APPENDIX C: TECHNICAL SUPPORTING DOCUMENTS

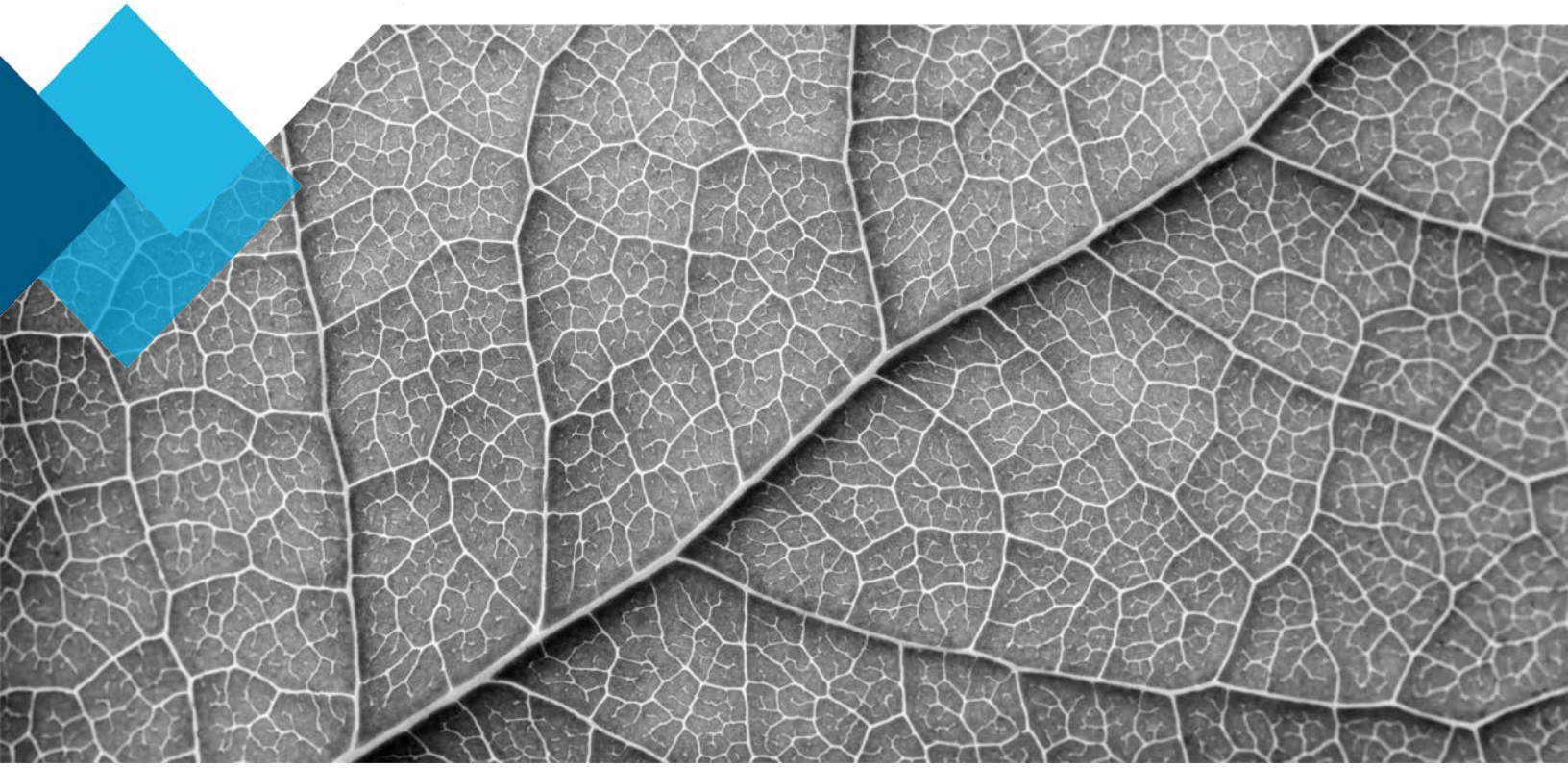
APPENDIX C-1: HYDROGEOLOGY REPORT

SNC·LAVALIN

Hamilton LRT – Environmental Project Report Addendum

Hydrogeological Update – Final Report

Steer Davies Gleave



Environment & Geoscience

FEBRUARY 24, 2017

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1 INTRODUCTION

1.1 Summary Project Description

The approved 2011 Environmental Project Report (EPR) identified the B-Line LRT route alignment to run from McMaster University to Eastgate Square, passing through the City of Hamilton's downtown.

Metrolinx and the City of Hamilton have identified the need to revise the project to:

- Address design modifications to the 2011 EPR LRT (the B-Line, Steer Davies Gleave, 2001a) alignment, moving some sections from side-running at the edge of the street to centre-running in the middle of the roadway, generally between Dundurn and the Delta, and moving one section from centre-running in the middle of the road to side-running at the edge of the road, generally between Dalewood Avenue and Cootes Drive;
- Complete the assessment of a spur line (the A-Line) in mixed traffic along James Street North connecting the new West Harbour GO Station and potentially down to the City's redeveloping Waterfront area;
- Reconfigure the MacNab Street bus terminal and include a high order pedestrian connection from King Street B-Line to Hamilton GO Centre; and,
- Complete the assessment of an Operations Maintenance and Storage Facility (OMSF) where light rail vehicles would be maintained and stored, along with its run-in track in mixd traffic on Frid Street and Longwood Road to Main Street West, across the Longwood Road bridge (Note: the assessment of the Longwood Bridge rehabilitation and ancillary pedestrian and active transportation facilities will be completed as a separate addendum).

The Environment & Geoscience business unit of SNC-Lavalin Inc. (SNC-Lavalin) was retained to complete an updated hydrogeological assessment for the support of the EPR Addendum prior to the construction of the Hamilton Light Rail Transit (LRT) project (the project). This report updates prior hydrogeological reports to match the revised alignments and updated design information.

1.2 Purpose of the Hydrological Update Report

The following document was developed in support of the EPR Addendum, currently being conducted by Steer Davies Gleave (SDG) on behalf of the City of Hamilton and Metrolinx. It provides a review and update of the hydrogeological components of the EPR to include minor design modifications to the 2011 EPR LRT (the B-Line) alignment, complete the assessment of the Spur line (A-line), and assess the new OMSF site.

This portion of the update Addendum includes:

- Review design information for the amended Hamilton LRT system (including A-Line, B-Line and OMSF);
- Review previous hydrogeological assessment reports for Hamilton LRT B-Line;
- Characterization (desktop study) of geological and hydrogeological settings in the project study area (i.e., a 500 m radius from the construction limits of the project);

- Assess potential impacts to the groundwater regime within the project study area that may occur as a result of the construction activities associated with the project; and,
- Recommend mitigation measures to address the potential impacts identified.

The study Area includes the route alignment and stop locations along the B-Line from McMaster University to the Queenston Traffic Circle, the A-Line branch from Downtown to serve the West Harbour GO Station, and the Operations, Maintenance and Storage Facility (OMSF) identified east of Longwood Road along with the connection to the B-Line route via shared-running tracks on Longwood Road.

2 DETAILED PROJECT DESCRIPTION

Below is a general description of the project components. **Figure 2.1** shows a graphical representation geographical extent of the project. Further design details can be found in the Hamilton LRT Design Workbook 1 (SDG, 2016).

2.1 B-Line (McMaster University to Queenston Traffic Circle)

The B-Line commences at McMaster University, with a new combined LRT and bus terminal (serving local Hamilton Street Railway (HSR) buses and regional GO and other bus services) to be constructed in the northeast corner of the intersection of Main Street West at Cootes Drive.

The B-Line route follows the north side of Main Street West to Dalewood Avenue, where it transitions to the centre of the two-way roadway, then continues in the centre of the two-way section of Main Street West to Paradise Road, from which it continues on the north side of the one-way westbound section of Main Street West to Highway 403.

The LRT route then crosses Highway 403 (The Chedoke Expressway) and the associated ramps to/from King Street and Main Street via a dedicated LRT bridge, then follows the south side of King Street West over the CP rail line to Dundurn Street.

From Dundurn Street to The Delta, the existing one-way westbound King Street West/East is, apart from a few short lengths, converted to two–way running with LRT in the centre of the street.

From Dundurn Street the B-Line LRT route continues in the centre of King Street West to James Street, where it connects with the A-Line. Though not currently integrated with the LRT, the existing MacNab bus terminal is reconfigured to provide additional capacity for local buses.

The route continues along King Street East through Downtown and International Village, generally with a single traffic lane on one side of the route only.

From Wellington Street the route continues in the centre of King Street East to The Delta. An underpass is provided to allow the LRT to cross beneath the CP freight line crossing at East Bend Avenue. Road traffic will continue to cross at grade as at present.

From The Delta to Queenston Traffic Circle the B-Line runs in the centre of Main Street East.

A new off-street LRT and bus terminal is provided at Queenston Traffic Circle on the site of the former City Motor Hotel and the adjacent ‘Herbies’ site. The proposed layout allows for the LRT to be extended in future to Eastgate Square.

A total of fourteen LRT stops are provided on the B-Line alignment at McMaster University, Longwood Road, Dundurn Street, Queen Street, James Street, Catharine Street, Victoria Street, Wentworth Street, Sherman Avenue, Scott Park, Delta, Ottawa Street, Kenilworth Avenue and Queenston Traffic Circle.

2.2 A-Line (King Street to Waterfront)

The A-Line route runs from a terminus north of King Street along James Street North to the northern terminus at The Waterfront. The route is shared running with other traffic, except for the terminals at each end of the route.

Connections are provided between the A- and B-Lines at the King Street / James Street intersection to allow A-Line vehicles to get to and from the OMSF via the B-Line route.

A total of five LRT stops are provided at MacNab Terminal, Cannon Street, West Harbour GO Station, Ferrie Street and The Waterfront.

2.3 Pedestrian Link to Hunter Street Go Centre

The pedestrian link from the A- and B-Lines to the Hunter Street GO Station will be developed as part of the next stage of project development.

2.4 Operations, Maintenance and Storage Facility (OMSF)

A preferred site for the OMSF has been identified near Longwood Road, north of Aberdeen St.

This is connected to the B-Line route via shared-running tracks on Frid Street and Longwood Road. A delta junction at the Main Street/Longwood Road intersection allows light rail vehicles to enter and leave service from either direction (see **Figure 2.2**).

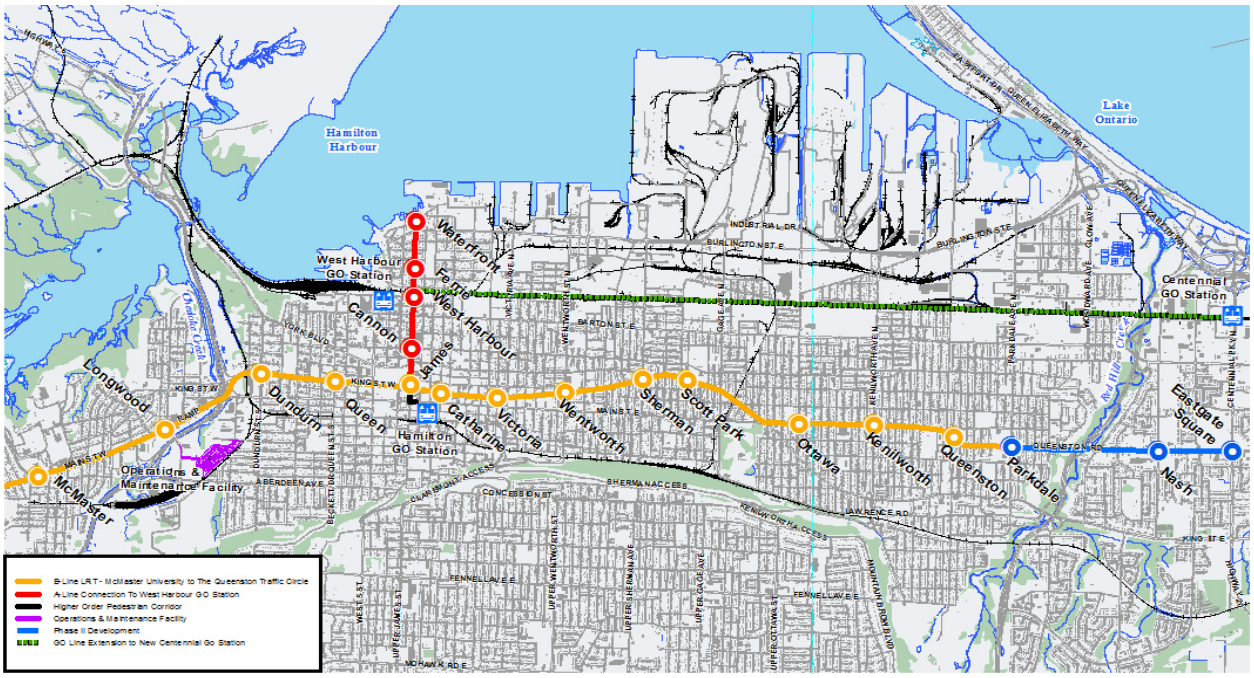

Figure 2.1: Hamilton LRT Project Overview

Legend

- Operations and Maintenance Facility (OMSF)
- Proposed LRT B-Line 2016
- Road
- Drainage

N

40 20 0 40 80 120 M

Scale: 1:2,000

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Hamilton LRT Environmental Assessment Addendum
Ecological Update

Operations Maintenance Facility (OMSF)

Date: 2017/02/15	File Number: 638045	Sub Code: ENVR
Figure: **2.2**		Rev. **0**

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3 LOCAL PHYSICAL SETTINGS

There are no major changes to the B-Line corridor comparing to the previous B-Line route, except its total length and stops (shorter and fewer than before). The proposed A-Line Spur is a relatively short route and the OMSF is relatively close to the B-Line. As such, the overall physical assessment remains largely the same as described in the previous hydrogeological reports.

The local physical setting within the project study area (i.e., 500 m radius from the site) are referenced mainly from the Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study (Charlesworth & Associates and SNC-Lavalin, 2006); and Vulnerability Assessment and Scoring of Wellhead Protection Areas (Earthfx, 2010).

3.1 Topography and Surface Water Features

The topography within the study area is typically flat, sloping gently towards Hamilton Harbour and Lake Ontario. The majority of the study area is heavily urbanized with significant building structures along the central corridors.

Main surface water features present in the study area include Chedoke Creek, Burlington Bay (including Cootes Paradise) and Hamilton Harbour.

- The Chedoke Creek sub-watershed comprises a broad area above the escarpment and tapers down to a very narrow valley where the creek discharges directly to Cootes Paradise.
- Hamilton Harbour is located at the most western end of Lake Ontario. Breached sand bars separate the bay from the lake and Cootes Paradise. Hamilton Harbour is approximately 21.5 square kilometres in size.
- Cootes Paradise is an 840-hectare wildlife sanctuary located at the western end of Burlington Bay. Tributaries of the North Cootes Paradise, Spencer Creek, and Chedoke Creek watersheds discharge to Cootes Paradise. It contains a shallow, freshwater coastal marsh that is 250 hectares in size. Cootes Paradise marsh is an important waterfowl staging habitat and the largest nursery habitat for fish in the Hamilton region. It is designated as a Provincially Significant Class 1 Wetland and an Area of Natural and Scientific Interest. It is also listed as an Environmentally Sensitive Area by the City of Hamilton.

3.2 Physiography

The study area is located within the Iroquois Plain, which consists of mainly the lacustrine deposits and lake-bottom sediments. The width of this plain varies, but is usually about 3 kilometres wide within the City of Hamilton area. Between Lake Ontario and the Niagara Escarpment, the plain is cut by a number of creeks that historically had lagoons or marshes at their outlet to the Lake.

3.3 Geology

Quaternary Deposits

The majority of the amended LRT corridor lies within the glaciolacustrine deposits of the Iroquois Plain, consisting of glaciolacustrine sand and silt, and some gravel. Towards the east end of the B-Line,

Paleozoic bedrock (shale and dolomite) and Halton Till (silty to clayey till) are present. Some localized modern alluvial deposits are located near Chedoke Creek. Overburden thickness across the project alignment varies, ranging from a few meters to approximately 30 m.

Bedrock

Bedrock in the project study area consists of the Queenston Formation (from Upper Ordovician age), which is predominantly red shale with green siltstone bands. The formation thickness is estimated to be 300 m as a minimum, with the upper surface of the formation described as weathered. The bedrock elevations are relatively flat, between approximately 76 m above mean sea level (amsl) and 91 m amsl, except in the Chedoke Creek area.

The entire study area is noted to be below and hydrogeologically downgradient of, the Niagara escarpment.

3.4 Hydrogeology

Regional Aquifers

There are two (2) types of regional aquifers in the Hamilton area: overburden aquifers and bedrock aquifers. The overburden aquifers consist of granular deposits within the shallow overburden, and the thicker overburden along bedrock valleys (i.e., the Dundas Valley).

A sand and gravel aquifer overburden aquifer is located west of Highway 403 in the Chedoke Creek and Cootes Paradise areas. It underlies the western portion of the B-Line near the terminus at McMaster University and also underlies the OMSF site.

There are no bedrock aquifers that underlie the proposed alignment. Both the Salina and Guelph Amabel and Lockport Formation aquifers are south or west of the current alignment limits.

No other regional aquifers are identified in the study area (**Appendix A**).

Groundwater Conditions

Groundwater levels range from approximately 2 m below ground surface (bgs) to 16 m bgs to the west of the Highway 403 corridor, and from 2 to 9 m bgs east of Highway 403 in the project study area. Groundwater levels are expected to be slightly shallower towards the Hamilton Harbour.

Groundwater flow directions are generally from the southern highlands toward Hamilton Harbour and Lake Ontario. Where infrastructure is present below the groundwater table (i.e., watermains, storm and sanitary sewers, tunnels and/or other linear corridors) they may result in preferential pathways that have localized and limited impacts on groundwater flows.

Recharge Areas

Regionally, there is a small linear feature in the southwestern extent of the Dundas Valley (below the escarpment) and the central area of Spencer Creek (in the area of the Norfolk Sand Plain and the Flamborough Plain) above the escarpment identified as being significant to recharge. Small portions of

the Stoney Creek and Red Hill Creek watersheds are also deemed as significant groundwater recharge areas.

There are no significant groundwater recharge areas identified in the study area, with most of the alignment being located along an area mapped as a discharge zone. Some low potential recharge zones are located along York Boulevard (Dundurn Park and Hamilton Cemetery areas) between Highway 403 and Hamilton Harbour, as well as near the shoreline of the Harbour (i.e., north portion of A-Line). However, these are either outside of the alignment impact areas or in highly developed areas of the City and unlikely to have permeable surfaces that would allow recharge to occur (**Appendix B**).

The closest high recharge area (above the escarpment) is located approximately 850 m south of the B-Line (central and eastern portions).

Groundwater Vulnerability

Groundwater vulnerability (intrinsic susceptibility) is generally defined as the likelihood of groundwater contamination due to the introduction of a contaminant at the ground surface. The key attributes are the depth to the water table or aquifer, and the hydraulic conductivity of the geological material in the unsaturated zone.

Based on the above assessment criteria, groundwater vulnerability is considered to be high in the middle portion of B-Line and along entire A-Line; medium for the remaining portions of the corridors, except near the west end of B-Line in the Dundas Valley, where it is considered low (**Appendix C**).

If, during the construction of the project, a spill (or other forms of contaminant release) occurs at the ground surface in these vulnerable areas, the contaminant (source) will infiltrate into the ground and migrate downwards through the unsaturated zone along a “pathway” towards the water table in a short period of time (due to the shallower groundwater table and higher hydraulic conductivity, i.e., sand and gravel). When the contaminant reaches the water table, in the groundwater system, it is very difficult to remediate as groundwater moves relatively slow and flushing out an aquifer (or purging/pumping) can take a very long time. Therefore, when working in these vulnerable areas, it is very important to prevent contamination from happening in the first place.

4 SOURCE WATER PROTECTION

Information related to source water protection is referenced from the Assessment Report for the Hamilton Region Source Protection Area (Halton-Hamilton Source Protection Committee, 2015).

4.1 Well Head Protection Areas

No Wellhead Protection Areas (WHPAs) are identified within or near the study area boundaries. The closest WHPA (Greensville well field) is located approximately 5 km northwest of the western portion of B-Line.

4.2 Intake Protection Zones

The Woodward Municipal Supply system is the only drinking water system that draws water from Lake Ontario located within the Hamilton Region Source Protection Area. It has three intake pipes, but only one is currently in use.

To protect the quality of Lake Ontario water, the nearshore environment in the vicinity of the surface water intake was assessed and delineated. The delineated areas could offer protection to the water supply through the implementation of policies. These delineated areas are called intake protection zones (IPZ). Three zones (IPZ-1, IPZ-2 and IPZ-3) have been delineated for the Woodward drinking water intake system (**Appendix D**).

The northern portion of A-Line extends to an area is near the boundary of IPZ-3 but does not encroach on it.

4.3 Existing Groundwater Users

The proposed LRT corridors are located in heavily urbanized areas that utilize a municipal drinking water supply system, no private groundwater users/wells are expected within the project study area.

4.4 Groundwater Monitoring Requirements

For the purpose of source water protection, a groundwater monitoring program should be developed during the detailed design phase of the project, especially for the portion that is near the intake protection zone (i.e., norther portion of A-Line). The monitoring program should include both groundwater level and water quality monitoring to ensure that no adverse impact to the water sources will occur as a result of the construction of the project.

5 POTENTIAL CONTAMINATION SOURCES

Potential sources of contamination are documented as per the following investigation summaries.

5.1 Dillon Report (2009)

A number of potential contaminated sites were been identified along the B Line route through the review of a variety of geotechnical and environmental reports. As a result, it is likely that contaminated soil and groundwater will be encountered during the construction of the project. The site locations identified by Dillon as having with actual or potential contamination are summarized in **Table 1**.

Table 1: Potential Contaminated Sites (Dillon 2009)

Nearest Major Intersection	Geotechnical Report Number	Report Reference Information	Actual/Potential Contamination Investigation and/or Type
King Street & Gage Avenue	517[1]	Sitest Engineering, 1989. Geotechnical Investigation, Proposed Sanitary Sewers, King Street (Gage to Glendale), Hamilton, Ontario. File No. 8903.	Gasoline
King Street & Ottawa Street	646[1]	Mountainview Geotechnical Ltd., 1992. Geotechnical Investigation, Proposed Sewer Installations, City of Hamilton. Project No. S0220.	Petroleum hydrocarbons
Main Street West & Cootes Drive	684[1]	Trow Consulting Engineers Ltd., 1993. Phase I Geo-Environmental Assessment, Cootes Drive Rail Lands, Hamilton Ontario. Project: H02917-E.	Phase I Investigation
Main Street West & Cootes Drive	693[1]	Trow Consulting Engineers Ltd., 1993. Follow-up Environmental Testing, CP Rail Right-of-Way Adjacent to Cootes Drive, Hamilton Ontario. Project: H02917-E.	Follow-up to Phase I (684[1]), to investigation potential PAH impacts in soil and groundwater.
Main Street, King Street & Highway 403	695[1]	Peto MacCallum Ltd., 1993. Geotechnical Investigation King/Main Street Storage Tank, Hamilton, Ontario. Job No. 93HF100	Refuse fill (historical landfill)
Main Street East & Sherman Avenue	ESA1_29[1]	Jacques Whitford, 2008. Soil Analytical Results – Northern and Western Property Lines, Former Sunoco Retail Outlet No. 5995. 790 Main Street East, Hamilton, Ontario. Project No. 102865	Petroleum hydrocarbons
Main Street West & Cootes Drive	ESA1_33[1]	WESA, 2008. Phase I Environmental Site Assessment of City of Hamilton Rail Trail Corridor, Hamilton, Ontario. File: W-B5247-00.	Phase I Investigation
Main Street East & Gage Avenue	ESA1_34[1]	AMEC Earth & Environmental, 2007. Phase I Environmental Site Assessment, Commercial Property, 979 Main Street East & 56 East Bend Avenue South, Hamilton, Ontario. TB71002.	Phase I Investigation
Main Street East & Gage Avenue	ESA2_13[1]	Peto MacCallum Ltd., 2008. Phase II Environmental Site Assessment 979 Main Street East and 56 East Bend Road South, Hamilton, Ontario. PML Ref.: 08HX011	Phase II Investigation – includes petroleum hydrocarbons

5.2 SNC-Lavalin Report (2011)

In 2011, SNC-Lavalin reviewed additional available information from City of Hamilton databases and completed a field visit to further identify potential contamination sources in the vicinity of the site (along

B-Line). Based on the review and site visit, the following additional sites (see **Table 2**) were identified that may have potentially contaminating activities.

Table 2: Sites with Potentially Contaminating Activities (SNC-Lavalin 2011)

Location	Potentially Contaminating Activity	Potential Contaminant	Reference
Queenston Road & Parkdale Avenue S.	Auto repair shop	Petroleum hydrocarbons, metals and VOCs	Hamilton report ID # 997
King Street E. & Gage Avenue N.	Auto battery shop and Auto sales shop	Petroleum hydrocarbons, metals and VOCs	Field observation
Main Street E. & Ottawa Street N.	Auto tire and repair shop	Petroleum hydrocarbons, metals and VOCs	Field observation
	Auto repair shop		Hamilton report ID # 969
Main Street E. & Kenilworth Avenue N.	3 auto repair shops, dry cleaning depot	Petroleum hydrocarbons, metals and VOCs	Field observation
	Auto garage - oil and lube services; Auto glass and gas station		Hamilton reports ID # 990 and # 984
Queenston Road & Parkdale Avenue S.	Auto repair shop	Petroleum hydrocarbons, metals and VOCs	Field observation

5.3 SNC-Lavalin Update Report (2016)

As part of the updated assessment on the refined alignments (including B-Line and A-Line Spur) and selection of the OMSF, the following new locations have been identified as potentially being sources of contamination to the works.

Location	Potentially Contaminating Activity	Potential Contaminant	Reference
Harbour West, Hamilton Port Authority	Fuel pumping station	Petroleum hydrocarbons and VOCs	Field observation
James St. N. and Macaulay St. E.	Marine supplies shop with oil change services	Petroleum hydrocarbons, metals and VOCs	Field observation
James St. N. and Cannon St. W.	Auto repair shop	Petroleum hydrocarbons, metals and VOCs	Field observation
Cannon St. E. and Hughson St. N	2 Auto repair shops	Petroleum hydrocarbons, metals and VOCs	Field observation

Based on a review of aerial photography, the proposed OMSF site has been used as an industrial facility since at least 1934. Various companies have occupied the property including registered waste generators such as Hamilton Metal Trading Inc., CTK Railcar Service Inc. and Elko Industrial Trading. These companies were listed as generators of hazardous wastes from 1986 to 2011. During a field inspection the following potentially contaminating activities were noted at the proposed MSF site:

- Scrap metals and stains were noted in warehouse building. The floor consist of old wood tiles;
- An old spur line is still present north of the building;
- A train tanker of unknown content was noted north of the building;
- Scrap metal was noted in the northern portion of the site.

The following concerns were noted on the surrounding properties:

- A steel manufacturer, Steel Republic, is present on the adjacent property to the north and east of the site;
- Two above ground storage tanks (ASTs) were observed on the adjacent property to the east of the site;
- One auto repair shop is located approximately 150 m east of the site;
- Tanks on the CN property are located approximately 50 m east of the site;
- Fill of unknown origin and quality was present on an adjacent property west of the site.

More detailed contamination source information can be found in the updated Contamination Overview Study report completed by SNC-Lavalin in November 2016.

6 POTENTIAL IMPACTS AND MITIGATION MEASURES

Based on the current design information (at-grade construction) for the proposed Hamilton LRT project, no significant impacts to the groundwater regime are expected, as no significant groundwater recharge areas or wellhead (municipal well field) protection areas are present, and no private drinking water wells are expected in the project study area. However, minor localized disturbance and impacts to groundwater may occur due to project related construction activities. These could include construction dewatering (for structure foundations) and utility relocation (especially in shallow groundwater level areas, i.e. near shoreline or creeks); accidental spills or releases of contaminants (i.e., fuel, lubricating oil and metals) during refueling, operations and maintenance of the equipment; and potential contaminated soil and/or groundwater handling.

The potential impacts and recommended mitigation measures (**Table 3**) are listed as follows:

Table 3: Potential Impacts and Mitigation Measures

Potential Impacts	Mitigation Measures
Temporary reduction of groundwater flow to surface water bodies and wetlands due to construction dewatering.	- Limit dewatering duration and volumes as minimal as possible.
Mobilization and discharge of contaminated groundwater (likely to be encountered as potential contamination sources were identified, as described in Section 5) due to construction dewatering.	- Groundwater sampling should be conducted prior to discharge to assess baseline groundwater qualities. - Discharge water should be treated prior to discharge if contamination/exceedance is detected. - If extracted water is to be directed to the natural environment (i.e., creeks, ditches), proper erosion and sediment control measures should be implemented.
Groundwater contamination due to accidental spills or release of contaminants especially in those groundwater highly vulnerable areas (i.e., shallow groundwater level and regional aquifer areas, near shoreline) and intake protection zones.	- Educate and train staff on procedures and protocols to avoid spills. - Refuel equipment and vehicles on spill pads and/or in designated areas. - Store and handle hazardous materials properly to prevent from releasing into the natural environment. - Remove and dispose waste materials by licensed contractors.
Groundwater contamination due to contaminated soil stockpiling (if any generated from excavation).	- Utilize MOECC soil management best practices, including developing soils management plans for the project. - Avoid stockpiling contaminated soil in groundwater highly vulnerable areas. - Cover contaminated soil piles during rain events (to prevent contaminants/leaches from releasing into the ground). - Dispose contaminated soil off-site (at a licenced waste facility) as soon as possible using licenced contractors.

Construction dewatering discharges are often conveyed to the City's storm and/or sanitary sewer infrastructure. If this potential option will be used to manage dewatering discharge, an agreement with Hamilton Water's Environmental Monitoring and Enforcement Group would be required to ensure that the discharged water complies with the City of Hamilton Sewer Use Bylaw. It is recommended that the City and its contractors contact the Superintendent, Environmental Monitoring and Enforcement Group in Hamilton Water, or send an email request to sewerusebylaw@hamilton.ca for more information to better understand discharges to the City's infrastructure. The City should also be informed if sites are historically contaminated with diesel or other fuels for developing future groundwater remediation strategies and plans.

In addition, contingency plans should be developed to handle contaminated soil and/or groundwater (in case encountered) and accidental spills during the construction period to prevent or minimize potential groundwater contamination.

7 REFERENCES

Charlesworth & Associates, SNC-Lavalin Inc., 2006. Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study, Report to City of Hamilton, April 2006.

Dillon Consulting Limited (Dillon), 2009. City of Hamilton Rapid Transit Initiative Hydrogeology Report – Final, Report to City of Hamilton, March 2009.

Earthfx Incorporated (Earthfx), 2010. Vulnerability Assessment and Scoring of Wellhead Protection Areas, City of Hamilton, Ontario (Final Report), April 2010.

Halton-Hamilton Source Protection Committee, 2015. Assessment Report for the Hamilton Region Source Protection Area (Version 2.7), July 24, 2015.

SNC-Lavalin Inc., 2011. Technical Report, Hamilton LRT – B Line, Updated Hydrogeological Report, Report to City of Hamilton, October 2011.

Steer Davies Gleave, 2016. Design Workbook 1, Hamilton LRT, May 2016.

Appendix A

Regional Aquifers

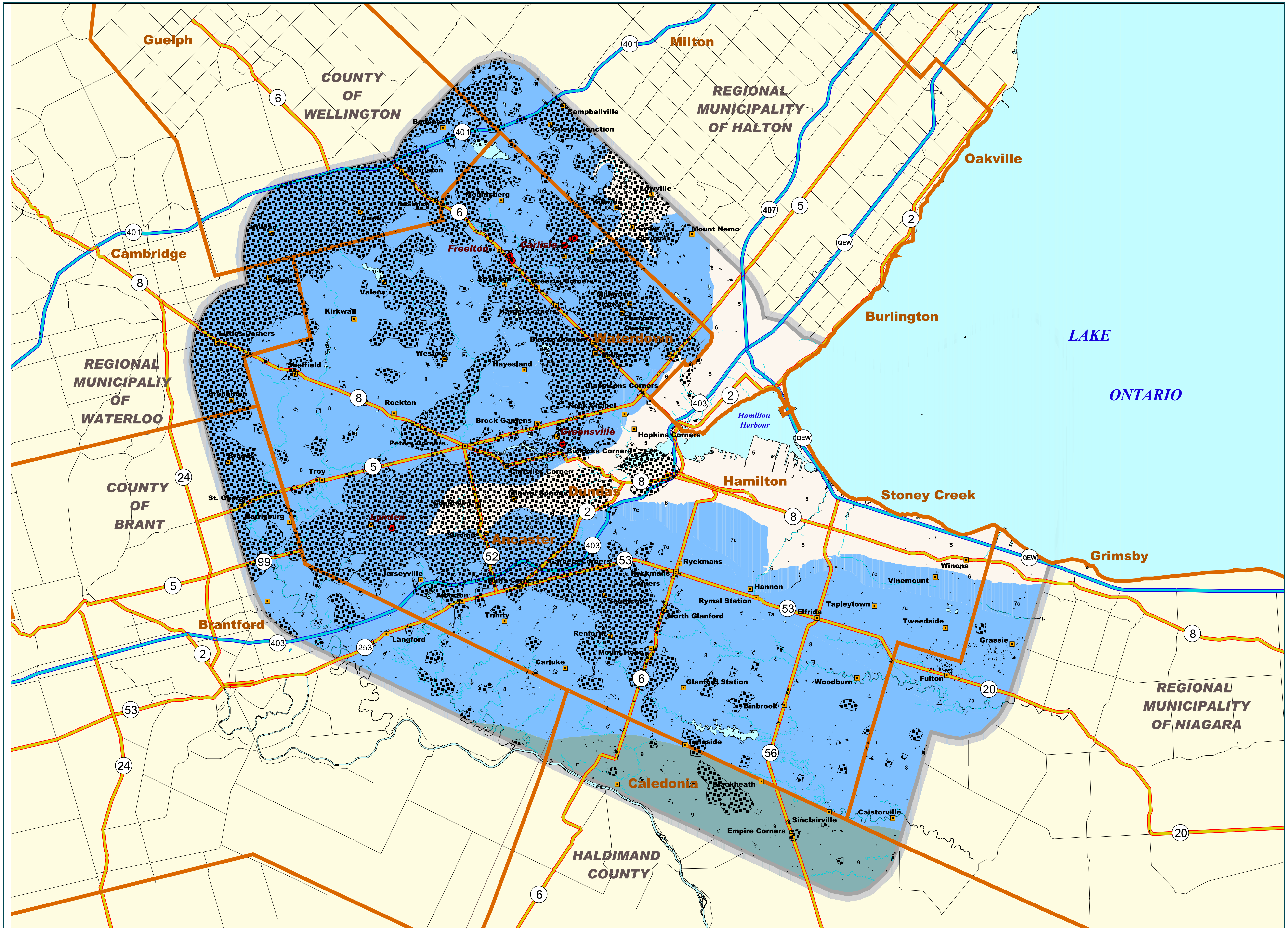

Figure: 2.7

Regional Aquifers

- Sand and Gravel Aquifer
- Bedrock Aquifer Salina Formation
- Bedrock Aquifer Guelph-Amabel/Lockport Formation

City of Hamilton Groundwater Resources Characterization and Wellhead Protection Study

Hamilton

Source; Paleozoic Geology.
Derived from Ministry of Northern Development and Mines published maps (1976-79) by SLE&C.

- A Map Sheet (A to D)
- Municipal Well
- Town/Village
- Watercourse
- Major Highway
- Highway
- Road
- Municipal Boundary
- Study Area
- Waterbody
- Built Up

1000 0 1000 2000 3000 4000 5000 6000 7000 Meters

The information conveyed by this map is regional in nature and is not suitable for use in site specific evaluations. The map should be interpreted in conjunction with the accompanying written report.

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Charlesworth & Associates

Appendix B

Groundwater Recharge Areas

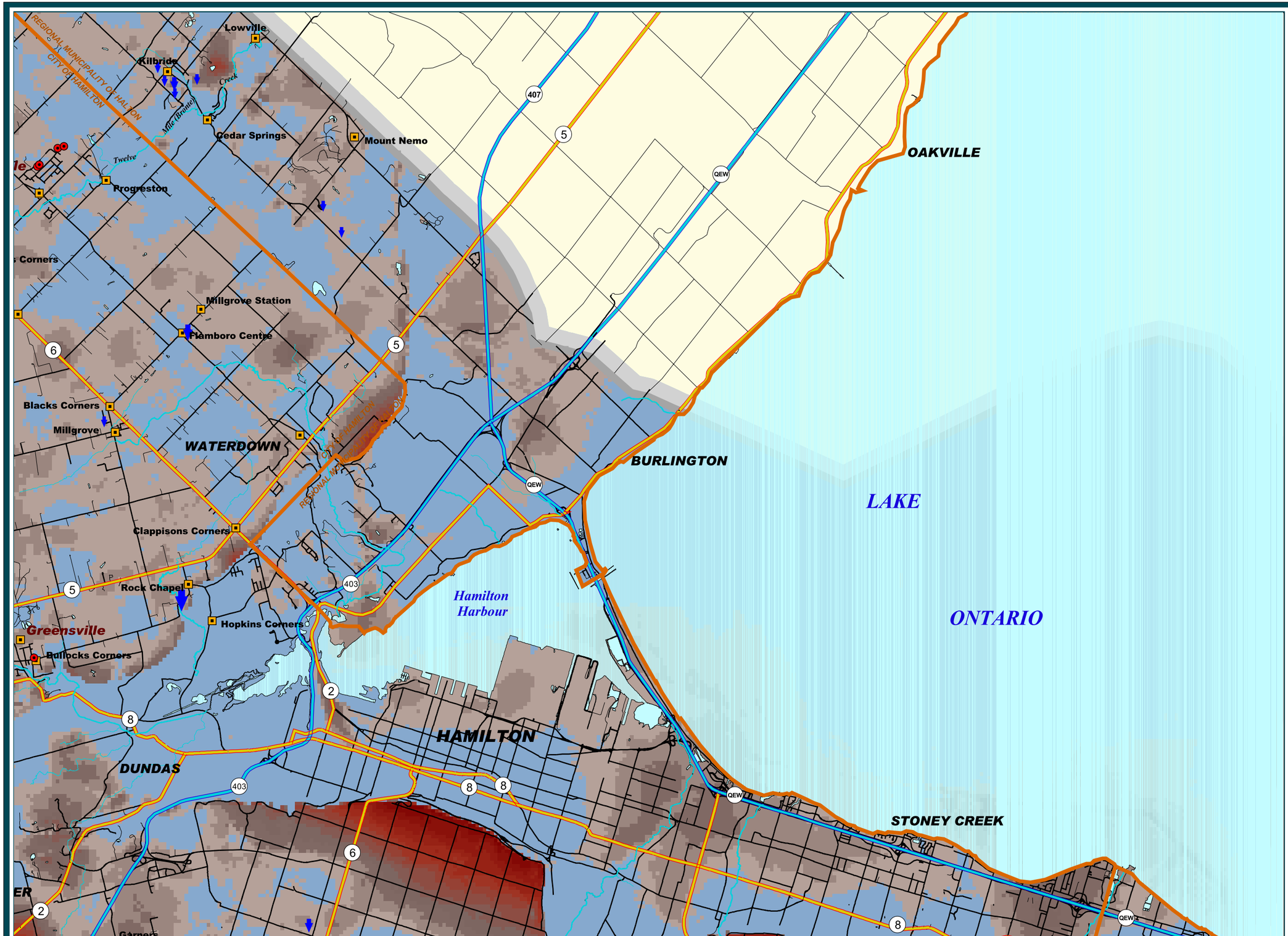


Figure: 3.14C

Downward Vertical Gradient

(Potential Recharge Areas)

Recharge Potential

High

Medium

Low

Nested Wells (Downward Gradient)

- 10 to 12
- 8 to 10
- 5 to 8
- 2 to 5
- 0 to 2

Discharge Area (Upward Gradient)

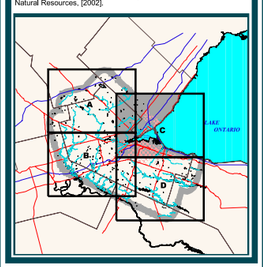
- Municipal Well
- Town/Village
- Watercourse
- Major Highway
- Highway
- Road
- Municipal Boundary
- Study Area
- Waterbody

1000 0 1000 2000 Meters

City of Hamilton Groundwater Resources Characterization and Wellhead Protection Study

Hamilton

Source: Suface based on the Water Well Information System (WWIS) Access database compiled by EarthFX for the MOE (2002).
Base Data - Natural Resources and Values Information System [NRVIS computer file].
Toronto, Ontario: The Ontario Ministry of Natural Resources, [2002].



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Appendix C

Groundwater Vulnerability

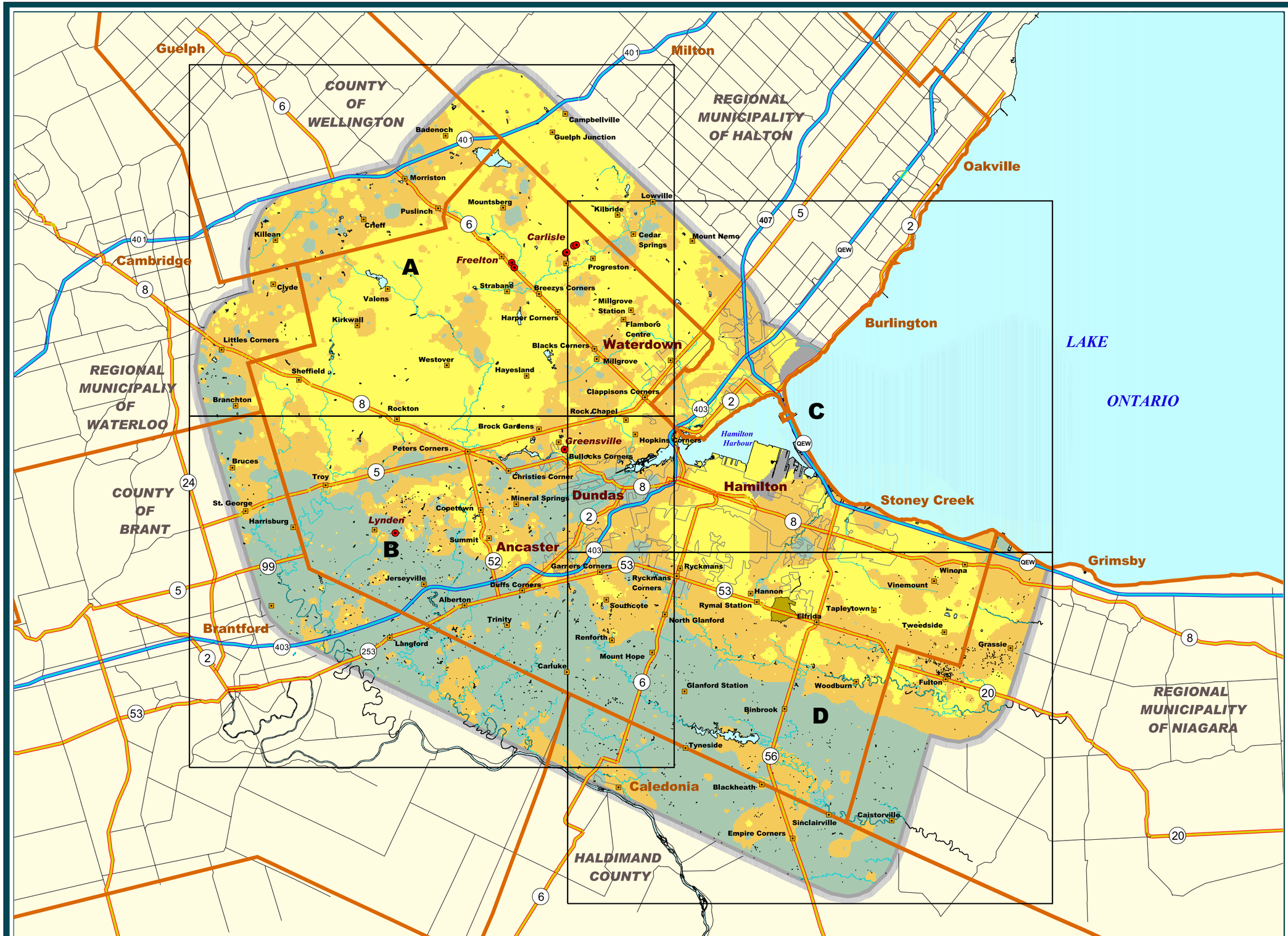

Figure: 3.24

Groundwater Intrinsic Susceptibility Index (GwISI)

- High (<30)
- Medium (30-80)
- Low (>80)
- No Data
- Eramosa Karst Area

- Map Sheet (A to D)
- Municipal Well
- Town/Village
- Watercourse
- Major Highway
- Highway
- Road
- Municipal Boundary
- Study Area
- Built Up
- Waterbody

1000 0 1000 2000 3000 4000 5000 6000 7000 Meters

City of Hamilton Groundwater Resources Characterization and Wellhead Protection Study

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The information conveyed by this map is regional in nature and is not suitable for use in site specific evaluations. The map should be interpreted in conjunction with the accompanying written report.

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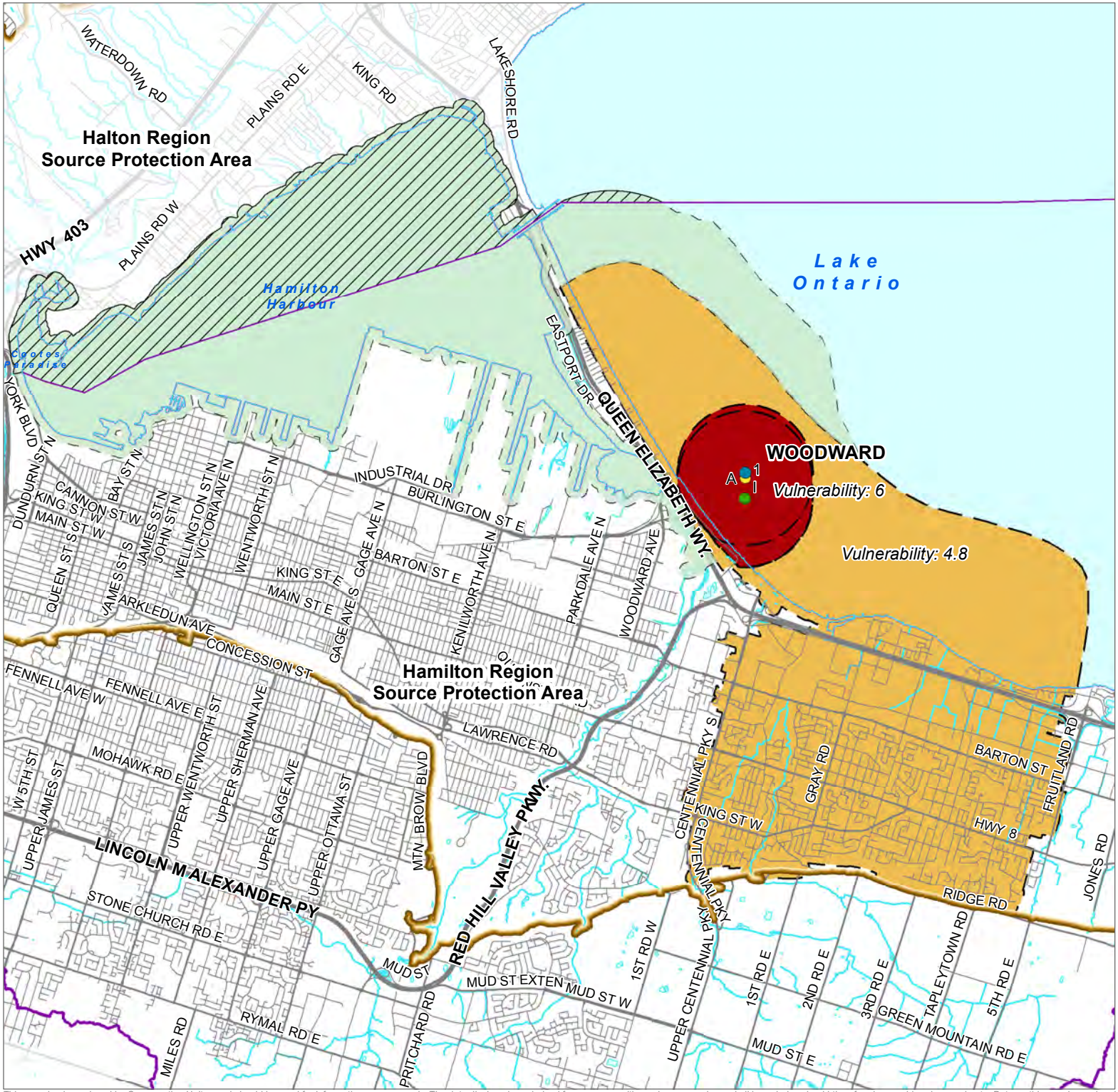
SNC·LAVALIN Engineers and Constructors

Charlesworth & Associates

Appendix D

Intake Protection Zones



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Figure 6.1

Woodward Intake Protection Zone (IPZ)

Legend

- Source Protection Region
- Source Protection Area (SPA)
- Niagara Escarpment

Roads

- Highway
- Regional
- Local
- Hydrography
- Waterbody

Municipal Intake

- Intake-1, Operational
- Intake-2, Non Operational
- Intake-3, Non Operational

Intake Protection Zones (IPZs)

- IPZ-1
- IPZ-2
- IPZ-3
- Area of IPZ-3 extending into Halton SPA

Intake Class 1 - Drinking Water System Class
I - Water System Type

Source : City of Hamilton / Lake Ontario Collaborative / Stantec Consulting Inc. as amended 2009.

Projection : UTM NAD 83 Zone 17
Date : November 2014

N W E S

0 395 790 1,580 2,370
Meters

1:80,000

Conservation Halton · Hamilton Conservation Authority · Ontario

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