NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Phase 1 Desktop Assessment, Environment Report

TOWNSHIP OF MANITOUWADGE, ONTARIO



APM-REP-06144-0074

OCTOBER 2014

This report has been prepared under contract to the NWMO. The report has been reviewed by the NWMO, but the views and conclusions are those of the authors and do not necessarily represent those of the NWMO.

All copyright and intellectual property rights belong to the NWMO.

For more information, please contact:
Nuclear Waste Management Organization
22 St. Clair Avenue East, Sixth Floor
Toronto, Ontario M4T 2S3 Canada
Tel 416.934.9814
Toll Free 1.866.249.6966
Email contactus@nwmo.ca
www.nwmo.ca

October 2014

PHASE 1 DESKTOP ASSESSMENT

Environment Report - Township of Manitouwadge, Ontario

Submitted to:
Nuclear Waste Management Organization
22 St. Clair Avenue East, 6th Floor
Toronto, Ontario
M4T 2S3

REPORT

Report Number: 12-1152-0026 (4100)(4105)
APM-REP-06144-0074

Distribution:

pdf Copy - NWMO

pdf Copy - Golder Associates Ltd.

Golder Associates

Table of Contents

1.0 INTRODUCTION 2

2.0 COMMUNITIES AND INFRASTRUCTURE 4

2.1 Communities 4

2.2 Infrastructure 4

2.3 Protected Areas 5

2.3.1 Parks and Reserves 5

2.3.2 Heritage Sites 5

2.4 Land Use 5

3.0 DESCRIPTION OF THE ENVIRONMENT 8

3.1 Physiography 8

3.2 Geology 8

3.2.1 Bedrock Geology 8

3.2.2 Quaternary Geology 9

3.3 Natural Environment 9

3.3.1 Natural Environment Overview 9

3.3.2 Natural Areas 9

3.3.3 Terrestrial Features and Wildlife 10

3.3.4 Aquatic Features and Fish 10

3.3.5 Endangered, Threatened and Special Concern Species 11

3.3.6 Aboriginal Interests and Traditional Knowledge 13

3.4 Background Environmental Conditions 13

3.4.1 Air Quality 13

3.4.2 Background Radiation 14

3.4.3 Soil Quality 15

3.4.4 Water Quality 15

3.4.5 Lake Sediment Chemistry 15

3.4.6 Potential Sources of Pollutants 15

3.5 Surface Water Hydrology 16
3.6 Groundwater and Wells 16
3.6.1 Overburden Aquifers 17
3.6.2 Bedrock Aquifers 17
3.7 Climate and Meteorology 17
3.7.1 Temperature 18
3.7.2 Precipitation 18
3.7.3 Wind 18
3.8 Natural Hazards 19
3.8.1 Earthquakes and Seismicity 19
3.8.2 Tornadoes and Hurricanes 19
3.8.3 Drought and Flooding 19
3.8.4 Snow and Ice 19
3.8.5 Forest Fires and Lightning 20
3.8.6 Landslides and Tsunamis 20
4.0 SUMMARY 22
5.0 REFERENCES 26

TABLES

Table 1: Population Statistics for the Manitouwadge Area 4
Table 2: Potential Endangered, Threatened and Special Concern Species in the Manitouwadge Area 11
Table 3: NPRI Regional Sources of Air Emissions 13
Table 4: Registered Landfills in the Manitouwadge Area 16
Table 5: Water Well Record Summary for the Manitouwadge Area 17
Table 6: Monthly Wind Normals for Geraldton, Ontario 18

FIGURES

Figure 1: Manitouwadge and Surrounding Lands
Figure 2: Satellite Imagery of the Manitouwadge Area
Figure 3: Manitouwadge Area Land Ownership

Figure 4: Manitouwadge – Parks and Protected Lands

Figure 5: Forest Management Units of the Manitouwadge Area

Figure 6: Bedrock Geology of the Manitouwadge Area

Figure 7: Quaternary Geology of the Manitouwadge Area

Figure 8: Digital Elevation Model (DEM) of the Manitouwadge Area

Figure 9: Manitouwadge – Terrestrial Ecology

Figure 10: Manitouwadge – Aquatic Ecology

Figure 11: Manitouwadge – Background Radiation Levels

Figure 12: Manitouwadge Surface Water Drainage and Water Wells

Figure 13: Manitouwadge and Geraldton1971-2000 Temperature Data Summary

Figure 14: Manitouwadge and Geraldton1971-2000 Precipitation Data Summary

1.0 INTRODUCTION

The Township of Manitouwadge in north-central Ontario expressed interest in continuing to learn more about a facility to manage Canada's Used Nuclear Fuel through the Nuclear Waste Management Organization's (NWMO) Adaptive Phased Management Site Selection Process (NWMO, 2010). This process is seeking to find a site for a deep geological repository that will provide safe long-term containment and isolation with an informed and willing host community. The process is presently at an early stage.

Part of the process is focussed on determining if there are environmental features that would preclude the potential for a facility to be constructed and operated in the vicinity of Manitouwadge. To this end, this report provides a general description of the environment in the Township of Manitouwadge and surrounding area. It is complemented by reports prepared in parallel which characterize the geoscientific conditions and community well-being profile of this area. These reports are summarized, with other information, in an integrated Preliminary Assessment Report.

This report is not an environmental assessment. Its purpose is to provide a high level description of the current human and natural environment based on readily available sources of data. Additional detailed information for specific locations would be sought at subsequent phases of the work.

The Manitouwadge area here is the same as that used for the Phase I Geoscientific Desktop Assessment for Manitouwadge. This area is shown on Figure 1, and includes the Township of Manitouwadge and surrounding area.

2.0 COMMUNITIES AND INFRASTRUCTURE

2.1 Communities

The Township of Manitouwadge is approximately 373 km^2 in size[1] and is 60 km northeast of Lake Superior approximately 55 km north of the Trans-Canada Highway (Highway 17). By road, the settlement of Manitouwadge is approximately 420 km east of Thunder Bay and 445 km north of Sault Ste. Marie, based on distances along major roads. Figure 2 presents satellite imagery for the area taken in 2006. Table 1 summarizes the total population and population density for the Township of Manitouwadge and District of Thunder Bay (Unorganized)[2].

Table 1: Population Statistics for the Manitouwadge Area

Political Boundary	Population	Population Density per km²
Township of Manitouwadge	2,105	6.0
District of Thunder Bay, Unorganized	5,909	0.1

Source: 2011 Census of Population (Statistics Canada, 2013)

The Township of Manitouwadge maintains a municipal government (MMAH, 2009). Land ownership within the Manitouwadge area, including areas of Crown land[3], Crown Reserve[4] lands, and reserves and private lands, is shown on Figure 3.

There are a number of First Nation and Métis communities and organizations in the Manitouwadge area including Ojibways of Pic River (Heron Bay), Ojibways of Pic Mobert, Ginoogaming First Nation and Long Lake #58 First Nation. Métis Councils in the area include the Thunder Bay Métis Council, Greenstone Métis Council and Superior North Shore Métis Council.

Further information on Manitouwadge and its surrounding communities, including First Nations and Métis communities, is provided in the Community Well Being profile report for Manitouwadge.

2.2 Infrastructure

Figure 1 shows the location of the primary infrastructure corridors in the Manitouwadge area. The main transportation route is Highway 614 which passes south to north from the Trans-Canada Highway (Highway 17) into Manitouwadge. Local logging roads cover much of the Manitouwadge area. A Canadian National (CN) railway passes through the northeast corner of the Manitouwadge area, passing through the settlement area of Hillsport. One 115kV electrical transmission runs from the southwest corner of the Manitouwadge area, through the community of Manitouwadge and into the settlement areas of Willroy and Geco. A second 44kV transmission line runs from Manitouwadge eastward towards Hornepayne. As shown on Figure 1, the Manitouwadge airport is located southwest of Manitouwadge along Highway 614 (NRCan, 2009a). There are no

[1] Area calculated using Geographic Information System (GIS) municipal boundaries from the Ministry of Municipal Affairs and Housing (MMAH, 2009).

[2] This is the unorganized area in the Thunder Bay District that comprises all parts of the district that are not part of an incorporated municipality or a First Nations reserve.

[3] Crown land is divided on the Figure into Crown Leased Land, Non-freehold Disposition Public and Unpatented Public Land. Crown Leased land is acquired by MNR for reasons based on ecological sustainability, including ecosystem health, the protection of natural and cultural assets, recreation, and / or the protection of people and property. Non-freehold Dispositions Public are a tenure holding, usually for a set term and a specific purpose (e.g., Lease, Licence of Occupation, Land Use Permit, Beach Management Agreement and Easement), excluding permanent disposition in the form of a patent. Unpatented Public Land is generally land that has never been granted or sold by the Crown to people or organizations for their private use and are under the mandate or management of the MNR.

[4] Crown Reserves are Crown lands that have been withdrawn from dispositioning under Section 21 of the Crown Minerals Act.

gas pipelines within the Manitouwadge area (NRCan, 2009b). There are two operating landfills (MOE, 2013a) and a wastewater treatment plant within the Manitouwadge area.

2.3 Protected Areas

2.3.1 Parks and Reserves

There are no provincial parks within the Manitouwadge area. There are two conservation reserves located partially within the Manitouwadge area. Figure 4 shows the location of these protected areas.

Conservation reserves are lands set aside by the government (municipal, provincial or federal) to protect ecosystems that are representative of a natural region, protect significant elements of natural and cultural heritage, and maintain biodiversity. The two conservation reserves in the Manitouwadge area are the Isko Dewabo Lake Complex Conservation Reserve and the North Thornhen Lake Moraine Conservation Reserve (MNR, 2013a). The Isko Dewabo Lake Complex Conservation Reserve straddles the southern boundary of the Manitouwadge area west of Highway 614 and covers an area of 29.67 km^2 (of which 8.2 km^2 are within the Manitouwadge area). This conservation reserve consists of moderately broken ground moraine with a sparse mixed conifer and deciduous forest and bog (MNR, 2013a). The North Thornhen Lake Moraine Conservation Reserve is partially located in the northeastern part of the Manitouwadge area and is 4.54 km^2 in size. This site is located on the top of a flat end moraine deposit and contains mostly lacustrine deposits and a mixed (largely deciduous) forest (MNR, 2013a).

2.3.2 Heritage Sites

The cultural heritage screening examined known archaeological and historic sites in the Manitouwadge area, using the Ontario Archaeological Sites Database, the Ontario Heritage Trust Database, the Parks Canada Database and the National Historic Sites Database. There are two known archaeological sites in the Manitouwadge area (von Bitter, 2013). There are no provincially designated historic sites and one federally designated historic site within the Manitouwadge area (MTCS, 2013; OHT, 2013; Parks Canada, 2013).

The first archaeological site is a campsite of unknown cultural affiliation or time period located 24 km northeast of Manitouwadge. The second site is a pre-contact Aboriginal campsite, with an historic component, located on the southwest end of Ramsey Lake and on the west side of an outlet to White Otter River.

Archaeological potential is established by determining the likelihood that archaeological resources may be present on a subject property. In archaeological potential modelling, a distance criterion of 300 m is generally employed for known archaeological resources, water sources and early Euro-Canadian settlements (Government of Ontario, 2011). The presence of local heritage sites would need to be further confirmed in discussion with First Nation and Métis communities and organizations in the area.

2.4 Land Use

Land use described in this section refers to commercial land use such as forestry, mining, trapping and agriculture, but not recreation or aboriginal spiritual use.

The Town of Manitouwadge was developed as a mining community and continues to be a hub for mining and forestry operations in the region (Township of Manitouwadge, 2013). Forestry is a major industry in the

Manitouwadge area with forested areas supporting commercial timber harvesting. Forest Management Units[5] (FMU) in the Manitouwadge area are shown on Figure 5 (MNR, 2013b). The northern and western portions of Manitouwadge area are located within the Big Pic Forest (FMU 067). The southern and eastern parts of the Manitouwadge area are located within the Pic River Forest (FMU 965) with the southeastern corner located within the White River Forest (FMU 060). A sliver of the Nagagami Forest (FMU 390) is located along the eastern edge of the Manitouwadge area. The Big Pic Forest, managed by Nawiinginokiima Forest Management Corporation (NFMC) (based on a Forest Management Plan developed by Green Forest Management Inc. (GFMI)), is a total of 643,990 hectares (ha) in size with 88% being managed as productive forest. This forest is comprised mostly of black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), white birch (*Betula papyrifera*) and balsam poplar (*Populus balsamifera*) (GFMI, 2013a; NFMC, 2014). The Pic River Forest, also currently managed by NFMC, is a total of 495,904 ha in size with 82% being managed as productive forest (GFMI, 2013b). The White River Forest covers a total of 612,567 ha of which 78% is managed as productive forest comprised primarily of seven forest types including upland conifer, jack pine, poplar, white birch, mixed wood, lowland conifers and tolerant hardwood (Domtar, 2008). The Nagagami Forest is a total of 448,390 ha with 99% of the area managed as productive forest by Jackfish River Management Ltd. (JRML) on behalf of Nagagami Forest Management Ltd. (NGML). The Nagagami Forest is comprised of seven forest units including lowland conifer forest, upland conifer forest, poplar forest, mixed-wood forest, jack pine forest, white birch forest, and white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) forest (JRML, 2011). In total, the Manitouwadge area contains 334,246 ha of woodlands, which is 83% of the land coverage (LIO, 2013).

Within forested areas, there is a risk of forest fires. The three locations where forest fires have affected an area of greater than 200 ha within the Manitouwadge area between 1976 and 2010, are shown on Figure 5.

There are currently no active mines in the Manitouwadge area. However, six past producing mines are located within the Manitouwadge greenstone belt[6] (Figure 6). Four of the past producing mines have remaining reserves, including the Will-Echo-1,2, Will-Echo-3, Willroy Zone 1 and the Willroy mines (OGS, 2011). The Geco and Big Nama mines are past producing mines without reserves. The Geco mine, which closed in 1995, was the most productive and the last active mine, producing copper, zinc and silver (Zaleski and Peterson, 1995).

Active metallic mineral exploration is currently focused in the Manitouwadge greenstone belt and the tonalite suite surrounding the Loken Lake pluton, where active mining claims and mineral occurrences are documented. Exploration in these areas is mainly focused on identifying targets at depth and along the folded extensions of the Manitouwadge greenstone belt (Zaleski and Peterson, 1995). Active mining claims are also documented near faults in the metasedimentary rocks of the Quetico Subprovince and in an area near the Dotted Lake pluton (Figure 6). However, no economically exploitable resources have been identified in these areas to date (AECOM, 2014).

A number of mineral occurrences are documented in the Mineral Deposit Inventory (OGS, 2011) within the Manitouwadge area. A few iron mineral occurrences are recorded within the Manitouwadge greenstone belt,

[5] Ontario's Crown forest is divided into geographic planning areas, known as Forest Management Units. Most of these units are managed by individual forest companies who carry out various activities which are subject to the Ontario Ministry of Natural Resources (MNR) regulations and approvals. Activities include forest management planning, harvest, forest renewal, access road construction, monitoring and reporting.

[6] [6] A greenstone belt is a zone of volcanic and sedimentary rocks that have undergone metamorphic alteration. The name comes from the green hue imparted by the colour of the dominant minerals within the rocks.

Black-Pic batholith[7], the Quetico metasedimentary rocks and the Everest Lake pluton (OGS, 2011). Base metal sulphides, associated with hydrothermal activity, represent the dominant mineral potential within the Manitouwadge area (Zaleski and Peterson, 1995). Base metal occurrences are recorded within the Manitouwadge greenstone belt, Rawluk Lake pluton, Black-Pic batholith and within the Quetico metasedimentary rocks. The economic viability of these occurrences has not been proven to date (AECOM, 2014).

There are a number of small-scale sand and gravel pits within the Manitouwadge area, primarily located in mapped glaciofluvial sediments (Figure 7). There is one active quarry located in the Manitouwadge area, located 5 km west of Hillsport.

As noted in Section 3.3, other land uses include hunting and trapping.

[7] Batholiths are made of multiple masses, or plutons, of igneous rock that have melted and intruded surrounding strata at great depths.

3.0 DESCRIPTION OF THE ENVIRONMENT

3.1 Physiography

The Township of Manitouwadge lies in the Abitibi Upland physiographic region, a broadly rolling surface of Canadian Shield bedrock that occupies most of north-central Ontario (NRCan, 2009c). Within this area, bedrock is typically either exposed at surface or shallowly covered with Quaternary[8] glacial deposits or post-glacial organic soils (Thurston, 1991). In the Manitouwadge area, land surface is generally rugged ranging from elevations of about 482 metres above sea level (masl) to the west of the settlement area of Manitouwadge to a low of about 195 masl in the Nama Creek valley to the southwest of the settlement of Manitouwadge. The area north of the Township of Manitouwadge is generally rugged terrain, while the Black River and Pic River valleys contain relatively flat-lying areas.

Figure 8 presents the topography of the Manitouwadge area as a digital elevation model (DEM).

3.2 Geology

3.2.1 Bedrock Geology

The bedrock geology of the Manitouwadge area is shown on Figure 6. Geologically, the Manitouwadge area straddles the boundary between the Quetico and Wawa subprovinces, which are part of the western region of the Superior Province of the Canadian Shield – 3 billion to 2.6 billion year old rocks that form the core of the North American continent. The Wawa Subprovince is about 900 km long and 150 km wide and the Quetico Subprovince is approximately 1,000 km long by 75 km wide. Both of these subprovinces extend from Minnesota in the United States to approximately 1,000 km long by 75 km wide to northeastern Ontario, where they are truncated by the Kapuskasing Structural Zone. The bedrock geology in the Manitouwadge area within the Wawa Subprovince is comprised large granitoid bodies, commonly composed of tonalite to granodiorite that surround greenstone belts and occur as intrusions within them. Granitoid intrusions also occur within the metasedimentary rocks of the Quetico Subprovince. All of these lithographic units are cross-cut by northwest and northeast trending dykes.

Metasedimentary rocks of the Quetico Subprovince extend over the northernmost part of the Manitouwadge area. These metasedimentary rocks display evidence of variable deformation and metamorphism, and transformation into gneisses and migmatites (Williams and Breaks, 1996; Percival, 1989; Zaleski et al., 1999). The central part of the Manitouwadge area is dominated by rocks of the Manitouwadge greenstone belt which extends from the central part of the Township of Manitouwadge to the east of the Manitouwadge area. From southwest to northeast, the Manitouwadge greenstone belt transitions from mafic metavolcanic rocks to felsic metavolcanic rocks to metasedimentary rocks (Zaleski and Peterson, 1995). The Black-Pic batholith, a multi-phased, regionally extensive intrusion, extends over the southernmost part of the Manitouwadge area. It includes horneblende-biotite, monzodiorite, foliated tonalite and pegmatic granite (Williams and Breaks, 1989). There are also several relatively small felsic intrusions in the Manitouwadge area, including the Fourbay Lake pluton, the Loken Lake pluton, the Rawluk Lake pluton and the Dotted Lake pluton.

[8] Quaternary refers to the last 2.6 million years of Earth's history.

3.2.2 Quaternary Geology

The Quaternary geology of the Manitouwadge area is shown on Figure 7. The oldest known Quaternary deposits in the Manitouwadge area are thin basal till deposits laid down during the late Wisconsinan glaciations. The glacial retreat from the Manitouwadge area is estimated to have occurred approximately 9,000 years ago when the ice receded to the northeast (Barnett, 1992; Kristjansson and Geddes, 2009).

Overburden within the Manitouwadge area consists largely of till, glaciolacustrine deposits and glaciofluvial outwash deposits, as well as some smaller amounts of organic deposits. The tills are largely located in the northern and eastern parts of the Manitouwadge area, with some areas located within the Township of Manitouwadge. Glaciolacustrine deposits are found in the Pic River and Black River valleys, as well as the valleys of the tributaries for these rivers. Adjacent to some of the glaciolacustrine deposits are glaciofluvial sediments, deposited by glacial meltwater and include ice-contact and outwash deposits. A number of eskers occur as ridges of sand and gravel throughout the Manitouwadge area. Most of these eskers occur within the glaciofluvial ice-contact deposits and trend towards the northeast. There are some organic soils present along water courses across the Manitouwadge area. These deposits tend to have a limited thickness, as determined by regional studies, and generally have a limited aerial extent.

3.3 Natural Environment

3.3.1 Natural Environment Overview

The Township of Manitouwadge is located along Highway 614 and includes the shores of Manitouwadge Lake and Perry Lake (Figure 1). Many small inland lakes and rivers occur within the Manitouwadge area; while these are not easily accessible to the public, they are attractive to fishermen and hunters seeking less traveled areas. Forested areas in the Manitouwadge area support commercial timber harvesting. The natural environment associated with the Manitouwadge area contains an abundance of plant and animal communities, some of which have special status or designations. The following sections describe the protected natural areas and the terrestrial ecology and aquatic ecology, with a focus on rare species that may be most sensitive to impacts from alterations or changes to the landscape.

3.3.2 Natural Areas

As discussed in Section 2.3.1, there are two conservation reserves and no provincial parks located within the Manitouwadge area. There are no Earth Science Areas of Natural and Scientific Interest (ANSI) or candidate ANSI within the Manitouwadge area. Four International Biological Program Sites are located within the Manitouwadge area and are shown and numbered on Figure 9. These four sites include: Slingshot Creek Poplar Forest (1), Industrial Road Bog (2), Highway 614 Pond and Bog South of Huggard Lake (3) and Manitou Falls (4). International Biological Programs are tracked by the Ontario Ministry of Natural Resources (MNR) and receive certain regulatory protection. An Official Plan for the Township of Manitouwadge was drafted in 1986, but does not identify any environmental protection areas (Conlin, 1986).

There are no Provincially Significant Wetlands (PSW) identified within the Manitouwadge area, but some unclassified wetlands are present. Wetlands identified in the Land Information Ontario (LIO) natural resources data layers (LIO, 2013) have been depicted on Figure 10. The Manitouwadge area contains 24,878 ha of wetlands, which is 6% of the land coverage according to LIO data. The MNR periodically updates their LIO information and wetland areas and boundaries are subject to change. Field studies conducted at the appropriate times are able to provide ground truthing and sensitivity/significance analysis for existing wetlands. If wetlands

have the potential to be affected by a proposed activity, they would typically require evaluation of significance according to the Ontario Wetland Evaluation System (OWES).

3.3.3 Terrestrial Features and Wildlife

The Manitouwadge area lies within the Boreal Forest Region and this terrain cradles wetlands, lakes and rivers that support a diversity of fish and wildlife. As noted in Section 2.4 and shown on Figure 5, the Manitouwadge area contains portions of four FMUs: the Big Pic Forest (FMU 067), the White River Forest (FMU 060), the Pic River Forest (FMU 965) and a small portion of the Nagagami Forest (FMU 390) (MNR, 2013b). Typical forest types in the area include: black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), white birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) (GFMI, 2013a,b; Domtar, 2008; JRML, 2011). The Manitouwadge area occurs within Wildlife Management Units[9] (WMU) 21A and 21B. This area is considered important for the trapping of furs and hunting of game. Management of woodland caribou (*Rangifer tarandus*), moose (*Alces alces*), marten (*Martes americana*) and pileated woodpecker (*Dryocopus pileatus*) along with other sensitive wildlife populations are of particular importance (MNR, 2013c). Known caribou range has been identified throughout the Manitouwadge area (Figure 9). The entire Manitouwadge area is within the Lake Superior Uplands Linkage of woodland caribou habitat. Most of the area is classified as a discontinuous zone, with the northeast corner classified as continuous caribou habitat, as identified in Ontario's Woodland Caribou Conservation Plan (MNR, 2009). Documented feeding, wintering and calving sites for moose are depicted on Figure 9. Concentration and nesting areas for raptors, herons and waterfowl are also considered an important management concern; known locations are also shown on Figure 9.

3.3.4 Aquatic Features and Fish

As discussed in more detail in Section 3.5, the Manitouwadge area spans across several watersheds. The Manitouwadge area falls within Fisheries Management Zone[10] (FMZ) 7 for which the MNR has a Fisheries Management Plan (MNR, 2013d). Fish that are commonly harvested include walleye (*Sander vitreus*), northern pike (*Esox lucius*), lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), smallmouth bass (*Micropterus dolomieu*) and yellow perch (*Perca flavescens*) (MNR, 2013d). Water bodies present are mainly warm and cool water classified, interspersed with the occasional smaller cold water body (Figure 10). Aquatic areas (excluding wetlands) comprise 18,180 ha, which is 4.5% of the Manitouwadge area according to LIO data. The many small lakes are popular destinations for sport fishing and tourism. The fish populations are managed to maintain and maximize their size and availability to anglers.

Fish and fish habitat are managed by the MNR and the Department of Fisheries and Oceans Canada (DFO). General information is available publicly for each FMZ, but more detailed information must be obtained directly from these agencies for further investigations. Publicly available data for each FMZ may not be consistent for each area. Although there is consistency in the types of data collected by MNR for each area, data deemed sensitive within the FMZ may not be reported or shown on mapping. Field verification will be required to determine the actual fish habitat and use by species across the landscape.

[9] Wildlife Management Units are geographic units of land on which the Ontario Ministry of Natural Resources (MNR) bases the sustainable management of species, hunting seasons and harvest limits.

[10] Fisheries Management Zones are the units of management for lakes in Ontario. Fish are monitored and assessed at the zone level and fishing regulations, such as catch limits, are based on these zones.

3.3.5 Endangered, Threatened and Special Concern Species

The Manitouwadge area covers a large geographic area consisting of diverse aquatic and terrestrial habitats, and is within many migratory corridors for birds, insects and mammals. The Natural Heritage Information Centre (NHIC) database (NHIC, 2013) shows the occurrence of species that are listed as Endangered (END), Threatened (THR) or Special Concern (SC) either under the provincial *Endangered Species Act* (ESA) (Government of Ontario, 2007), or the Federal *Species at Risk Act* (SARA) (Government of Canada, 2012). The Royal Ontario Museum range maps (ROM, 2013) indicate the potential for Species at Risk (SAR) to exist within the Manitouwadge area, based on the principles of range mapping. Habitats within the Manitouwadge area could directly or indirectly support the needs of 15 designated SAR. All potentially occurring SAR within the area are listed in Table 2.

Species listed as provincially or federally END are significant because these species and their habitats receive the highest level of protection afforded under applicable legislation. The four species listed as END include the provincially END eastern cougar (*Puma concolor*), little brown myotis (*Myotis lucifugus*), northern myotis (*Myotis septentrionalis*) and golden eagle (*Aquila chrysaetos)*. Six species have been identified that are listed as THR in Ontario and or federally. The remaining five species are listed as SC either provincially or federally.

The ranges of SAR species are generally identified through a reference grid, noting detailed field study is required to confirm the extent that a listed species or its habitat occurs in a specific geographic area. Based on the available background information, the range of eastern cougar overlaps the area, but this species is extremely secretive and can cover a very large home range for each individual. The Manitouwadge area is at the edge of the currently known area where bats are affected by a novel fungal disease that is causing major mortality. Little brown myotis and northern myotis were recently added to the ESA. Golden eagles are likely to pass through this area during migration, but typically nest farther north (MNR, 2014). The aurora trout, a subspecies of brook trout, was originally found in two lakes where it has been re-established through stocking efforts. Previously aurora trout was listed as federally END, however in 2011 it removed from the SARA list as is not distinct enough from brook trout to be considered a unique species and therefore it is not eligible for status assessment (COSEWIC, 2011). Reassessment of the species' status under the SARA is currently underway and it may become relisted in the future.

The records identified here represent either known occurrences or are based on range mapping as published by the MNR, noting that the list is typically updated annually. In addition to species that are listed on the ESA and SARA, species of conservation concern including those that are considered regionally rare, uncommon or in significant decline would also be considered in the evaluation of wildlife of the area. Many of these species are not tracked in public databases, and therefore a complete list could be developed in future through specific data requests to agencies and field investigations.

With reference to Table 2, there were no species of amphibian or reptile or plants, mosses or lichens identified as END, THR or SC within the Manitouwadge area.

Table 2: Potential Endangered, Threatened and Special Concern Species in the Manitouwadge Area

Common Name	Scientific Name	ESA Status[1]	SARA (Schedule)[2]	Source[3]
Mammals				
Eastern cougar	*Puma concolor*	END		ROM

Common Name	Scientific Name	ESA Status[1]	SARA (Schedule)[2]	Source[3]
Little Brown myotis	*Myotis lucifugus*	END		BCI, Mammal Atlas
Northern myotis	*Myotis septentrionalis*	END		BCI, Mammal Atlas
Wolverine	*Gulo gulo*	THR		ROM
Woodland caribou (Forest-dwelling boreal population)	*Rangifer tarandus caribou*	THR	THR	ROM, Mammal Atlas
Birds				
Bald eagle	*Haliaeetus leucocephalus*	SC		OBBA
Black tern	*Chlidonias niger*	SC		ROM
Canada warbler	*Cardellina canadensis*	SC	THR	OBBA
Common nighthawk	*Chordelies minor*	SC	THR	OBBA, ROM
Golden eagle	*Aquila chrysaetos*	END		ROM
Olive-sided flycatcher	*Contopus cooperi*	SC	THR	OBBA
Rusty blackbird	*Euphagus carolinus*	NAR	SC	OBBA, ROM
Short-eared owl	*Asio flammeus*	SC	SC	OBBA, ROM
Fish and other Aquatic Species				
Aurora Trout [4]			NAR	COSEWIC
Lake sturgeon (Great Lakes-Upper St. Lawrence and Northwestern Ontario Population)	*Acipenser fulvescens*	THR		ROM
Invertebrates				
Monarch butterfly	*Danaus plexippus*	SC	SC	ROM

Notes:

blank: species not assessed; NAR: species assessed to be not at risk; SC: special concern species; THR: threatened species; END: endangered species

[1] - Status on the Species at Risk of Ontario list of the Endangered Species Act (ESA) (Government of Ontario, 2007)

[2] - Status listed on the federal Species at Risk Act (Government of Canada, 2012)

[3] - Data obtained from the Natural Heritage Information Centre (NHIC, 2013); Royal Ontario Museum (ROM, 2013) range maps; Ontario Herpetofaunal Summary Database (Herp Atlas) (Oldham and Weller, 2000); Atlas of the Breeding Birds of Ontario (OBBA) (BSC, 2006); Bat Conservation International Species Profiles (BCI, 2013a,b); Ontario Butterfly Atlas (Butterfly Atlas) (Jones et al., 2013); Ontario Odonata Atlas (Odonata) (NHIC, 2005); Mammal Atlas of Ontario (Mammal Atlas) (Dobbyn, 1994)

[4] – The Aurora Trout was listed as END under the SARA in June 2013. COSEWIC re-evaluated the species' status in 2011 and determined it ineligible for assessment as the species is not distinct enough from brook trout. Reassessment of the species' status under the federal SARA is currently underway.

3.3.6 Aboriginal Interests and Traditional Knowledge

Traditional lifestyles, culturally significant wildlife and the extent of sacred and ceremonial locations important to First Nation and Métis communities and organizations are important factors to be considered when identifying potential repository locations for further detailed study.

For this phase of the work, the extent to which such information has been sought is that which can be found in publicly available sources. Known archaeological sites, many of which are Aboriginal, are noted in Section 2.3.2. Trapline License Areas, which cover much of the Manitouwadge area, are shown on Figure 3. Figure 9 presents terrestrial ecology mapping for the area and Figure 10 presents aquatic resource mapping.

It is recognized that this does not fully represent the environmental issues and concerns of First Nation and Métis communities and organizations in the area and that further information and discussion is required before a more complete picture can be developed.

Discussions with First Nation and Métis communities and organizations and field investigations would be undertaken in later phases of the work program to further enhance the environmental understanding of specific locations.

3.4 Background Environmental Conditions

3.4.1 Air Quality

Air quality monitors in north-central Ontario indicate that ground-level ozone and particulate matter fall within normal values compared to the national average (EC, 2013a). Table 3 provides a list of industrial facilities that reported air and water emissions through Environment Canada's National Pollutant Release Inventory (NPRI) database within the same postal code range as the Township of Manitouwadge (EC, 2013b). The list includes sites in Copper Cliff, Dubreuilville, Hillsport, Hornepayne, Marathon and Wawa which have local air emissions. Additional sources that may affect background air quality include rail operations and the Highway 614, both of which traverse the area.

Table 3: NPRI Regional Sources of Air Emissions

NPRI ID	Facility Name	City
10374	Hydro One Remote Communities Inc. - Armstrong Diesel Generating Station	Armstrong
3238	Ontario Power Generation Inc. - Atikokan Generating Station	Atikokan
10376	Hydro One Remote Communities Inc. - Bearskin Diesel Generating Station	Bearskin Lake
10378	Hydro One Remote Communities Inc. - Biscotasing Diesel Generating Station	Biscotasing
10397	Tembec - Chapleau Sawmill	Chapleau
11238	First Nickel Inc. - Lockerby Mine	Chelmsford
5928	Safety-Kleen Canada Inc. - Chelmsford Branch	Chelmsford
11227	Fisher Wavy Inc. - Fisher Wavy - Sudbury	Copper Cliff
444	Vale Canada Limited - Copper Cliff Smelter	Copper Cliff
1465	Vale Canada Limited - Clarabelle Mill	Copper Cliff
1467	Vale Canada Limited - Copper Cliff Nickel Refinery	Copper Cliff
10203	Vale Canada Limited - Copper Cliff Mine (North)	Copper Cliff
10204	Vale Canada Limited - Copper Cliff Mine (South)	Copper Cliff

NPRI ID	Facility Name	City
11877	Vale Canada Limited - Ellen Pit	Denison Township
7361	King Packaged Materials Co. - Onaping Falls	Dowling
11454	Mines Richmont inc - Island Gold Mine	Dubreuilville
1236	Xstrata Canada Corporation - Sudbury Nickel Smelter Complex	Falconbridge
10381	Hydro One Remote Communities Inc. - Gull Bay Diesel Generating Station	Gull Bay
10144	Union Gas Limited - Hagar LNG Plant	Hagar
3197	Williams Operating Corporation - Williams Mine	Hemlo
10382	Hydro One Remote Communities Inc. - Hillsport Diesel Generating Station	Hillsport
25458	Olav Haavaldsrud Timber Company Limited - Olav Haavaldsrud Timber Company	Hornepayne
10385	Hydro One Remote Communities Inc. - Lansdowne Diesel Generating Station	Lansdowne House
11154	FNX Mining Company Inc. - McCreedy West Mine	Levack
11608	FNX Mining Company Inc. - Levack Mine	Levack
10199	Vale Canada Limited - Coleman Mine	Levack
2869	DB Operating Corporation - David Bell Mine	Marathon
1400	Newmont Canada Corporation - Golden Giant Mine	Marathon
10450	Eacom Timber Corporation - Nairn Centre Sawmill	Nairn Centre
10405	Atlantic Power LP - Nipigon Power Plant	Nipigon
10386	Hydro One Remote Communities Inc. - OBA Diesel Generating Station	OBA
11906	Hydro One Remote Communities Inc. - Marten Falls Diesel Generating Station	Ogoki Post
1233	Xstrata Canada Corporation - Sudbury Operations Mines/Mill - Onaping Area	Onaping
11369	Fisher Wavy Inc. - Fisher Wavy - Sault Ste. Marie	Sault Ste. Marie
11466	FNX Mining Company Inc. - Podolsky Mine	Sudbury
10389	Hydro One Remote Communities Inc. - Sultan DGS	Sultan
2607	Terrace Bay Pulp Inc. - Terrace Bay Pulp	Terrace Bay
6771	TransCanada PipeLines Ltd. - Station 62 - Upsala	Thunder Bay
10010	Wesdome Gold Mines Ltd. - Eagle River Mill	Wawa
10392	Hydro One Remote Communities Inc. - Webequie Diesel Generating Station	Webequie

3.4.2 Background Radiation

The source of background radiation in the Manitouwadge area is attributed to naturally occurring radioactive materials (NORM), specifically potassium, uranium and thorium-bearing minerals. The background radiation for the Manitouwadge area is presented on Figure 11. Statistically, the majority of the dose rates in the Manitouwadge area range from approximately 5 to 50 nGy/h, with an average of approximately 25 nGy/h. This range of dose rates and averages are consistent with regional dose rates for north-central Ontario. NORM minerals are typically elevated in granitic geology and local dose rate highs are attributed to granitic batholiths, such as the Fourbay Lake pluton. These highs are consistent with dose rate highs in other areas of north-central Ontario.

A recent survey by Health Canada of radon gas concentrations in Canadian homes shows the percentage of residences in the District of Algoma Health Unit testing below the national guideline of 200 Bq/m^3 to be 91%, while those testing between 200 and 600 Bq/m^3 were 8% and the remaining 1% testing above 600 Bq/m^3 (Health Canada, 2013).

Additional detailed information on background radiation is available in the geophysical interpretation report (PGW, 2014).

3.4.3 Soil Quality

A preliminary desktop review indicated that there is no specific information on background soil quality in the Manitouwadge area. Outside of industrial areas, soil concentrations are expected to be consistent with Ontario Typical Background ranges, as noted in Table 1 of Ontario Ministry of the Environment (MOE) Regulation 153/04, as amended (Government of Ontario, 2004).

3.4.4 Water Quality

The Township of Manitouwadge obtains its municipal water supply from five drilled wells. The 2012 annual report on water quality from the Manitouwadge Drinking Water System, operated by Manitouwadge Public Works, compared monitored water quality to the requirements of the Ontario *Safe Drinking Water Act* (O. Reg. 170/03) (Government of Ontario, 2003) and regulations therein (i.e., Ontario Drinking Water Standards, Objectives and Guidelines (ODWS) (Government of Ontario, 2006)). The report indicated that in 2012 there were no exceedances for any measured organic parameter (e.g., pesticides, herbicides, PCBs, volatile organics) or bacteriological parameters (Manitouwadge Public Works, 2013). In Wells 2, 3 and 5 on September 5, 2012, concentrations of sodium were measured at 45 to 51 mg/L. While this is below the aesthetic objective of 200 mg/L, the local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L. The Ontario Spills Action Centre and the Thunder Bay District Health Unit were notified, warning notices were posted and local physicians were advised to alert patients on sodium restricted diets (Manitouwadge Public Works, 2013). In addition, there was an exceedance of the operation guideline for hardness (80-100 mg/L) with measured concentrations of 312 to 360 mg/L in Wells 2, 3 and 5 in September 2012. No corrective actions were required (Manitouwadge Public Works, 2013).

Surface water hydrology, groundwater and wells are further discussed in Sections 3.5 and 3.6.

3.4.5 Lake Sediment Chemistry

Lake sediment chemistry data was collected in the Manitouwadge area by the Geological Survey of Canada (GSC) as part of a geochemical reconnaissance program for northwestern Ontario (Friske et al, 1991). While the raw data is available in the GSC Open File, the file does not provide any reporting on the findings of the study.

3.4.6 Potential Sources of Pollutants

There are a number of potential sources of pollutants in the Manitouwadge area including landfills, transportation corridors, domestic septic systems and local industries.

There are two operating landfill sites within the Manitouwadge area, the Manitouwadge Waste Disposal Site (operated by the Township of Manitouwadge) and the Hillsport Landfill (operated by the MNR) (Table 4). There are also two closed landfills within the Manitouwadge area (MOE, 2013a).

Table 4: Registered Landfills in the Manitouwadge Area

Certificate of Approval (C of A) Number	Site Name	Location	Status
A591706	Client: The Ontario Paper Co. Limited	Gemmel Township, 10 kilometres Northeast of Manitouwadge Township of Manitouwadge	Closed
A591707	Manitouwadge Landfill Client: The Corporation of the Township of Manitouwadge	Caramat Road Township of Manitouwadge	Open
A7185601	Client: Ministry of Natural Resources	Lot 3, Concession 1 Township of Manitouwadge	Closed
A7494801	Hillsport Client: Ministry of Natural Resources	Unorganized	Open

Source: Ontario Landfill List (MOE, 2013a)

Transportation corridors, such as Highway 614, logging roads and rail lines, traverse the Manitouwadge area, and are considered to be potential sources of pollution, as a result of salt application for de-icing and mobile air emissions from internal combustion. There is also a potential for chemical releases along transportation routes as a result of spills or accidents. Local septic systems are a potential source of the release of pollutants, mainly as a result of septic waste and possibly as a result of chemical disposal into the septic system. Industrial operations in the area may be a source of pollutants, due to the potential release of chemicals as a result of spills or improper chemical handling practices. No specific releases of the above-named pollutants into the environment were identified in this review.

3.5 Surface Water Hydrology

As shown on Figure 12, the Manitouwadge area straddles a drainage divide with most of the area located within the Pic River tertiary watershed of the Lake Superior drainage basin. The White tertiary watershed located in the southeastern corner of the Manitouwadge area also forms part of the Lake Superior drainage basin. Along the eastern edge of the Manitouwadge area are the Upper Kenogami and the Nagagami tertiary watersheds of the Hudson Bay drainage basin. Within the Pic River tertiary watershed, including the Pic and Black Rivers, drainage is generally from north to south towards Lake Superior. Tributaries to the Pic River include White Otter River, Nama Creek and Macutagon Creek. Within the White tertiary watershed, drainage is generally to the south along the Gum River. Drainage in the Upper Kenogami and Nagagami tertiary watersheds is generally towards the northeast.

3.6 Groundwater and Wells

Information concerning groundwater in the Manitouwadge area was obtained from the MOE Water Well Information System (WWIS) database (MOE, 2013b). The locations of known water wells are shown on Figure 12. In addition to the Township of Manitouwadge, which obtains its municipal water supply from groundwater, there are a number of other wells in the Manitouwadge area that serve individual private residences. Most of these wells obtain water from the overburden or shallow bedrock. The WWIS database contains 52 water well records in the Manitouwadge area, 50 of which provided useful information regarding well

yield and other parameters noted in Table 5 (AECOM, 2014). Most of the water wells are located along Highway 614 within the Township of Manitouwadge.

Table 5: Water Well Record Summary for the Manitouwadge Area

Water Well Type	Number of Wells	Total Well Depth (m)	Static Water Level (m below surface)	Tested Well Yield (L/min)	Depth to Top of Bedrock (m)
Overburden	20	4.6 to 30.2	0.9 to 11.0	68 to 2,795	N/A
Bedrock	30	1.8 to 119.2	0.6 to 10.7	4.5 to 27	0 to 29.6

3.6.1 Overburden Aquifers

There are 20 water well records in the Manitouwadge area that can be confidently assigned to the overburden aquifer, ranging in depth from approximately 5 to 30 m. Well yields are variable with recorded values of 68 to 2,795 L/min, with the range being explained by the diversity of materials encountered during drilling (from sand to gravel) and the types of wells installed (private domestic supply, municipal supply and industrial supply). These well yields do not necessarily reflect the maximum sustained yield that might be available from overburden aquifers. The limited number of well records and their concentration along main roadways limits the available information regarding the extent and characteristics of the overburden aquifers in the Manitouwadge area.

3.6.2 Bedrock Aquifers

No information was found on deep bedrock groundwater conditions in the Manitouwadge area at a typical repository depth of approximately 500 m. In the Manitouwadge area there are 30 well records that can be confidently assigned to the shallow bedrock aquifer, ranging from approximately 2 to 119 m in depth. Measured pumping rates in the bedrock wells ranged from 4.5 to 27 L/min. These well yields reflect the purpose of the wells (i.e., private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from the shallow bedrock aquifers.

The MOE's WWIS indicates that no potable water supply wells are known to exploit aquifers at typical repository depths in the Manitouwadge area or anywhere else in northern Ontario (MOE, 2013b). Experience from other areas in the Canadian Shield has shown that active groundwater flow is generally confined to shallow fractured localized systems. In these shallow regions, flow tends to be dependent on the secondary permeability created by fractures. In deeper regions, hydraulic conductivity tends to decrease as fractures become less common and less interconnected. Increased vertical and horizontal stresses at depth tend to close or prevent fractures, thereby reducing permeability and resulting in diffusion-dominated groundwater movement.

3.7 Climate and Meteorology

The climate assessment for Manitouwadge is based on Environment Canada's Manitouwadge and Geraldton climate stations 1971-2000 normals. Manitouwadge is the nearest climate station to this location but does not measure winds. Geraldton, located within the municipality of Greenstone is approximately 105 km northwest of Manitouwadge is the nearest station that reports winds in their climate normals. The Manitouwadge climate station has more than 25 years of data during the 1971-2000 climate normal, and the 30 year period from 1971-2000 is the most recent period for which climate normal are available from Environment Canada. Geraldton has 20 years of data for the same period. Parameters measured at the Manitouwadge station include temperature and precipitation, while Geraldton reports these parameters as well as wind.

The Manitouwadge area is within a temperate and humid continental climate zone, with mild summers and cold winters. The major driver for precipitation is weather systems that cross the Canadian prairies, the American Midwest and deep south that move northward into the region; these weather systems are responsible for transporting moisture from the Great Lakes and the Gulf of Mexico. Most precipitation falls during the late spring and into early fall in the form of showers and thunderstorms associated with traversing weather systems. In the winter, snowfall amounts can be greater than 40 cm and are associated with strong winter storm weather. Prolonged periods of extreme cold can also be experienced in the region during the winter.

3.7.1 Temperature

Temperature data were obtained from Environment Canada's 1971-2000 climate normals for Manitouwadge and Geraldton meteorological stations (EC, 2013c). Temperatures in the Manitouwadge area can reach highs of 39°C in summer months and lows of -45°C in winter months. The annual average temperature is 1°C, where the average summer temperature is approximately 16°C and the average winter temperature is -15°C. Figure 13 shows monthly temperatures for Manitouwadge, displaying daily average, maximum and minimum and extreme values over the calendar year. The corresponding temperature plot for Geraldton, also shown on Figure 13, is generally cooler than Manitouwadge, as this station is located further north.

3.7.2 Precipitation

As shown on Figure 14, the annual average precipitation in the Manitouwadge area is 859 mm, where one cm of snow is considered to be equal to one mm of equivalent rainfall. The region receives more precipitation in the summer and fall months (June through October), with an average of more than 80 mm each month during that period. Manitouwadge is far enough from Lake Superior that lake effect snow plays little role in winter precipitation amounts. Figure 14 presents monthly precipitation data obtained from Environment Canada's 1971-2000 climate normals for the Manitouwadge and Geraldton meteorological stations, including total rainfall, rainfall, snowfall and all-time extreme values over the calendar year. Geraldton generally receives less precipitation than Manitouwadge (EC, 2013c).

3.7.3 Wind

West winds prevail in the Manitouwadge area, changing to southwest in the winter and south in the late summer and early autumn. Table 6 presents the monthly wind data obtained from Environment Canada's 1971-2000 climate normals for the Geraldton meteorological station (EC, 2013c). Wind speed and direction are an average for each month over the calendar year.

Table 6: Monthly Wind Normals for Geraldton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (km/h)	10.8	10.9	11.9	11.9	11.9	12.1	10.7	10.3	12.1	12.5	11.7	10.4
Most Prevalent Direction (from)	W	SW	SW	NE	S	W	W	S	S	S	W	W

3.8 Natural Hazards

3.8.1 Earthquakes and Seismicity

The Manitouwadge area lies within the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). The Manitouwadge area has a low seismic hazard rating (NRCan, 2009d). Since 1627, no earthquakes exceeding a magnitude m_N 6 have been known to occur within 1,000 km of the Manitouwadge area. According to the National Earthquake Database (NEDB) for the period between 1985 to present two earthquakes with magnitudes of 2.1 and 2.2 have been recorded in the Quetico Subprovince immediately northwest of Hillsport (Figure 3.20). Other seismic events in close proximity to the area have epicentres 7 km to the east, near Granitehill Lake (magnitude 2.6) and 15 km to the south (magnitude 2.1) (NRCan, 2013).

In summary, available literature and recorded seismic events indicate that the Manitouwadge area is located within a region of low seismicity.

3.8.2 Tornadoes and Hurricanes

As noted in Table 6, average monthly wind speeds in the Manitouwadge area are low, ranging from 10 to 12 km/hr. The Manitouwadge area experiences thunderstorms in the summer months and is located in an area with low tornado frequency (<0.1 tornadoes per year / 10,000 km^2), but where there is a potential for F0-F1 tornadoes (Sills et al., 2012). The Manitouwadge area is situated too far away from the Atlantic Ocean to be susceptible to hurricanes. The National Building Code of Canada recommends a design 1/50 maximum[11] hourly wind pressure for the Hornepayne and White River areas of 0.30 kPa, which is a typical value for Ontario (NRC, 2010).

3.8.3 Drought and Flooding

According to precipitation climate normals for the region (Figure 13), the Manitouwadge area experiences on average between 50 and 110 mm of precipitation each month, and is therefore unlikely to experience drought conditions that would affect the viability of local water sources. The single day extreme rainfall and snowfall events on record at the Manitouwadge station (Figure 14) are 89 mm of rain and 37 cm of snow. In years where there is a high snowpack accumulation, the spring freshet can result in a nominal increase in water levels in local streams and rivers. As noted on Figure 12, the Manitouwadge area lies at the head and middle of a number of watersheds, making the size of the upstream catchments areas modest. This, in combination with the rugged terrain in areas, makes for a possible risk of flash flooding in the some areas. The potential for flooding to affect a repository facility would depend on the specific location.

3.8.4 Snow and Ice

As noted on Figure 14, the Manitouwadge area receives on average about 295 cm of snowfall per year, primarily between the months of October and April. No single month receives an average snowfall greater than 65 cm. The highest single day snowfall accumulation on record is 37 cm. The National Building Code of Canada recommends a design 1/50 snow load (S_s + S_r)[12] for the White River area of 4.9 kPa and for the Hornepayne area of 4.0 kPa, which are typical to high values for northern Ontario (NRC, 2010). Local lakes and water bodies

[11] Hourly wind speeds having the annual probability of occurrence of a 1 in 50 year return period.

[12] The combined snow and rain load that has an annual probability of occurrence in a 1 in 50 year period.

freeze over in the winter months in the Manitouwadge area, as average daily temperatures from November to March typically range from -17 to -4^{o}C.

3.8.5 Forest Fires and Lightning

Within heavily forested areas such as the Manitouwadge area there is a risk of forest fires. Locations where forest fires have occurred in the vicinity of the Manitouwadge area between 1976 and 2010 affecting an area of greater than 200 ha are shown on Figure 5. These forest fires combine to comprise less than 5% of the total Manitouwadge area. Forest fires can be initiated by lightning strikes or human activity, particularly if dry conditions are present in the forest understory. As previously noted, thunderstorms occur in the Manitouwadge area and lightning strikes are not uncommon in the summer months.

3.8.6 Landslides and Tsunamis

There are areas of steep slopes in the Manitouwadge area, which are generally comprised of crystalline rock with a thin veneer of soil cover. The physical nature of these slopes, combined with a potential for high precipitation events, results in a possible landslide risk for selected areas. There is no risk of tsunamis in the Manitouwadge area, owing to the very low seismicity and a lack of large water bodies.

4.0 SUMMARY

This report provides a high level description of the environment in the Township of Manitouwadge and surrounding area.

The Township of Manitouwadge is situated in the District of Thunder Bay (Unorganized) about 60 km northeast of Lake Superior and is approximately 373 km^2 in size, with a population of 2,105 (Statistics Canada, 2013). Manitouwadge is about 55 km north of Highway 17 (Trans-Canada Highway), and the closest settlements to Manitouwadge include Willroy, Geco, Barehead, Agonzon and Hillsport. Manitouwadge has a temperate and humid continental climate with mild summers and cold winters. Manitouwadge receives most of its yearly precipitation in the late spring and into the early fall.

There are a number of First Nation and Métis communities and organizations in the Manitouwadge area including Ojibways of Pic River (Heron Bay), Ojibways of Pic Mobert, Ginoogaming First Nation and Long Lake #58 First Nation. Métis Councils in the area include the Thunder Bay Métis Council, Greenstone Métis Council and Superior North Shore Métis Council.

Geologically, the Manitouwadge area straddles the boundary between the Quetico and Wawa Subprovinces, which are part of the western region of the Superior Province of the Canadian Shield. The bedrock geology in the Manitouwadge area is comprised largely of felsic intrusive rocks and metasedimentary rocks, with lesser amounts of metavolcanic and magmatic rocks. All of these lithographic units are cross-cut by northwest and northeast trending dykes. Metasedimentary rocks of the Quetico Subprovince extend over the northernmost part of the Manitouwadge area. The central part of the Manitouwadge area is dominated by rocks of the Manitouwadge greenstone belt which extends from the central part of the Township of Manitouwadge to the east of the Manitouwadge area. The Black-Pic batholith, a multi-phased, regionally extensive intrusion, extends over southernmost part of the Manitouwadge area.

There are no currently active mines and six past producing mines in the Manitouwadge area. Four of the past producing mines have remaining reserves. Active metallic mineral exploration is currently focused in the rocks of the Manitouwadge greenstone belt and the tonalite suite surrounding the Loken Lake pluton, where active mining claims and mineral occurrences are documented. Active mining claims are also documented near faults in the metasedimentary rocks of the Quetico Subprovince, Loken Lake pluton and in an area near the Dotted Lake pluton. However, no economically exploitable resources appear to have been identified in these areas to date.

Infrastructure within the Manitouwadge area includes Highway 614 which passes north-south from the Trans-Canada Highway (Highway 17) into Manitouwadge. A Canadian National (CN) railway passes through the northeast corner of the Manitouwadge area, passing through the settlement area of Hillsport. One 115kV electrical transmission runs from the southwest corner of the Manitouwadge area, through the community of Manitouwadge and into the settlement areas of Willroy and Geco. A second 44kV transmission line runs from Manitouwadge eastward towards Hornepayne. The Manitouwadge airport is located southwest of Manitouwadge along Highway 614 (NRCan, 2009a). There are no gas pipelines within the Manitouwadge area (NRCan, 2009b). There are two operating landfills and a wastewater treatment plant within the Manitouwadge area.

There are no provincial parks and two conservation reserves located partially within the Manitouwadge area. The Isko Dewabo Lake Complex Conservation Reserve covers approximately 3 km^2 and is located in the

southeast of the Manitouwadge area. The North Thornhen Lake Moraine Conservation Reserve is partially located in the northeastern part of the Manitouwadge area and is 0.4 km^2 in size.

The Manitouwadge area lies in the Boreal Forest Region. The northern and western portions of Manitouwadge area are located within the Big Pic Forest (FMU 067), managed by Green Forest Management Inc. (GFMI, 2013a). The Pic River Forest (FMU 965), covering much of the southern and eastern portions of Manitouwadge area, is also managed by Green Forest Management Inc. (GFMI, 2013b). The White River Forest (FMU 060) and the Nagagami Forest (FMU 390) occupy smaller areas within the southeastern corner and a sliver on the eastern boundary of the Manitouwadge area. In total, the Manitouwadge area contains 334,246 ha of woodlands, which is 83% of the land coverage (LIO, 2013). Typical forest types in the Manitouwadge area include black spruce, jack pine, trembling aspen, white spruce, balsam fir, white birch, balsam poplar, white pine and red pine (GFMI, 2013a,b; Domtar, 2008; JRML, 2011).

Trapping of fur bearing species and hunting of game are important activities in the Manitouwadge area. Management of woodland caribou, moose, marten and pileated woodpecker along with other sensitive wildlife populations are a particular concern to the MNR. The western portion of the Manitouwadge area is part of discontinuous woodland caribou habitat as identified in Ontario's Woodland Caribou Conservation Plan (MNR, 2009). There are no Areas of Natural and Scientific Interest (ANSI) within the Manitouwadge area; however, there are four International Biological Program sites. No Provincially Significant Wetlands (PSW) have been identified in the Manitouwadge area.

The Natural Heritage Information Centre (NHIC) database (NHIC, 2013) shows the occurrence of species that are listed as Endangered (END), Threatened (THR) or Special Concern (SC) either under the provincial *Endangered Species Act* (ESA) (Government of Ontario, 2007), or the federal *Species at Risk Act* (SARA) (Government of Canada, 2012). The Royal Ontario Museum range maps (ROM, 2013) is based on range mapping and indicates the potential for Species at Risk (SAR) to exist within the Manitouwadge area. Habitats within the Manitouwadge area could directly or indirectly support the needs of 16 designated Species at Risk (SAR). These species include five mammals (eastern cougar, little brown myotis, northern myotis, wolverine and woodland caribou), eight birds (bald eagle, black tern, Canada warbler, common nighthawk, golden eagle, olive-sided flycatcher, rusty blackbird and short-eared owl), two fish (aurora trout and lake sturgeon) and one invertebrate (monarch butterfly). No END, THR or SC concern amphibian or reptile species or plants, mosses and lichens are known to occur within the Manitouwadge area based on available sources.

The Manitouwadge area lies mainly within the Pic River tertiary watershed of the Lake Superior drainage basin. The White Lake tertiary watershed located in the southeastern corner of the Manitouwadge area also forms part of the Lake Superior drainage basin. Within the Pic River tertiary watershed, including the Pic and Black Rivers, drainage is generally from north to south towards Lake Superior. Tributaries to the Pic River include White Otter River and Nama Creek. Within the White tertiary watershed, drainage is generally to the south along the Gum River. Along the eastern edge of the Manitouwadge area are the Upper Kenogami and the Nagagami tertiary watersheds of the Hudson Bay drainage basin. Within the Manitouwadge area, terrain includes wetlands, lakes and rivers that support a diversity of fish and wildlife. Water bodies are mainly warm and cool water classified, interspersed with the occasional smaller cold water body. Fish that are commonly harvested include walleye, northern pike, lake trout, brook trout, smallmouth bass and yellow perch (MNR, 2013d).

Water wells in the Manitouwadge area obtain water from the overburden or the shallow bedrock. The Ontario Ministry of the Environment (MOE) Water Well Information System (WWIS) database contains 52 well records in

the Manitouwadge area, 50 of which provided useful information regarding well yield and other parameters. There are no records of water wells sourcing potable water aquifers at repository depths in the Manitouwadge area or elsewhere in the Ontario part of the Canadian Shield. The Township of Manitouwadge obtains its municipal water supply from groundwater.

Air, soil and surface water quality within the Manitouwadge area are expected to be within the normal range for north-central Ontario. Sources of background radioactivity in the Manitouwadge area are attributed to naturally occurring radioactive materials, specifically potassium, uranium and thorium-bearing minerals. The range of dose rates and averages are consistent with regional dose rates for north-central Ontario.

There are two known archaeological sites in the Manitouwadge area (von Bitter, 2013). The first archaeological site is a campsite of unknown cultural affiliation or time period located 24 km northeast of Manitouwadge. The second site is pre-contact Aboriginal campsite located on the southwest end of Ramsey Lake and on the west side of an outlet to White Otter River. The presence of local heritage sites would need to be further confirmed in discussion with First Nation and Métis communities and organizations in the area.

5.0 REFERENCES

AECOM Canada Ltd. (AECOM), 2014. Phase 1 Geoscientific Desktop Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel. Township of Manitouwadge, Ontario. NWMO Report Number APM-REP-06144-0075).

Barnett, P.J., 1992. Quaternary Geology of Ontario in Geology of Ontario, *in*; Ontario Geological Survey, Special Volume 4, Part 2, p. 1010–1088.

Bat Conservation International (BCI), 2013a. BCI Species Profiles: Myotis lucifugus. Retrieved from (http://www.batcon.org/index.php/all-about-bats/species-profiles.html?task=detail&species=2040&country=43&state=all&family=all&start=25). Accessed April 2013.

Bat Conservation International (BCI), 2013b. BCI Species Profiles: Myotis septentrionalis. Retrieved from (http://www.batcon.org/index.php/all-about-bats/species-profiles.html?task=detail&species=2306&country=43&state=40&family=100&limitstart=0). Accessed April 2013.

Bird Studies Canada (BSC), 2006. Environment Canada's Canadian Wildlife Service, Ontario Nature, Ontario Field Ornithologists and Ontario Ministry of Natural Resources. Ontario Breeding Bird Atlas Website. Retrieved from (http://www.birdsontario.org/atlas/index.jsp). Accessed July 2013.

Conlin Engineering and Planning Ltd. (Conlin), 1986. Township of Manitouwadge Official Plan. 86 p.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2011. COSEWIC report on the eligibility for the Aurora Trout (*Salvelinus fontinalis timagamiensis)* in Canada. 27 p.

Dobbyn, J.S., 1994. Atlas of the Mammals of Ontario. Federation of Ontario Naturalists, Toronto. 120 p.

Domtar Inc. (Domtar), 2008. Manitouwadge Forest 2008-2018 Forest Management Plan. April 2008. 373 p.

Environment Canada (EC), 2013a. National and Regional Air Quality, Air and Climate Indicators. Retrieved from (http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=03603FB3-1). Accessed June 2013.

Environment Canada (EC), 2013b. National Pollutant Release Inventory: Facility Reported Data. Retrieved from (http://www.ec.gc.ca/inrp-npri/). Accessed June 2013.

Environment Canada (EC), 2013c. National Climate Data and Information Archive. Retrieved from (http://climate.weatheroffice.gc.ca/climateData/canada_e.html). Accessed June 2013.

Friske, P.W.B., Hornbrook, E.H.W., Lynch, J.J., McCurdy, M.W., Gross, H., Galletta, A.C. and Durham, C.C. 1991. National geochemical reconnaissance lake sediment and water data, northwestern Ontario; Geological Survey of Canada, Open File 2360.

Government of Canada, 2012. *Species at Risk Act* (SARA). Retrieved from (http://www.sararegistry.gc.ca/default_e.cfm). Accessed May 2013.

Government of Ontario, 2011. Standards and Guidelines for Consulting Archaeologists. Ministry of Tourism, Culture, and Sport.

Government of Ontario, 2007. *Endangered Species Act* (ESA). Retrieved from (http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubpage/MNR_SAR_ENDNGR_SPC_TBSCS_EN.html). Accessed April 2013.

Government of Ontario, 2006. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. PIBS 4449e01. Revised June 2006.

Government of Ontario, 2004. *Environment Protection Act* (EPA). Ontario Regulation 153/04. Retrieved from (http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_040153_ev001.htm). Accessed May 2013.

Government of Ontario, 2003. *Safe Drinking Water Act*. Ontario Regulation 170/03. Retrieved from (http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_030170_e.htm). Accessed May 2013.

Green Forest Management Inc. (GFMI), 2013a. Phase II Planned Operations for the Big Pic Forest 2007-2017 Forest Management Plan. 70 p.

Green Forest Management Inc. (GFMI), 2013b. Pic River Forest 2013-2023 Forest Management Plan. 260 p.

Health Canada, 2013. Canadian Radiological Monitoring Network: Who We Are. Retrieved from (http://www.hc-sc.gc.ca/ewh-semt/contaminants/radiation/crmn-rcsr/who_we_are-qui_sommes_nous-eng.php). Accessed April 2013.

Jackfish River Management Ltd. (JRML), 2011. Forest Management Plan for the Nagagami S.F.L. 550047 for the 10-year period from April 1, 2011 to March 31, 2021. 429 p.

Jones, C., R. Layberry and A. Macnaughton, 2013. Ontario Butterfly Atlas Online. Retrieved from (http://www.ontarioinsects.org/atlas_online.htm). Toronto Entomologists' Association. Accessed May 2013.

Kristjansson F.J. and R.S. Geddes, 2009. Quaternary Geology of the Manitouwadge Area, Northern Ontario, Ontario Geological Survey, 2000 Series Map M.2684, Scale 1:50,000.

Land Information Ontario (LIO), 2013. Ontario Ministry of Natural Resources. Retrieved from (http://www.mnr.gov.on.ca/en/Business/LIO/). Accessed April 2013.

Manitouwadge Public Works, 2013. 2012 Annual Report: Water Treatment Subsystem Class I and Manitouwadge Water Distribution Subsystem Class I. Report prepared by Kirk Tourout and Paul Richard. February 28, 2013.

Natural Heritage Information Centre (NHIC), 2013. Ontario Ministry of Natural Resources. Retrieved from (http://www.mnr.gov.on.ca/en/Business/NHIC/). Accessed July 2013.

Natural Heritage Information Centre (NHIC), 2005. Ontario Odonata Atlas Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Retrieved from (http://nhic.mnr.gov.on.ca/odonates/about.html). Accessed July 2013.

National Research Council (NRC), 2010. National Building Code of Canada 2010, Volume 2. 1245p.

Natural Resources Canada (NRC), 2013. Earthquakes Canada Website. Retrieved from (http://earthquakescanada.nrcan.gc.ca). Accessed April 2013.

Natural Resources Canada (NRCan), 2009a. Aerodromes and Airports (2006). Atlas of Canada. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/energy.html#infrastructure). Accessed June 2013.

Natural Resources Canada (NRCan), 2009b. Pipeline Infrastructure (2006). Atlas of Canada. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/energy.html#infrastructure). Accessed June 2013.

Natural Resources Canada (NRCan), 2009c. Physiographic Regions. The Atlas of Canada – Physiographic Regions. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/geology.html). Accessed June 2013.

Natural Resources Canada (NRCan), 2009d. Significant Earthquakes and Seismic Hazard Map. The Atlas of Canada. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/geology.html). Accessed April 2013.

Nawiinginokiima Forest Management Corporation (NFMC), 2014. Year 6 Annual Report for the Big Pic Forest, For the year April 1,2012 to March 31, 2013. Retrieved from (http://www.efmp.lrc.gov.on.ca/eFMP/home.do). Accessed July 2014.

Nuclear Waste Management Organization (NWMO), 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. May 2010.

Oldham, M.J. and W.F. Weller, 2000. Ontario Herpetofaunal Atlas. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Retrieved from (http://nhic.mnr.gov.on.ca/MNR/nhic/herps/ohs.html). Accessed June 2013.

Ontario Geological Survey (OGS), 2011. Mineral Deposit Inventory—2011; Ontario Geological Survey.

Ontario Heritage Trust (OHT), 2013. Retrieved from (http://www.heritagetrust.on.ca/Home.aspx). Accessed July 2013.

Ontario Ministry of Municipal Affairs and Housing (MMAH), 2009. Restructured Municipalities, Ontario Map #2. Retrieved from (http://www.mah.gov.on.ca/Page5383.aspx). Accessed April 2012.

Ontario Ministry of the Environment (MOE), 2013a. Landfill Inventory Management Ontario (LIMO) List. Retrieved from (http://www.ene.gov.on.ca/environment/en/monitoring_and_reporting/limo/landfills/). Accessed July 2013.

Ontario Ministry of the Environment (MOE), 2013b. Water Well Information System (WWIS) Database. Accessed September 2013.

Ontario Ministry of Natural Resources (MNR), 2014. Golden Eagle – Ontario Recovery Strategy Series (Draft). Retrieved from (http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/MNR_SAR_SPEC_RCVRY_STRAT_EN.html). Accessed February 2014.

Ontario Ministry of Natural Resources (MNR), 2013a. Ontario's Crown Land Use Policy Atlas (CLUPA). Retrieved from (http://crownlanduseatlas.mnr.gov.on.ca/public.html). Accessed July 2013.

Ontario Ministry of Natural Resources (MNR), 2013b. Forest Management Plans. Retrieved from (http://www.efmp.lrc.gov.on.ca/eFMP/home.do?currentFmu=&language=en). Accessed July 2013.

Ontario Ministry of Natural Resources (MNR), 2013c. Wildlife Management Unit Maps. Queen's Printer for Ontario. Retrieved from (http://www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/256933.html). Accessed July 2013.

Ontario Ministry of Natural Resources (MNR), 2013d. Fisheries Management Zone Maps. Queen's Printer for Ontario. Retrieved from (http://www.mnr.gov.on.ca/en/Business/LetsFish/2ColumnSubPage/198481.html). Accessed July 2013.

Ontario Ministry of Natural Resources (MNR), 2009. Ontario's Woodland Caribou Conservation Plan. Ontario Ministry of Natural Resources. ISBN 978-1-4435-1383-8.

Ontario Ministry of Tourism, Culture, and Sport (MTCP), 2013. Heritage Properties Search Form. Retrieved from (http://www.hpd.mcl.gov.on.ca/scripts/hpdsearch/english/default.asp). Accessed July, 2013.

Parks Canada, 2013. Canada's Historic Places. Retrieved from (http://www.pc.gc.ca/progs/lhn-nhs/index.aspx). Accessed July 2013.

Paterson, Grant and Watson Limited (PGW), 2014. Phase 1 Desktop Geoscientific Preliminary Assessment - Processing and Interpretation of Geophysical Data. Township of Manitouwadge, Ontario. NWMO Report Number APM-REP-06144-0077).

Percival, J.A. and R.M. Easton, 2007. Geology of the Canadian Shield in Ontario: an update. Ontario Geological Survey, Open File Report 6196, Geological Survey of Canada, Open File 5511, Ontario Power Generation, Report No. 06819-REP-01200-10158-R00, 55 p.

Percival, J.A., 1989. A regional perspective of the Quetico metasedimentary belt, Superior Province, Canada. Canadian Journal of Earth Sciences, **26**, 677-693.

Royal Ontario Museum (ROM), 2013. Ontario's Biodiversity: Species at Risk. Retrieved from (http://www.rom.on.ca/ontario/risk.php). Accessed July 2013.

Sills, D., V. Cheng, P. McCarthy, B. Rousseau, J. Waller, L. Elliott, J. Klaassen and H. Auld, 2012. Using tornado, lightning and population data to identify tornado prone areas in Canada. *Preprints, 26th AMS Conference on Severe Local Storms, Nashville, TN*, Amer. Meteorol. Soc., Paper P59.

Statistics Canada, 2013. *Census Profile.* Retrieved from (http://www12.statcan.gc.ca /census-recensement/2011/dp-pd/prof/index.cfm?Lang=E). Accessed July 2013

Township of Manitouwadge, 2013. Township of Manitouwadge website. Retrieved from (http://www.manitouwadge.ca/). Accessed August 2013.

Thurston, P.C., 1991. Geology of Ontario: Introduction; *in* Geology of Ontario. Ontario Geological Survey. Special Volume No. 4, Part 1, p. 3-26.

von Bitter, R., 2013. Personal Communication on July 12, 2013 re: Archaeological Sites Database. Ministry of Tourism, Culture, and Sport.

Williams, H.R. and F.W. Breaks, 1996. Geology of the Manitouwadge-Hornepayne region, Ontario. Ontario Geological Survey, Open File Report 5953, 138 p.

Zaleski, E., O. van Breemen and V.L. Peterson, 1999. Geological evolution of the Manitouwadge greenstone belt and the Wawa-Quetico subprovince boundary, Superior Province, Ontario, constrained by U-Pb zircon dates of supracrustal and plutonic rocks. Canadian Journal of Earth Sciences **36**, 945-966.

Zaleski E. and V.L. Peterson, 1995. Depositional setting and deformation of massive sulfide deposits, iron-formation, and associated alteration in the Manitouwadge greenstone belt, Superior Province, Ontario. Economic Geology **90**, 2244-2261.

Report Signature Page

GOLDER ASSOCIATES LTD.





Jennifer Hancox, M.Sc., P.Geo.
Geoscientist

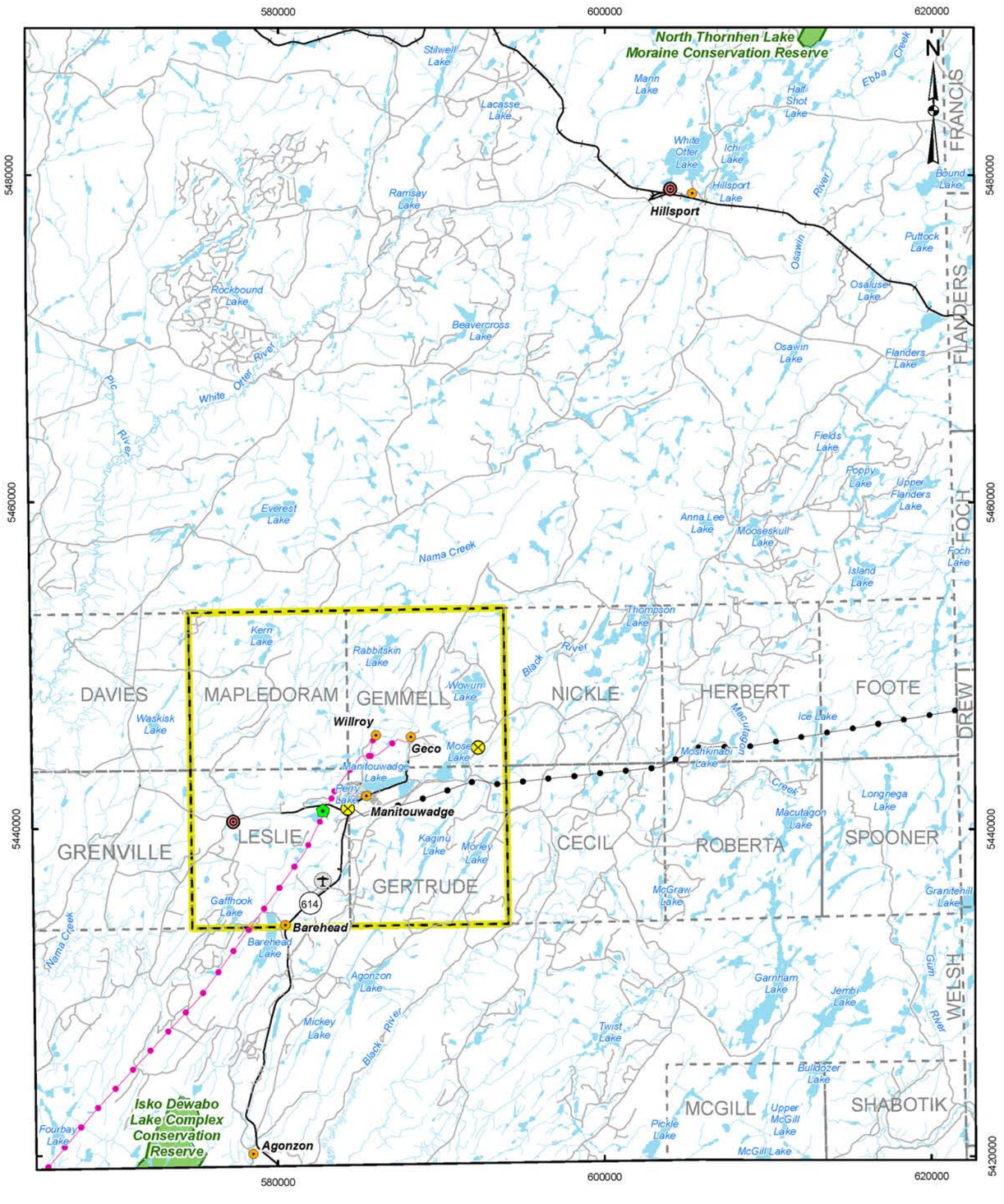
George Schneider, M.Sc., P.Geo.
Senior Geoscientist, Principal

JLH/GWS/wlm

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

c:\gws-work\1 - active\12-1152-0026 environment\4100 - manitouwadge\r7 nov gws\12-1152-0026 (4105) rpt nwmo manitouwadge 2014nov19 cln.docx

FIGURES



LEGEND

- Community
- Airport
- Domestic Waste Site (Operating)
- Domestic Waste Site (Closed)
- Waste Water Treatment Plant
- Main Road
- Local Road
- Railway
- 115 kV Transmission Line
- 44 kV Transmission Line
- Watercourse
- Waterbody
- Conservation Reserve
- Geographic Township
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Transmission Line - Strike, W.R., et al., The Hydro-Electric Power Commission of Ontario, December 1962, Fify-fifth Annual Report for the Year 1962, Toronto, Ontario.
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

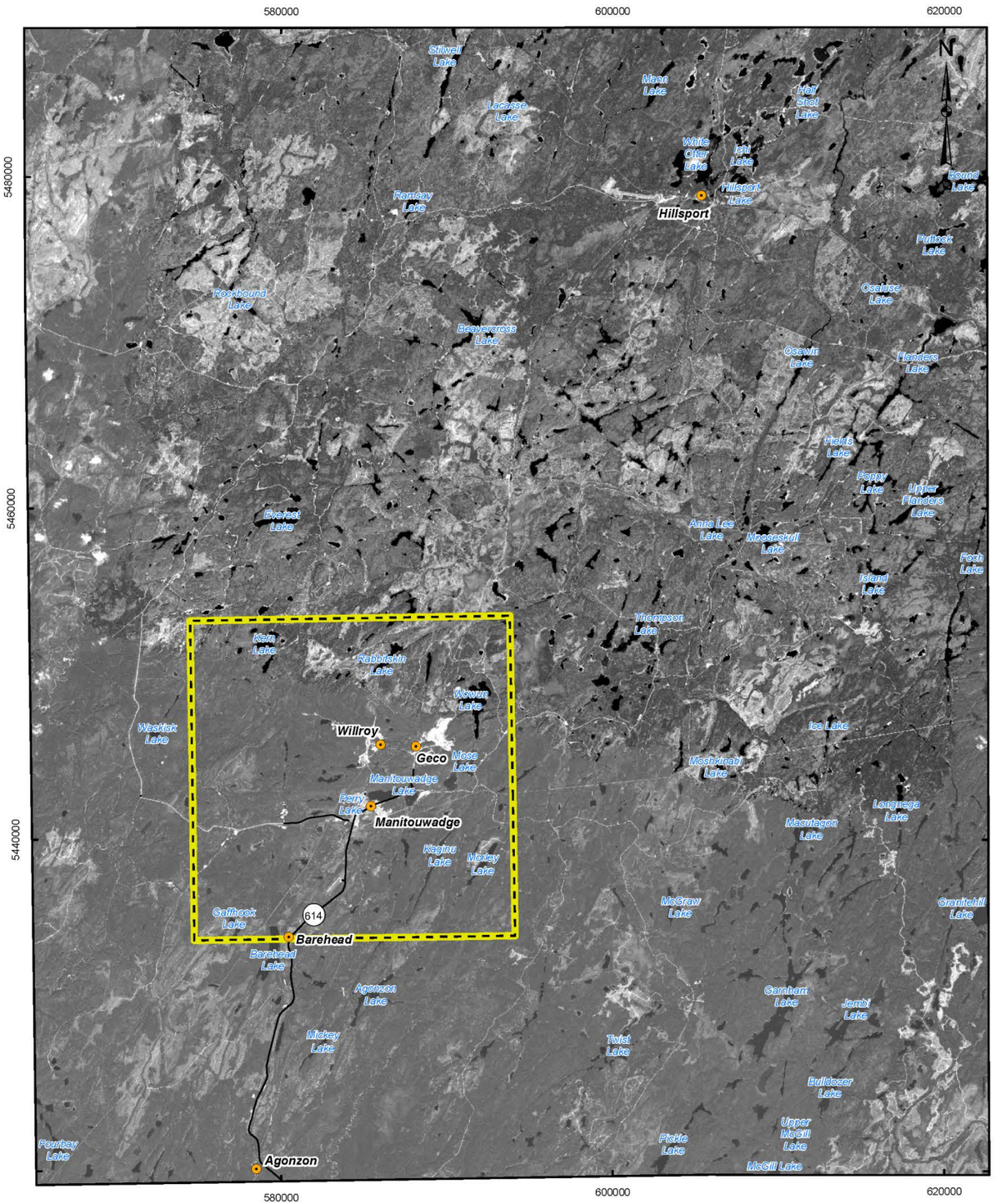
PROJECT
Environment Report
Township of Manitouwadge, Ontario

TITLE
Manitouwadge and Surrounding Lands

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	4 Jul. 2013	FIGURE: 1
GIS	JMC	19 Nov. 2014	
CHECK	JH	19 Nov. 2014	
REVIEW	GWS	19 Nov. 2014	

G:\Projects\2012\12-1152-0026_NWMO_Phase1_FeasibilityIt\GIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeandSurroundingLands.mxd



LEGEND

- Community
- Main Road
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Imagery - SPOT 5, Obtained from Geobase (2006, 10 m resolution)
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

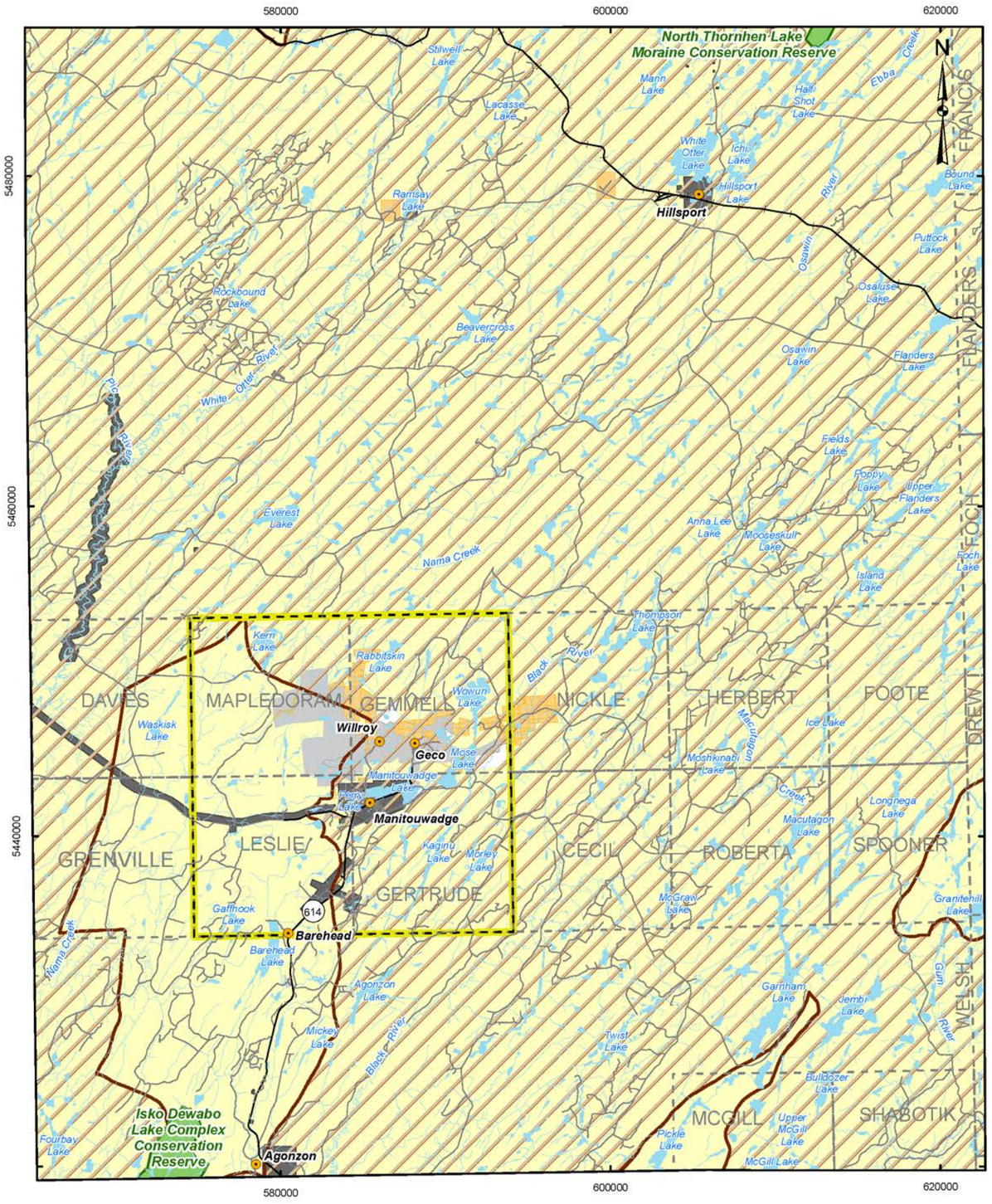
PROJECT
Environment Report
Township of Manitouwadge, Ontario

TITLE
Satellite Imagery of the Manitouwadge Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	5 Jul. 2013	**FIGURE: 2**	
GIS	JMC	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeSatelliteImagery.mxd



LEGEND

- Community
- Main Road
- Local Road
- Railway
- Watercourse
- Waterbody
- Conservation Reserve
- Private Land
- Crown Land - Non-Freehold Dispositions Public
- Crown Land - Unpatented Public Land
- Crown Reserves
- Regular Registered Trapline Area License
- Geographic Township
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Crown Reserves - Ministry of Northern Mines and Development (April 4, 2013)
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

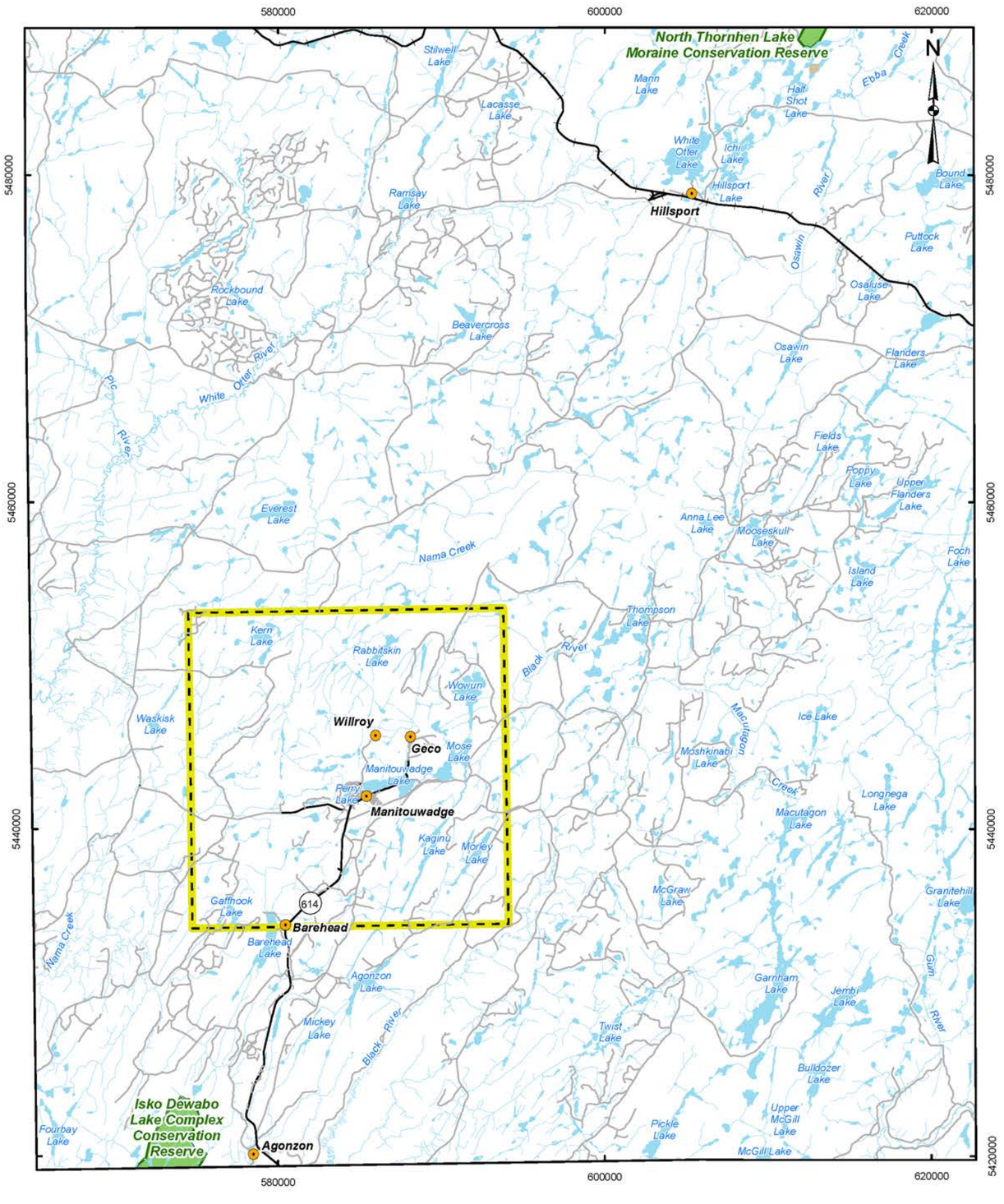
TITLE
Manitouwadge Area Land Ownership

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	5 Jul. 2013		
GIS	JMC	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

FIGURE: 3

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeLandOwnership.mxd



LEGEND

- Community
- Main Road
- Local Road
- Railway
- Watercourse
- Waterbody
- Conservation Reserve
- Significant Old Growth Forest
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

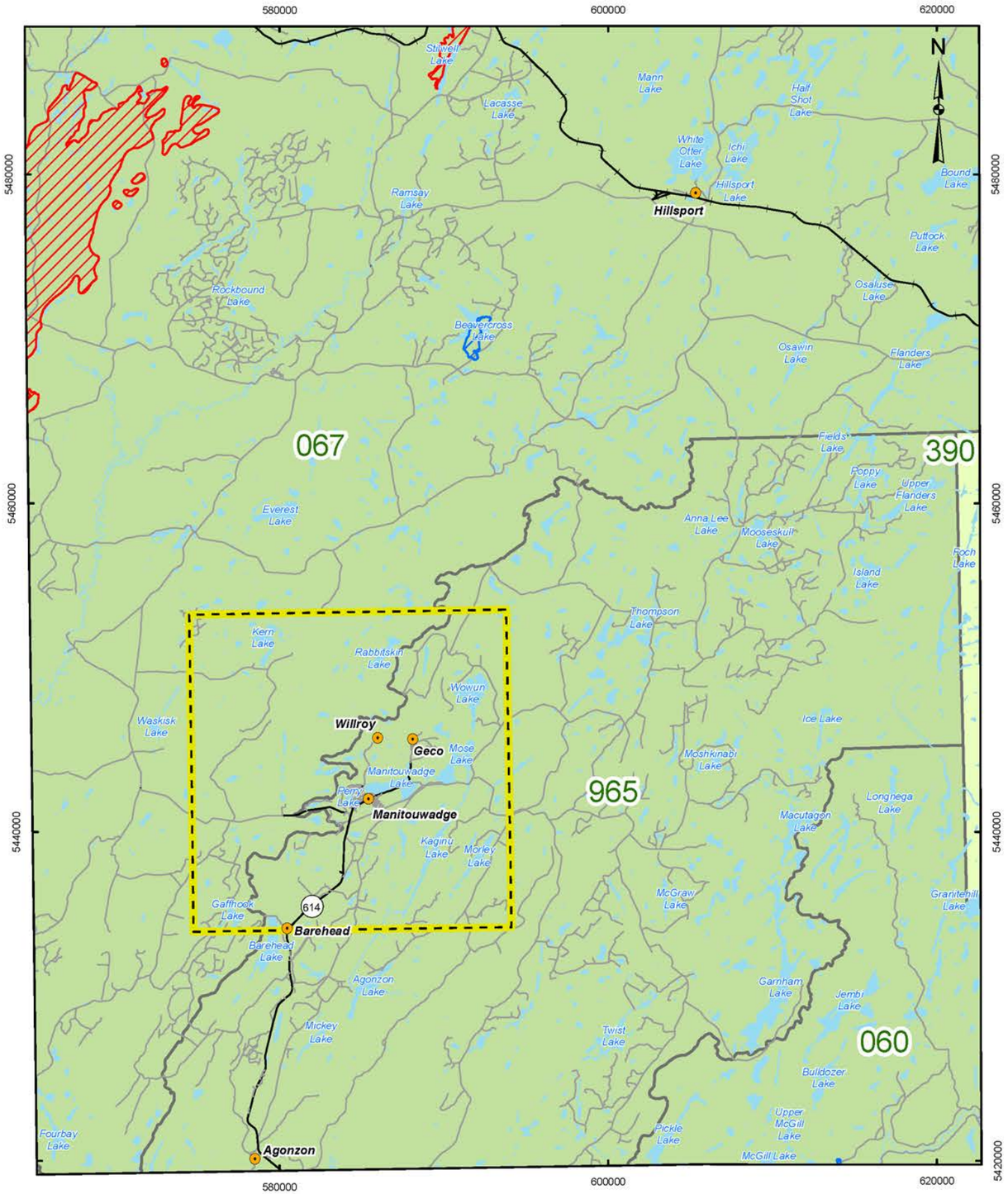
TITLE
Manitouwadge
Parks and Protected Lands

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	4 Jul. 2013		
GIS	JMC	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

FIGURE: 4

G:\Projects\2012\12-1152-0026_NWMO_Phase1_FeasibilityIGIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeProtectedLands.mxd



LEGEND

- Community
- MainRoad
- Local Road
- Railway
- Waterbody
- Municipal Boundary (Township of Manitouwadge)

Forest Fire Areas (greater than 200 hectares)

- 1976 - 1980
- 1981 - 1990
- 1991 - 2000
- 2001 - 2010

Forest Plan Renewal Year

- 2013
- 2014
- 2015
- 2016
- 2017

FOREST MANAGEMENT UNITS

060 - White River Forest
067 - Big Pic Forest
390 - Nagagami Forest
965 - Pic River Forest



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Forest Management Units & Forest Fire Areas - Canadian Forest Service. 2010
Canadian National Fire Database - Agency Fire Data. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta.
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

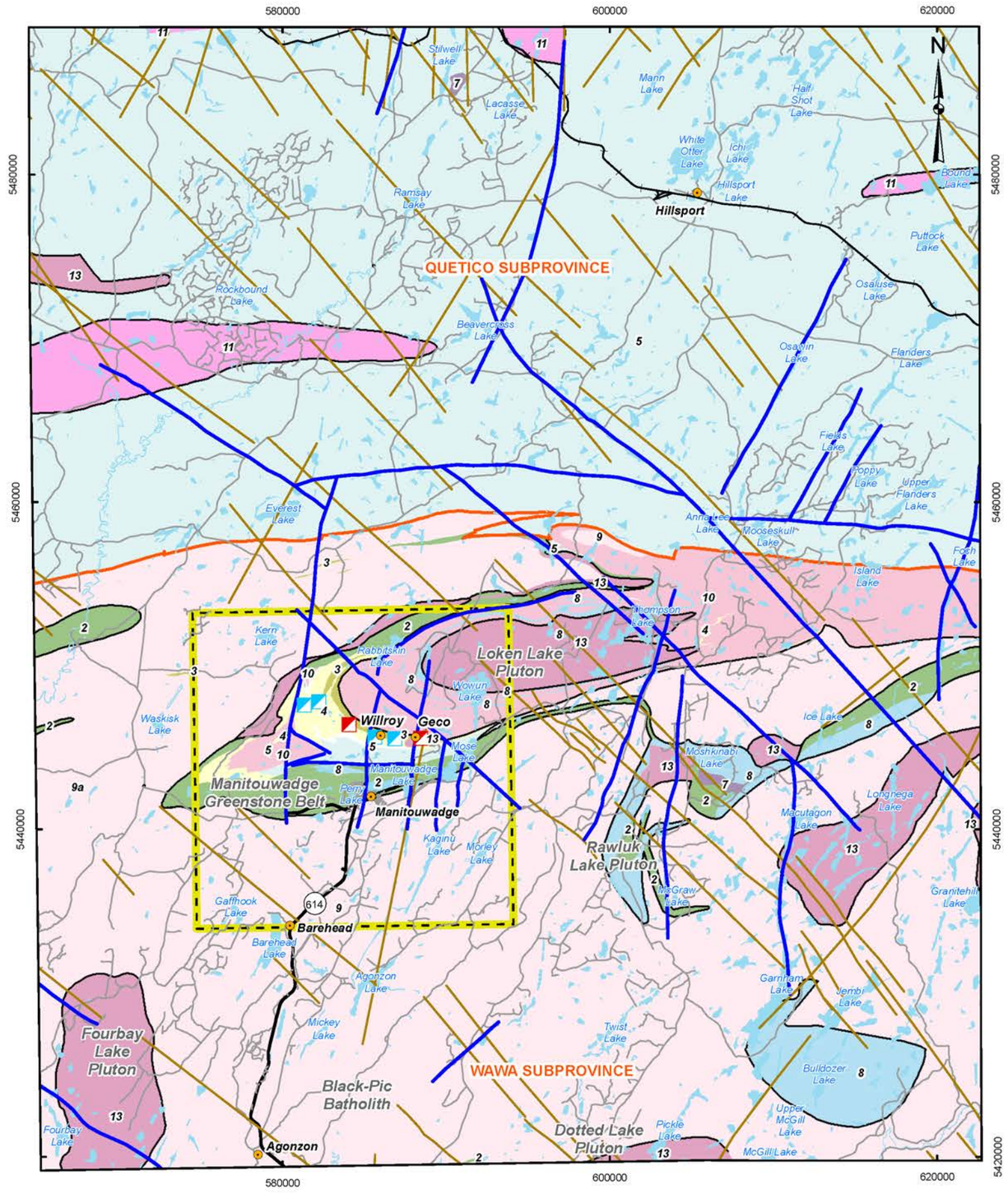
PROJECT
Environment Report
Township of Manitouwadge, Ontario

TITLE
Forest Management Units of the Manitouwadge Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	5 Jul. 2013	**FIGURE: 5**
GIS	JMC	2 Apr. 2014	
CHECK	JH	2 Apr. 2014	
REVIEW	GWS	2 Apr. 2014	

G:\Projects\2012\12-1152-0026_NWMO_Phase1_FeasibilityGIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeForestManagementUnits.mxd



LEGEND

- Community
- Past Producing Mine with Reserves
- Past Producing Mine without Reserves
- Main Road
- Local Road
- Railway
- Waterbody
- Geologic Dyke
- Geological Fault
- Geological Contact
- Subprovince Boundary

Bedrock Geology

- 13: Granite-granodiorite
- 11: Granite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 9a: Migmatized supracrustal rocks
- 8: Gabbro
- 7: Ultramafic plutonic rocks
- 5: Clastic sedimentary rocks
- 4: Felsic volcanic rocks
- 3: Felsic and immediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Bedrock Geology - OGS M2665, 2002; M2666, 2001; M2667, 2003; M2668, 2003 (1:250,000)
Faults - OGS MRD 126-REV1, 2011; M2668, 2003; GSC 1917A, 2001
Mineral Inventory - Mineral Deposit Inventory of Ontario v2, 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

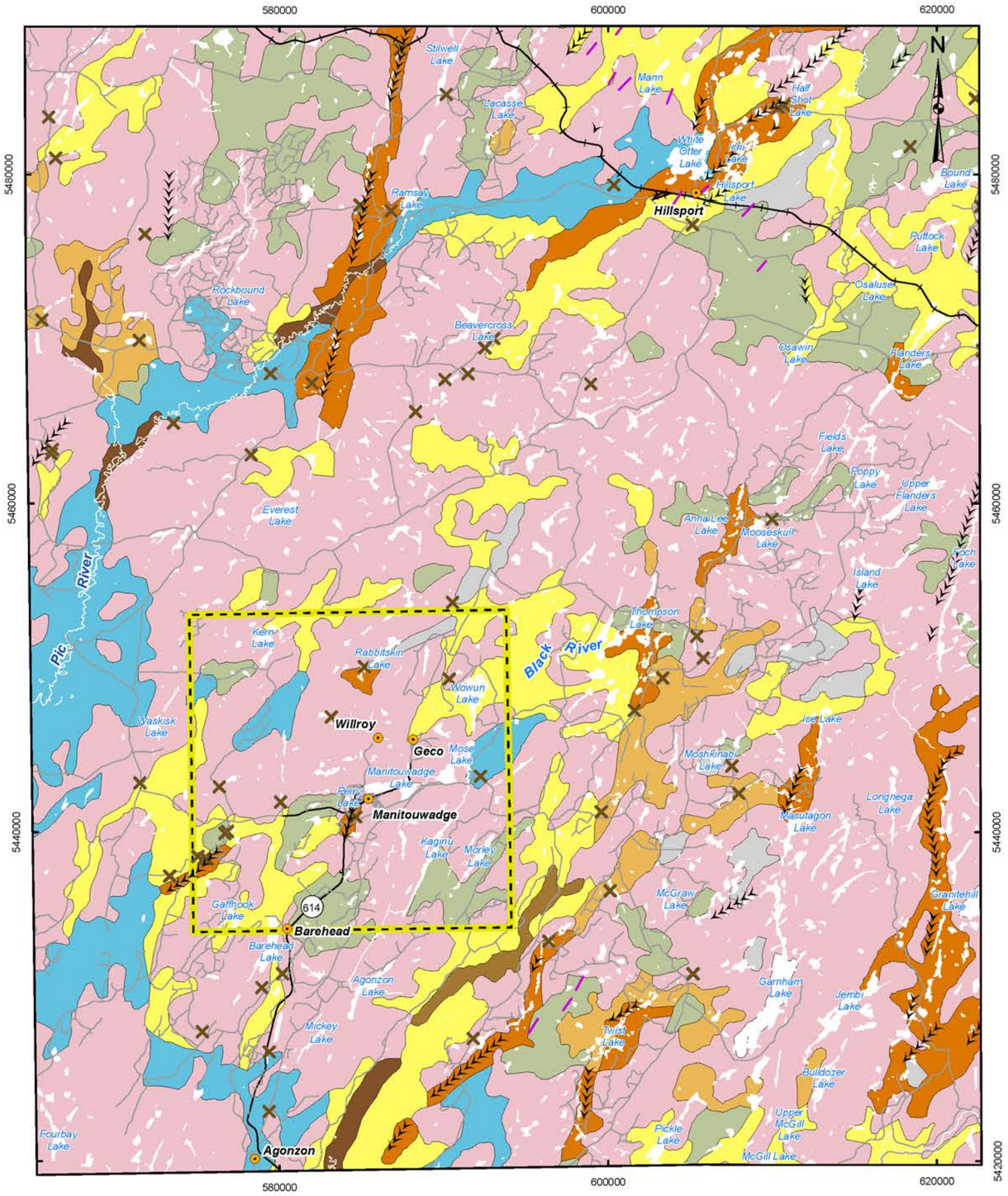
PROJECT
Environment Report
Township of Manitouwadge, Ontario

TITLE
Bedrock Geology of the Manitouwadge Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	9 Jul. 2013		
GIS	JMC	9 Jun. 2014	**FIGURE: 6**	
CHECK	JH	9 Jun. 2014		
REVIEW	GWS	9 Jun. 2014		

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\ManitouwadgeBedrockGeology.mxd



LEGEND

- Community
- Main Road
- Local Road
- Railway
- Pit (Gravel)
- Esker or Area of Eskers; Direction of Flow Known or Assumed
- Drumlin or Area of Drumlins
- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice Deposit
- 23: Glaciofluvial Outwash Deposits
- 24: Glaciolacustrine Deposits – Fine grained
- 25: Glaciolacustrine Deposits – Coarse grained
- 28: Fluvial Deposits - Pleistocene
- 31: Fluvial Deposits - Recent
- 32: Organic Deposits
- 33: Waterbody
- Municipal Boundary (Township of Manitouwadge)



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Geology - Modified EDS014-Surficial Geology of Ontario 1:1,000,000, 2000
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

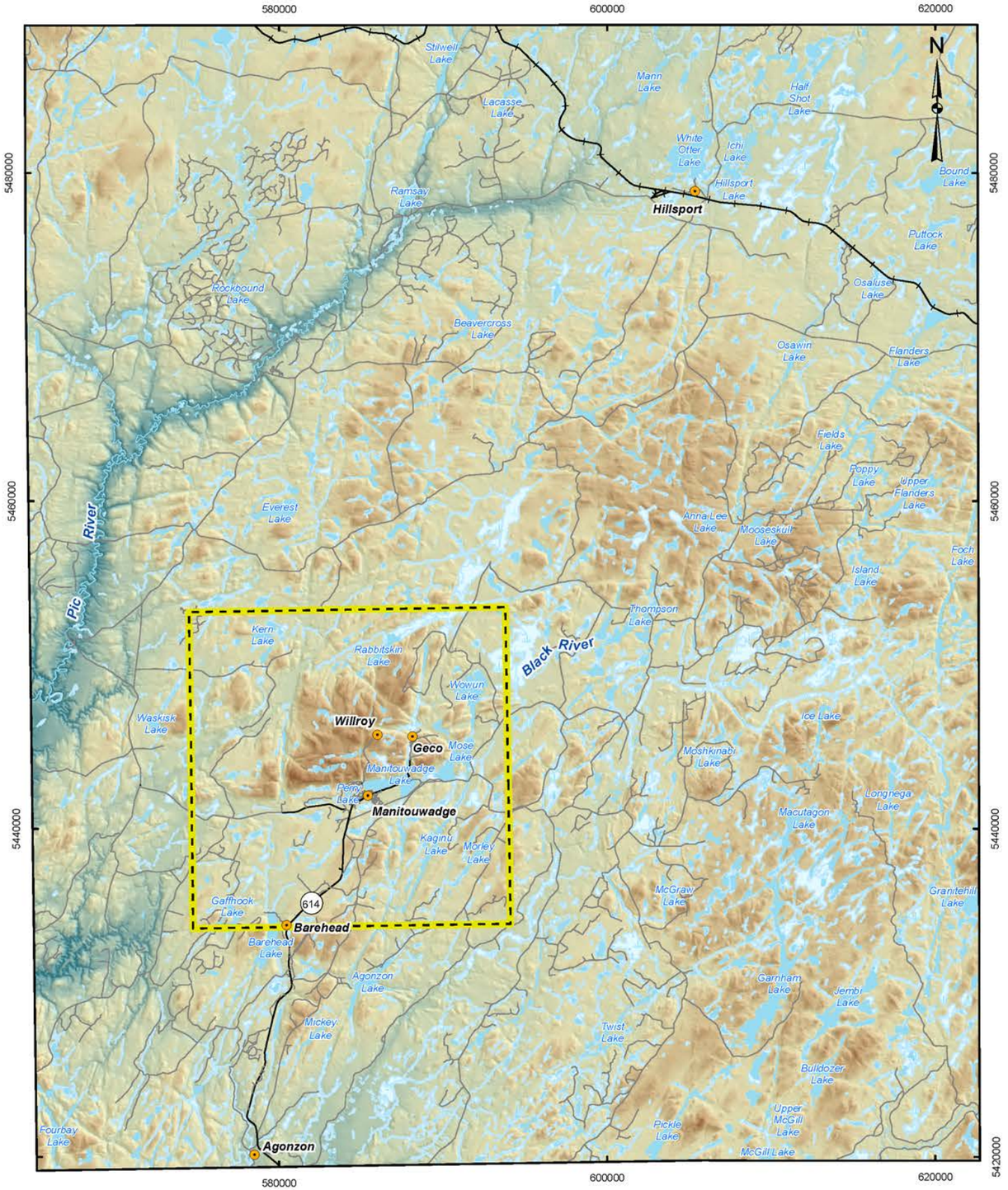
TITLE
Quaternary Geology of the Manitouwadge Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	10 Jul. 2013		
GIS	JMC	3 Apr. 2014		
CHECK	JH	3 Apr. 2014		
REVIEW	GWS	3 Apr. 2014		

FIGURE: 7

G:\Projects\2012\12-1152-0026_NWMO_Phase1_FeasibilityGIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\Manitouwadge\QuaternaryGeology.mxd



LEGEND

- Community
- Main Road
- Local Road
- Railway
- Waterbody
- Wetland
- Municipal Boundary (Township of Manitouwadge)

Elevation (masl)

485
450
400
350
300
250
195



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Digital Elevation Model - CDED slope raster: Geobase.ca (1:50,000)
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

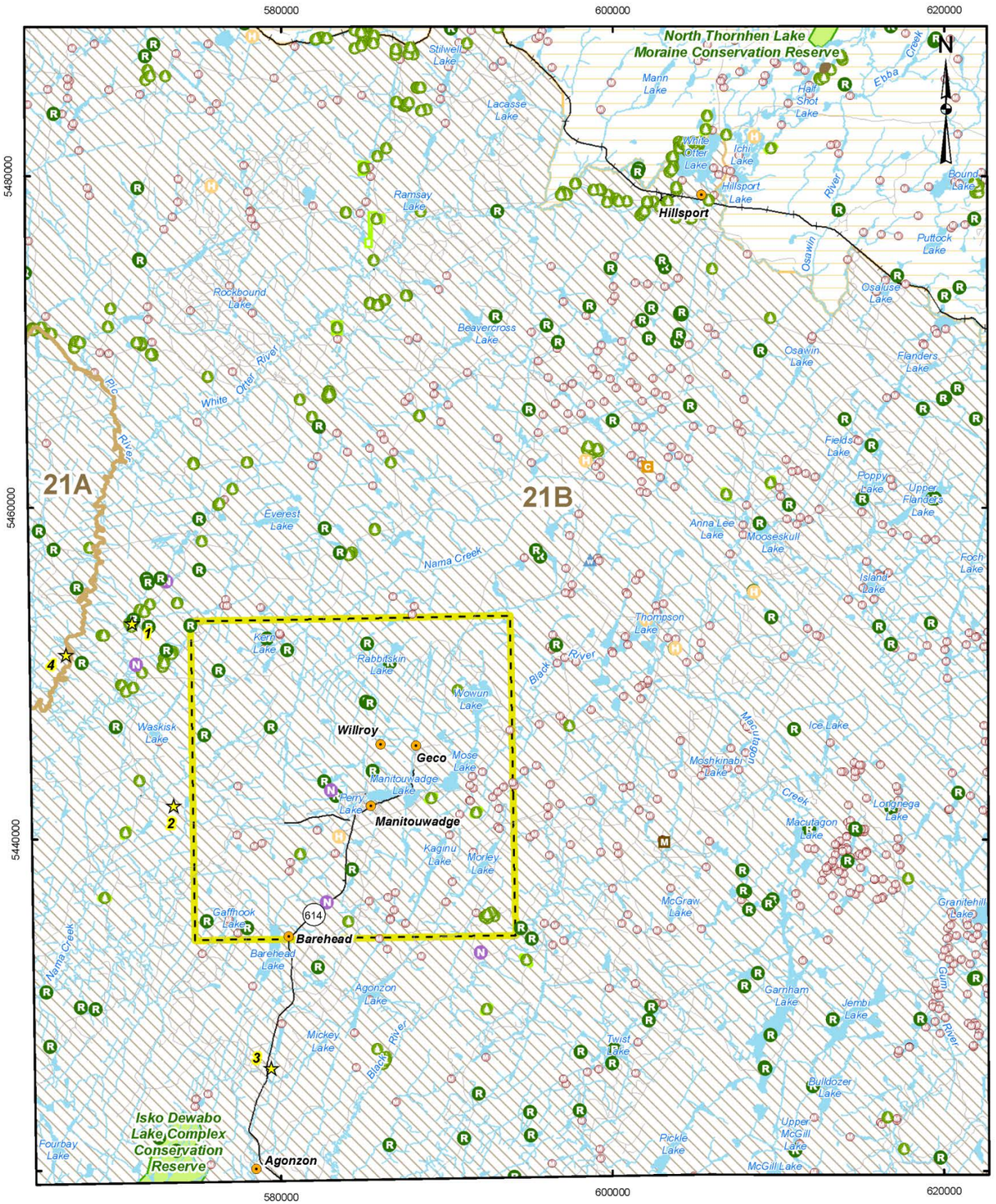
TITLE
Digital Elevation Model (DEM) of the Manitouwadge Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	5 Jul. 2013		
GIS	JMC	3 Apr. 2014		
CHECK	JH	3 Apr. 2014		
REVIEW	GWS	3 Apr. 2014		

FIGURE: 8

G:\Projects\2012\12-1152-0026_NWMO_Phase1_FeasibilityGIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\ManitouwadgeDigitalElevationModel.mxd



LEGEND

- Community
- Main Road
- Local Road
- Railway
- Watercourse
- Waterbody
- Provincial Park / Reserve
- Continuous Caribou Habitat
- Discontinuous Caribou Habitat
- Wildlife Management Units (21A, 21B)
- Municipal Boundary (Township of Manitouwadge)
- International Biological Program Sites

Wildlife and Forestry
- Forest Research Area
- Moose Aquatic Feeding Area

Nesting
- Heron
- Raptor
- Other

Significant Ecological Area
- Significant Woodland

Staging Area
- Waterfowl
- Waterfowl

Calving/Fawning Sites
- Caribou Calving Site
- Moose Calving Site



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

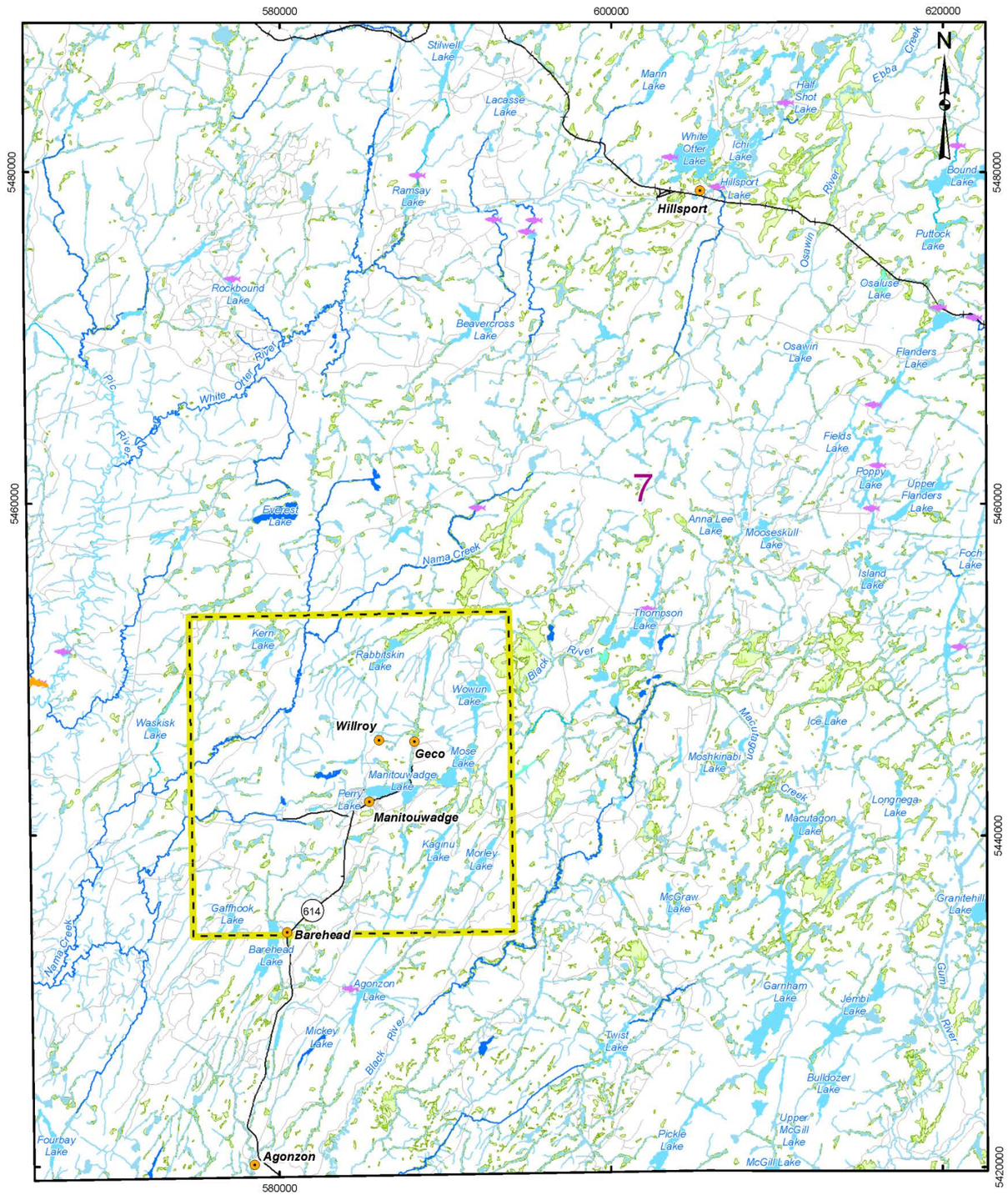
TITLE
Manitouwadge - Terrestrial Ecology

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	4 Jul. 2013		
GIS	JMC	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

FIGURE: 9

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeTerrestrialEcology.mxd





LEGEND

- Community
- Main Road
- Local Road
- Railway
- Watercourse (unspecified)
- Cold Watercourse
- Cool Watercourse
- Warm Watercourse
- Fisheries Management Zone (7)
- Municipal Boundary (Township of Manitouwadge)

Fisheries and Wetlands

- Spawning Area
- Fish Migration Route
- Waterbody (unspecified)
- Cold Waterbody
- Cool Waterbody
- Warm Waterbody

Natural Heritage

- Wetland

REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

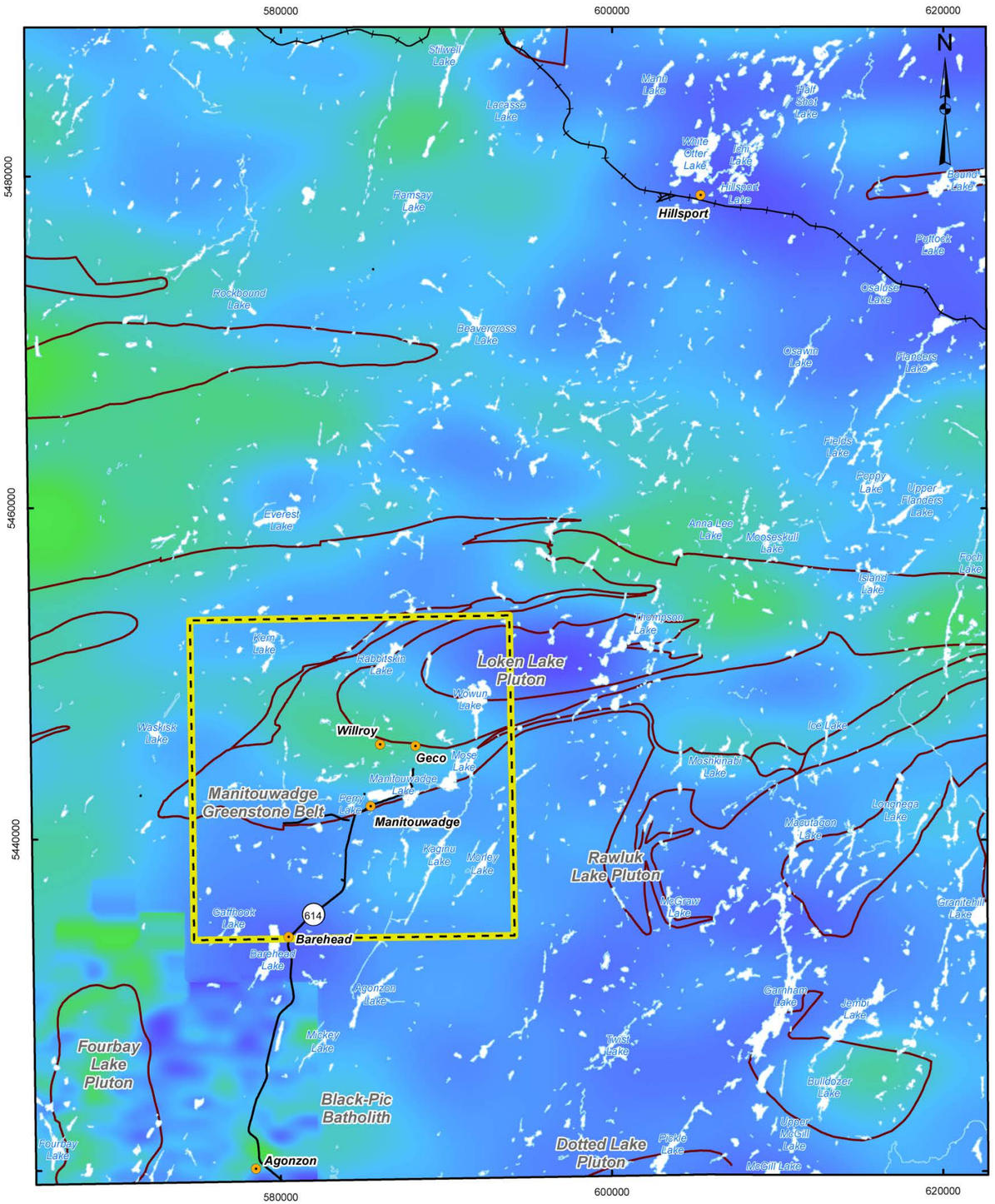
TITLE
Manitouwadge - Aquatic Ecology

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	4 Jul. 2013		
GIS	JMC	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

FIGURE: 10

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\ManitouwadgeAquaticEcology.mxd



LEGEND

- Community
- Main Road
- Railway
- Geological Contact
- Waterbody
- Municipal Boundary (Township of Manitouwadge)

Air Absorbed Radiation Levels (nGy/h)

110
100
90
80
70
60
50
40
30
20
10
0



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Radiometrics - GSC Canada - 250m -Natural Air Absorbed Dose Rate, 2012;
National Gamma-Ray Spectrometry Program Data Base, Airborne Geophysics Section,
GSC - Central Canada Division, Geological Survey of Canada, Earth Sciences Sector,
Natural Resources Canada
Bedrock Geology - OGS M2665, 2002; M2666, 2001; M2667, 2003;
M2668, 2003 (1:250,000)
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

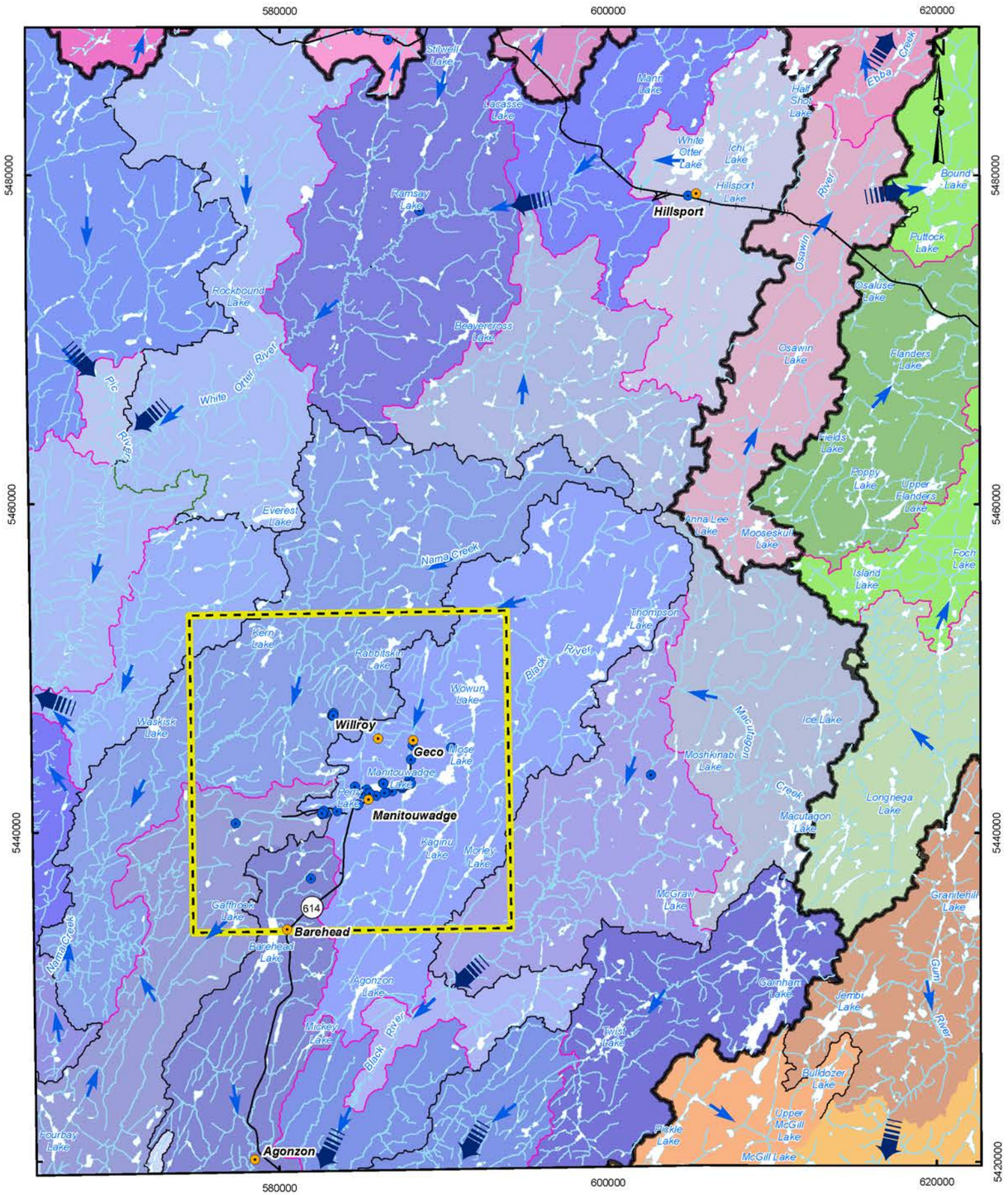
TITLE
Manitouwadge - Background Radiation Levels

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026		SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	5 Jul. 2013	
GIS	JMC	3 Apr. 2014	
CHECK	JH	3 Apr. 2014	
REVIEW	GWS	3 Apr. 2014	

FIGURE: 11

G:\Projects\2012\12-1152-0026_NWMO_PhaseI_FeasibilityIGIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeBackgroundRadiationLevels.mxd



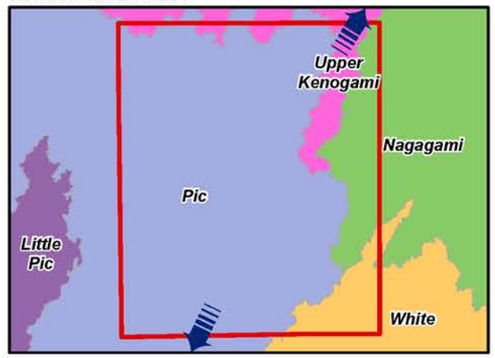
LEGEND

- Community
- MOE Well Location
- Main Road
- Railway
- Watercourse
- Waterbody
- Surface Water Flow Direction
- Watershed Outflow Point

Drainage Divides

- Delineated by MNR/AECOM
- Delineated by AECOM
- Delineated by MNR
- Tertiary Watershed
- Municipal Boundary (Township of White River)

TERTIARY WATERSHEDS



REFERENCE

Base Data - MNR LIO, obtained 2009-2013, CANMAP v2006.4
Wells - Ministry of the Environment, 2010
Watershed - LIO quaternary watershed (updated by AECOM)
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2013
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

6 3 0 6 12 18
SCALE 1:300,000 KILOMETRES

PROJECT
Environment Report
Township of Manitouwadge, Ontario

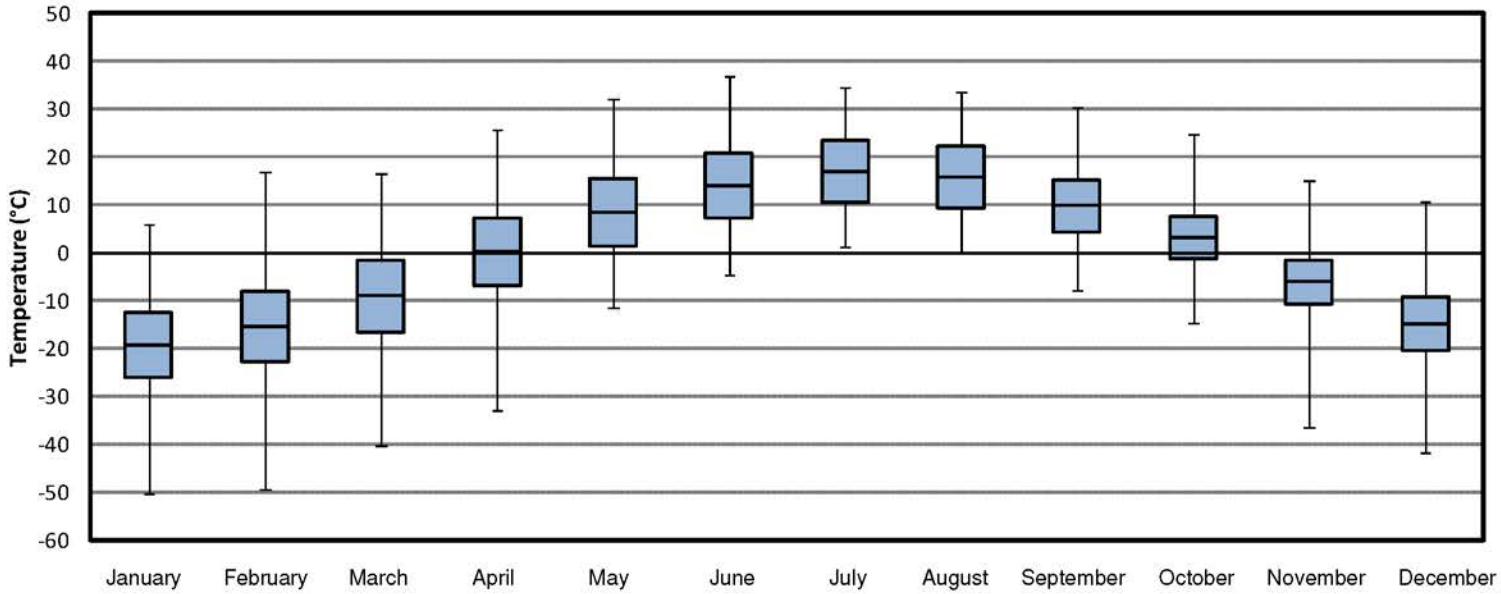
TITLE
Manitouwadge Surface Water Drainage and Water Wells

Golder Associates
Mississauga, Ontario

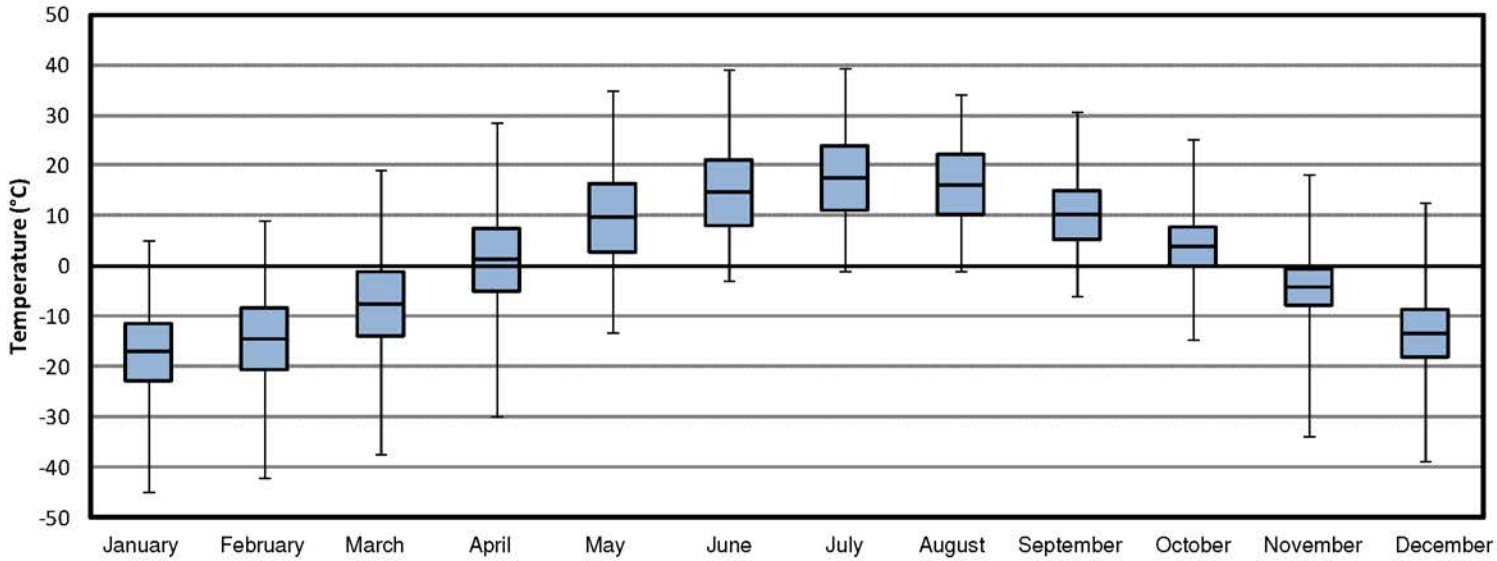
PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	27 Jan. 2011	FIGURE: 12	
GIS	JCJB	9 Jun. 2014		
CHECK	JH	9 Jun. 2014		
REVIEW	GWS	9 Jun. 2014		

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\ManitouwadgeManitouwadgeSurfaceWaterDrainageAndWaterWells.mxd

Geraldton Station



Manitouwadge Station



LEGEND

- Extreme Maximum (°C)
- Daily Maximum (°C)
- Daily Average (°C)
- Daily Minimum (°C)
- Extreme Minimum (°C)

DATA SOURCE

Environment Canada

PROJECT

Environment Report
Township of Manitouwadge, Ontario

TITLE

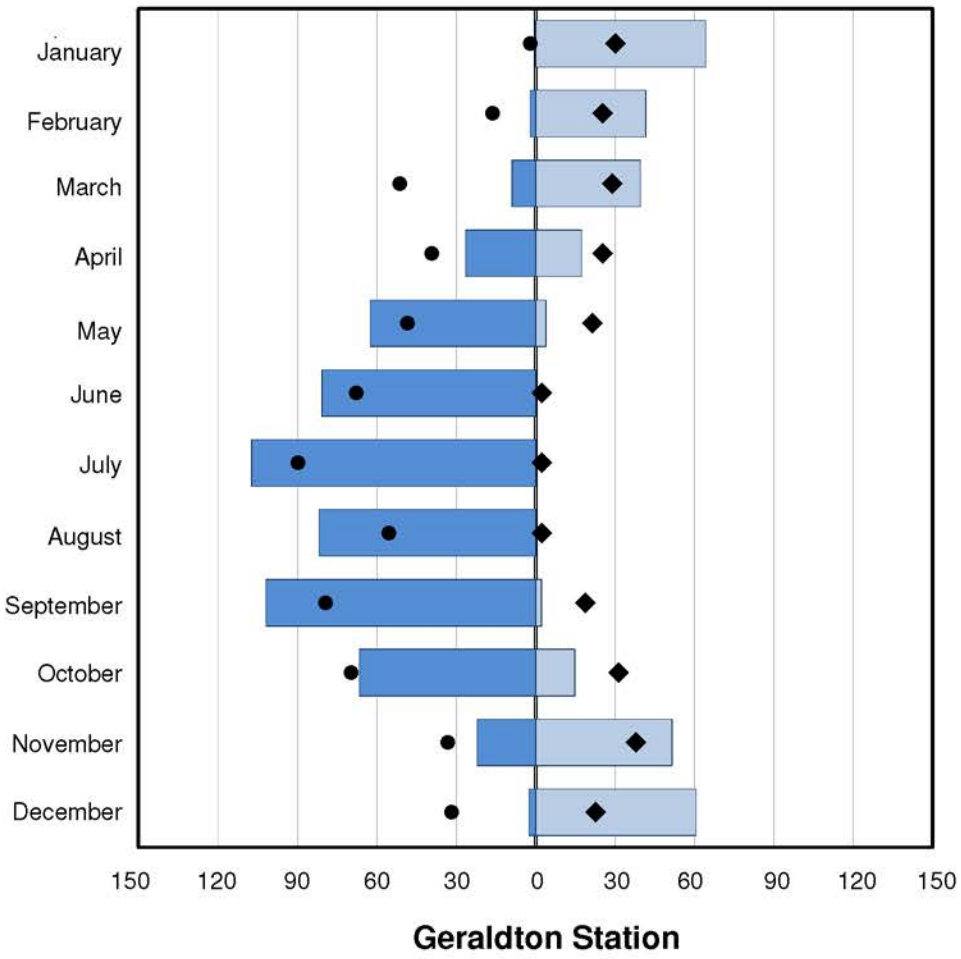
Manitouwadge and Geraldton 1971-2000 Temperature Data Summary

Golder Associates
Mississauga, Ontario

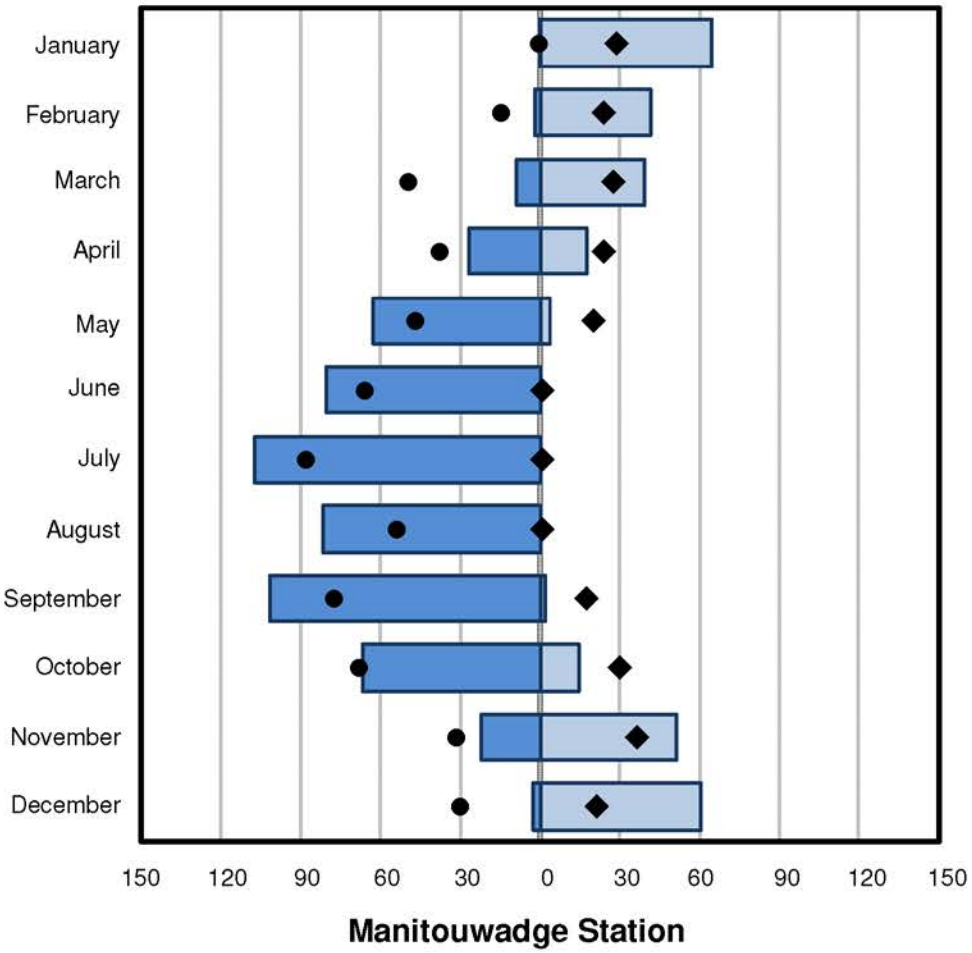
PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	23 July 2013		
GIS	PMJR	2 Apr. 2014		
CHECK	JH	2 Apr. 2014		
REVIEW	GWS	2 Apr. 2014		

FIGURE: 13

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\Manitouwadge&GeraldtonTemperatureDataSumary.mxd



Geraldton Station



Manitouwadge Station

LEGEND

- Monthly Rainfall (mm eq.)
- Monthly Snowfall (cm or mm eq.)
- Extreme Daily Rainfall (mm eq.)
- Extreme Daily Snowfall (cm or mm eq.)

DATA SOURCE

Environment Canada

PROJECT

Environment Report
Township of Manitouwadge, Ontario

TITLE

Manitouwadge and Geraldton 1971-2000 Precipitation Data Summary

Golder Associates
Mississauga, Ontario

PROJECT NO. 12-1152-0026			SCALE AS SHOWN	REV. 0.0
DESIGN	PRM	23 Jul. 2013		
GIS	PMJR	3 Apr. 2014		
CHECK	JH	3 Apr. 2014		
REVIEW	GWS	3 Apr. 2014		

FIGURE: 14

G:\Projects\2012\12-1152-0026_NWMO_Phase1_Feasibility\GIS\MXDs\Reporting\Env_Safety_Report\Manitouwadge\Manitouwadge&GeraldtonPrecipitationDataSummary.mxd

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
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
www.golder.com

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario, L5N 7K2
Canada
T: +1 (905) 567 4444

Golder Associates