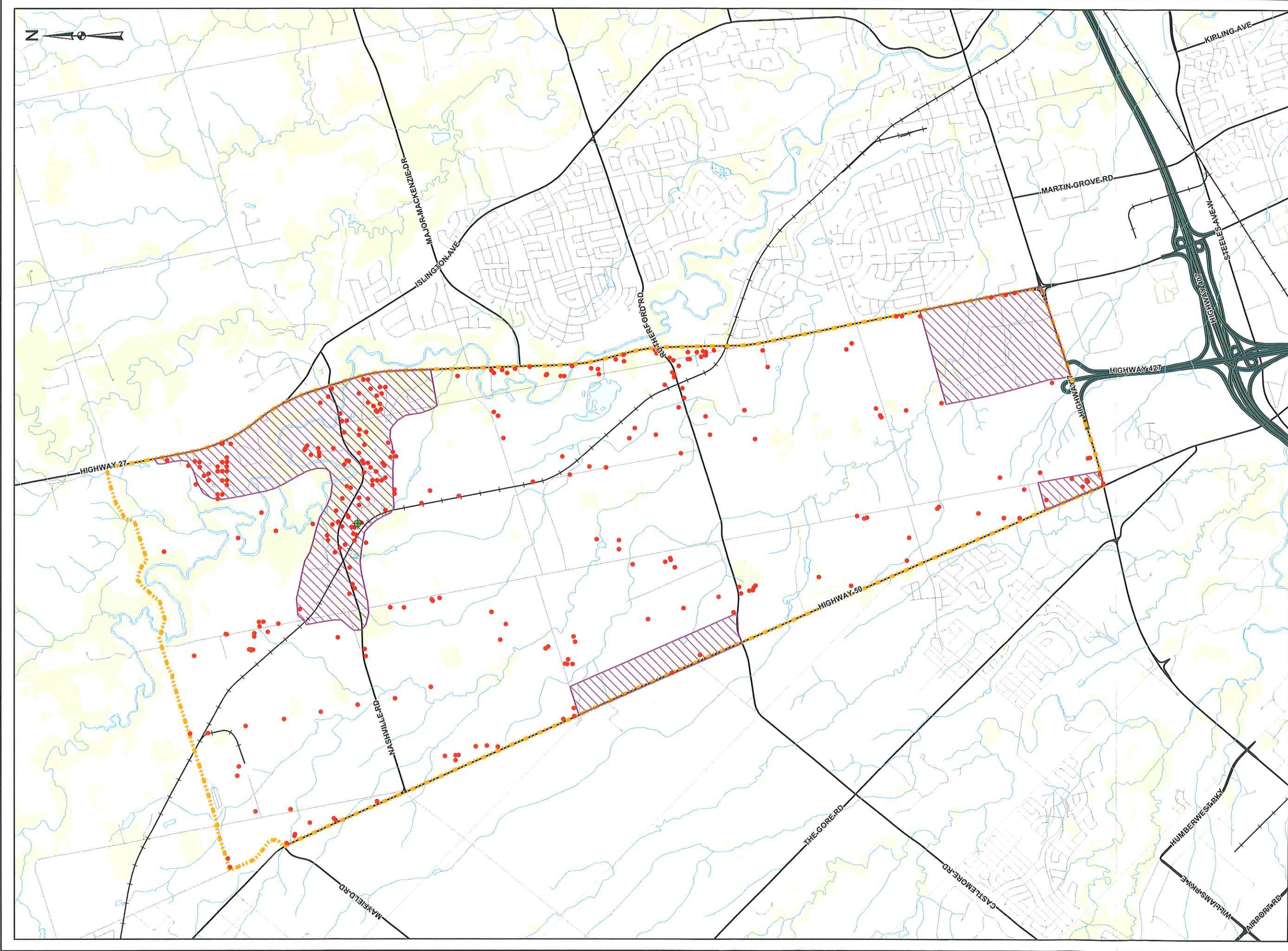
PROJECT
TOPOGRAPHIC RELIEF AND DRAINAGE

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PROJECT No.	06-111-012	SCALE	1:40,000	REV.	0
DESIGN	ASB	10 Oct. 2006			
CIS	KD	12 Feb. 2007			
CHECK	SMD	12 Feb. 2007			
REVIEW	RB	12 Feb. 2007			

FIGURE: 7

REFERENCE
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LEGEND

- York Region Production Well
- Study Area
- Municipally Serviced Areas
- MOE Water Well Record Location

REFERENCE

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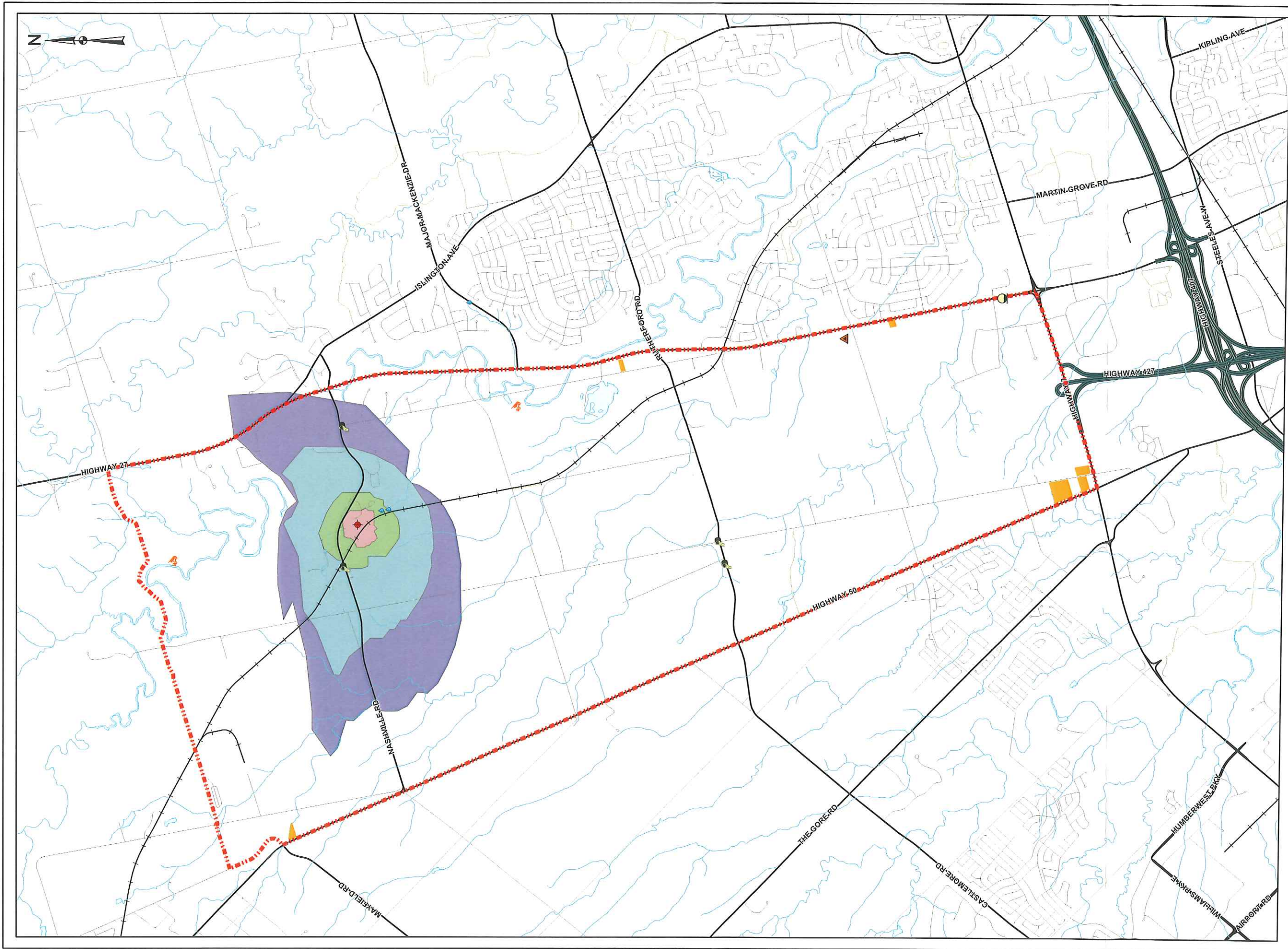
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**427 TRANSPORTATION CORRIDOR
ENVIRONMENTAL ASSESSMENT**

PROJECT
**MOE WATER WELL LOCATIONS AND
MUNICIPALLY SERVICED AREAS**

PROJECT No. 06-111-012		SCALE 1:40,000	REV. 0
DESIGN	ASB	10 Oct. 2006	
GIS	RD	09 Feb. 2007	
CHECK	SMD	09 Feb. 2007	
REVIEW	RB	09 Feb. 2007	



FIGURE: 8



LEGEND

POTENTIAL CONTAMINANT INVENTORY

Database Points	Property Code Based
Fuel Storage	Gas Station
PCB Location	
Spills	
Waste Dump	
PTTW	

WELL HEAD PROTECTION

Capture Zones

150 Day Zone
2 Year Zone
10 Year Zone
25 Year Zone
Study Area

York Region Production Well

REFERENCE

Base Data - Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources. © Queens Printer 2006. OGS - Digital Quaternary Geology of Southern Ontario, 2003. Datum: NAD 83 Projection: UTM Zone 17

Capture Zones Provided by York Region Produced by Geomatics Division Planning and Development Services Department © The Regional Municipality of York July 2004.

TITLE

427 TRANSPORTATION CORRIDOR
ENVIRONMENTAL ASSESSMENT

PROJECT

POTENTIAL CONTAMINANT INVENTORY
AND WELL HEAD PROTECTION AREA

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DESIGN	ASB	10 Oct 2006
GIS	TD	08 Feb 2007
CHECK	SMD	08 Feb 2007
REVIEW	RB	08 Feb 2007

PROJECT No: 06-111-012 SCALE: 1:40,000 REV: 0

FIGURE: 9