nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

March 24, 2011

The Corporation of the Township of Ignace
34 Highway 17 West,
P.O. Box 248
Ignace, ON POT 1TO

Attn: Mr. Wayne Hanchard, Administrator Treasurer

Re: **Adaptive Phased Management Initial Screening – The Corporation of the Township of Ignace**

Dear Mr. Hanchard,

Further to your request to Learn More about the Adaptive Phased Management program and request for an initial screening, I am pleased to attach a report outlining the findings from the initial screening, as described in the *Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel* (May, 2010). As you know, the purpose of the initial screening in Step 2 of the process is to determine whether, based on readily-available information and five screening criteria, there are any obvious conditions that would exclude the Township of Ignace from further consideration in the site selection process.

As the report indicates, the review of readily-available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Township of Ignace from further consideration in the NWMO site selection process. The initial screening suggests that there are areas within the boundaries and at the periphery of the Township of Ignace that are potentially suitable for hosting a deep geological repository for Canada's used nuclear fuel. It is important to note that this initial screening has not confirmed the suitability of your community. Should your community choose to continue to explore its potential interest in the project, your area would be the subject of progressively more detailed assessments against both technical and social factors. Several years of studies would be required to confirm whether a site within your area could be demonstrated to safely contain and isolate used nuclear fuel.

The process for identifying an informed and willing host community for a deep geological repository for the long-term management of Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future. The NWMO expects that the selection of a preferred site would take between seven to ten years. It is important that any community which decides to host this project base its decisions on an understanding of the best scientific and social research available and its own aspirations. Should the Township of Ignace continue to be interested in exploring the project, over this period there would be ongoing engagement of your community, surrounding communities and others who may be affected. By the end of this process, Ignace as a whole community would need to clearly demonstrate that it is willing to host the repository in order for this project to proceed.

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Toronto Ontario Canada M4T 2S3
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The next evaluation step would be to conduct a feasibility study as described in Step 3 of the site selection process. This feasibility study would focus on areas selected in collaboration with the community. As your community considers whether it is interested in advancing to the feasibility study phase, the NWMO encourages you to continue community discussion and further learning about the project. Support programs are available to assist your community to reflect on its long-term vision and whether this project is consistent with achieving that vision. Programs and resources are also available to engage your community residents in learning more about this project and becoming involved. We would be very pleased to provide further information about these programs.

Once again, I thank you for taking the time to learn about Canada's plan for the safe, secure management of Canada's used nuclear fuel.

Sincerely,

Kathryn Shaver

Kathryn Shaver,
Vice President, APM Public Engagement and Site Selection

March 2011

INITIAL SCREENING FOR SITING A DEEP GEOLOGICAL REPOSITORY FOR CANADA'S USED NUCLEAR FUEL

The Corporation of the Township of Ignace, Ontario

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

REPORT

Report Number: 10-1152-0110 (2000)

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EXECUTIVE SUMMARY

On August 26, 2010, the Corporation of the Township of Ignace expressed interest in learning more about the Nuclear Waste Management Organization (NWMO) site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel (NWMO, 2010). This report summarizes the findings of an initial screening, conducted by Golder Associates Ltd., to evaluate the potential suitability of the Ignace area against five screening criteria using readily available information. The purpose of the initial screening is to identify whether there are any obvious conditions that would exclude the Township of Ignace from further consideration in the site selection process. As per discussions between the NWMO and the Township Council, the initial screening focused on the Township of Ignace and its periphery, which are referred to as the "Ignace area".

The review of readily available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Township of Ignace from being further considered in the NWMO site selection process. The initial screening indicates that there are areas within the boundaries and at the periphery of the Township of Ignace that are potentially suitable for hosting a deep geological repository. Potential suitability of these areas would need to be further assessed during subsequent site evaluation stages, if the community of Ignace remains interested in continuing with the site selection process.

It is important to note that the intent of this initial screening is not to confirm the suitability of the Ignace area to host a deep geological repository, but rather to provide early feedback on whether there are known reasons to exclude it from further consideration. Should the community of Ignace remain interested in continuing with the site selection process, more detailed studies would be required to confirm and demonstrate whether the Ignace area contains sites that can safely contain and isolate used nuclear fuel. The process for identifying an informed and willing host community for a deep geological repository for Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future.

The five initial screening criteria are defined in the site selection process document (NWMO, 2010) and relate to: having sufficient space to accommodate surface and underground facilities, being outside protected areas and heritage features, absence of known groundwater resources at repository depth, absence of known natural resources and avoiding known hydrogeologic and geologic conditions that would make an area or site unsuitable for hosting a deep geological repository.

A brief summary of the assessment against each of the initial screening criterion is provided below.

Availability of Land

Review of available mapping and satellite imagery indicates that the Ignace area contains sufficient land to accommodate the surface and underground facilities associated with the repository and could be accessible for construction and field investigation activities.

Protected Areas, Heritage Sites, Provincial Parks and National Parks

The Ignace area contains sufficient land outside of protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities. The four provincial parks and two conservation reserves present in the Ignace area occupy a small portion of the land. Limited heritage constraints were identified in the Ignace area. Known archaeological sites are small and generally concentrated around Agimak Lake and some lakes and rivers mostly to the north of the Township of Ignace. There are no national historic sites in the Ignace area. The absence of locally protected areas would need to be confirmed in discussion with the community and Aboriginal peoples in the area during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

Absence of Known Groundwater Resources at the Repository Depth

The review of available information did not identify any known groundwater resources at repository depth (approximately 500 m) for the Ignace area. The Ontario Ministry of Environment Water Well Records indicates that no potable water supply wells are known to exploit aquifers at typical repository depths in the Ignace area or anywhere else in Northern Ontario. Water wells in the area source water from overburden or shallow bedrock aquifers at depths ranging from 4 to 154 m. Experience in similar geological settings across the Canadian Shield suggests that the potential for deep groundwater resources at repository depths is low throughout the Ignace area. The absence of groundwater resources at repository depth would need to be confirmed during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

Absence of Economically Exploitable Natural Resources as Known Today

Based on the review of readily-available information, the Ignace area contains sufficient land, free of known economically exploitable natural resources, to accommodate the required repository facilities. The Ignace area has a generally low potential for oil and gas resources and economic minerals. Past mining activities within the Township of Ignace were limited to the extraction of industrial stone (granite) at shallow depths. Potential for metallic mineral resources in the Ignace area is limited to localized areas at the periphery of the Township.

No Known Geological and Hydrogeological Characteristics That Would Prevent the Site from Being Safe

Based on the review of readily-available geoscientific information, the Ignace area comprises portions of land that do not contain known unsafe geological and hydrogeological conditions. There are a number of geological units with geoscientific characteristics that are potentially suitable for hosting a deep geological repository within the Ignace area. These units include the Indian Lake Batholith, as well as the White Otter Lake and Revell Batholiths.

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1.0 INTRODUCTION

On August 26, 2010, the Corporation of the Township of Ignace expressed interest in learning more about the Nuclear Waste Management Organization (NWMO) nine-step site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel (NWMO, 2010). This report presents the results of an initial screening, conducted by Golder Associates Ltd., as part of Step 2 in the site selection process to evaluate the potential suitability of the Ignace area against five screening criteria using readily-available information. As per discussions between the NWMO and the Township Council, the initial screening focused on the Township of Ignace and its periphery, which are referred to as the "Ignace area" in this report.

1.1 Background

The ultimate objective of Adaptive Phased Management (APM) is long-term containment and isolation of used nuclear fuel in a deep geological repository in a suitable rock formation. The NWMO is committed to implementing the project in a manner that protects human health, safety, security and the environment, while fostering the long-term well-being of the community and region in which it is implemented (NWMO, 2005).

In May 2010, the NWMO published and initiated a nine-step site selection process to find an informed and willing community to host the repository (NWMO, 2010). The site selection process is designed to address a broad range of technical and social, economic and cultural factors as identified through dialogue with Canadians and Aboriginal peoples, and draws from experiences and lessons learned from past work and processes developed in Canada to site facilities for the management of other hazardous material. It also draws from similar projects in other countries pursuing the development of deep geological repositories for used nuclear fuel. The suitability of potential candidate sites will ultimately be assessed against a number of site evaluation factors, both technical and social in nature.

The geoscientific suitability of candidate sites will be assessed in three main phases over a period of several years, with each step designed to evaluate the site in progressively greater detail upon request of the community. The three site evaluation phases include: Initial Screenings to evaluate the potential suitability of the community against a list of initial screening criteria, using readily-available information (Step 2); Feasibility Studies to determine if candidate sites within the proposed areas are potentially suitable for developing a safe deep geological repository for used nuclear fuel (Step 3); and Detailed Site Evaluations, at one or more selected sites, to confirm suitability based on detailed site evaluation criteria (Step 4). It is up to the communities to decide whether they wish to continue to participate in each step of the process.

1.2 Objectives and Approach for Conducting Initial Screenings

The overall objective of the initial screening is to evaluate proposed geographic areas against a list of screening criteria using readily-available information. Initial screening criteria (NWMO, 2010) require that:

1) The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

2) This available land must be outside of protected areas, heritage sites, provincial parks and national parks.

3) This available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

4) This available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.

5) This available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the safety factors outlined in Section 6 of the Site Selection Document (NWMO, 2010).

The initial screening step involves the systematic consideration of each of the five initial screening criteria on a qualitative basis using readily-available information from provincial, federal, municipal and other sources of information. It is not the intent of the initial screening study to conduct a detailed analysis of all available information, but rather to identify any obvious conditions that would exclude a community from further consideration in the site selection process. For example, a site with known economically exploitable natural resources or geological or hydrogeological characteristics that are clearly unfavourable would be excluded from further consideration.

For cases where readily-available information is limited and where assessment of some of the criteria is not possible at the screening stage, the area would be advanced to the feasibility study stage for more detailed evaluation, provided the community remains interested in continuing to participate in the siting process.

The initial screening commences with an analysis of readily-available information in order to develop an overall understanding of the geoscientific and other relevant characteristics of the site. The initial screening criteria are then applied in a systematic manner based on the understanding of the proposed area or site. The tasks involved include the following:

- Reviewing the regional and local physical geography, geology, seismicity, structural geology and Quaternary geology (surface geology);
- Reviewing the hydrogeology, including, regional groundwater flow, deep and shallow aquifers and hydrogeochemistry;
- Reviewing the economic geology, including petroleum resources, and metallic and non-metallic mineral resources;
- Applying the screening criteria; and
- Summarizing the findings with regards to potential suitability.

2.0 PHYSICAL GEOGRAPHY

2.1 Location

The Township of Ignace is situated in the District of Kenora in Northwestern Ontario, between Dryden and Thunder Bay, as shown on Figure 2.1. The Township of Ignace is approximately 100 km^2 (about 10 x 10 km) in size. The settlement area of Ignace is situated on the north shore of Lake Agimak, approximately 250 km northwest of Thunder Bay and 110 km southeast of Dryden (Figure 2.1). Satellite imagery for the Ignace area (Landsat 7, taken in 2006) is presented on Figure 2.2.

2.2 Topography

The Township of Ignace is located in the Canadian Shield physiographic region, a low-relief, dome-like, gently undulating land surface with an elevation of about 150 masl (meters above sea level) in the north, increasing to about 450 masl towards the south. Figure 2.3 shows the general physiographic regions of Ontario (Thurston, 1991), including the subdivision of the Canadian Shield physiographic region into the Severn Upland, the Nipigon Plain, the Abitibi Upland and the Laurentian Highlands.

The Township of Ignace lies in the Severn Uplands, a broadly rolling surface of Canadian Shield bedrock that occupies most of Northwestern Ontario and which is either exposed at surface or shallowly covered with Quaternary glacial deposits. Terrains in the Severn Uplands contain numerous lakes (Thurston, 1991) and the terrain of the Ignace area is typical in that regard.

The topography of the Ignace area is presented on Figure 2.4. The land surface elevation in the Ignace area is variable and generally decreases to the northeast. Within the Township of Ignace, land surface elevation decreases from 535 masl in the southwest to as low as 390 masl in the northeast. There is considerable relief between the lakes in most areas. Topographic highs generally correspond to bedrock outcrops, whereas topographic lows are generally areas of thicker overburden.

At the periphery of the Township of Ignace there are two major moraine ridges that represent dominant topographic features: the Hartman and Lac Seul Moraines and associated glacial deposits (eskers, tills, kames and outwash). These glacial deposits accumulated to different thicknesses and are located to general north and northeast of Highway 17 (see Section 3.4).

2.3 Drainage

The Township of Ignace is located within the Winnipeg River sub-basin. Surface water drainage for the Ignace area is shown in Figure 2.5. The Winnipeg River sub-basin is drained via the English, Seine and Turtle River systems into the Winnipeg River to the west, and then into the Nelson River basin, and eventually, into Hudson Bay (Lake of the Woods Control Board, 2010). The Winnipeg River sub-basin is further subdivided into the English River and the Rainy River sub-subbasins. While the Township of Ignace strictly lies within the English River sub-subbasin, the surrounding area to the north and south includes both the English River and Rainy River sub-subbasins, respectively. The Ignace area is abundant in lakes, which are interconnected by an intricate network of small and medium sized rivers, and by large rivers such as the Wabigoon River, Bending River and Gulliver River. Surface water generally flows to the northwest (Figure 2.5).

2.4 Protected Areas

Parks and Reserves

There are four provincial parks and two conservation reserves in the Ignace area. Figure 2.1 shows the location of these protected areas. The Sandbar Lake Provincial Park is 80 km^2 in size. Its southern tip occupies part of the northeast corner of the Township of Ignace. The Turtle River-White Otter Lake Provincial Park lies immediately south of the Township of Ignace and covers roughly 368 km^2 of area. The southernmost portion of the East English River Provincial Park and the 8.5 km^2 Bonheur River Kame Provincial Park lie about 17 km north and 26 km east of the Township of Ignace, respectively.

There are also two conservation reserves in the Ignace area: the Campus Lake (194 km^2) and Gulliver River (27 km^2) Conservation Reserves, approximately 8 km and 15 km south and southeast of the Township of Ignace, respectively (Atlas of Canada, 2010).

Heritage Sites

The cultural heritage screening examined known archaeological and historic sites in the Ignace area, using the Ontario Archaeological Sites Database. There are 45 known archaeological sites in the Ignace area. There are no National Historic Sites in the Ignace area.

Seven of the archaeological sites are located within the Township boundaries (Figure 2.1). Six of these sites are located on islands within Agimak Lake or on its shore and one site is located north of Agimak Lake close to the existing railway line. The latter is a historic Euro-Canadian storage structure probably related to the construction of the railway in the last half of the 19th century. Three of the sites on Agimak Lake are pre-contact Aboriginal sites including two Late Woodland period sites dating between 500 and 1,000 years ago and one other site is a 19th century Euro-Canadian logging camp with evidence for a historic Ojibwa component. Oral tradition indicates First Nations use on the lake during the 19th century. For the other two sites on Agimak Lake, aside from their location, no information is contained in the database (e.g. time period or cultural affiliation is not provided). The potential for archaeological and historical sites around Agimak Lake is considered to be high given the sites already documented within and around the lake.

The other 38 archaeological sites are at the periphery of the Township of Ignace. Eighteen of these are pictographs, or rock paintings. These paintings can be found along the shores of Mooseland Lake, Owl Lake and Mameigwess Lake. Those paintings found along the shores of Mameigwess Lake are of particular consideration as it is likely that they were painted entirely from the water since access to the paintings is probably only by boat (Dewdney and Kidd 1973). Ten of the sites at the periphery of the Township are pre-contact Aboriginal campsites or habitation sites, with seven identified as either Middle or Late Woodland. Of the remaining ten known archaeological sites, one is a small Hudson's Bay Company post, one is a fishing station, two are isolated finds and the remaining six are undetermined.

Also, local archaeologists have documented a number of sites in the Ignace area with archaeological potential (Smyk, 1990). Archaeological potential is established by determining the likelihood that archaeological resources may be present on a subject property. In archaeological potential modeling, a distance to water criterion of 300 m is generally employed for primary water courses, including lakeshores, rivers and large creeks, while a criterion of 200 m is applied to secondary water sources, including swamps and small creeks (Government of Ontario 1997). The presence local heritage sites would need to be further confirmed in discussion with the community and Aboriginal peoples in the area, if the community remains interested in continuing with the site selection process.

3.0 GEOLOGY AND SEISMICITY

3.1 Regional Bedrock Geology

The geology of the Ignace area consists of a layer of unconsolidated Quaternary deposits overlying 2.5 to 3 billion year old bedrock of the Canadian Shield – a stable craton that forms the core of the North American continent. The Canadian Shield is a collage of Archean plates and accreted juvenile arc terranes and sedimentary basins of Proterozoic age that were progressively amalgamated. It was originally an area of very large mountains and intense volcanic activity, and was the first part of North America to be permanently elevated above sea level.

As shown on Figure 3.1, the Township of Ignace is situated in the Superior Province of the Canadian Shield, which covers an area of approximately 1,500,000 km^2 stretching from the Ungava region of northern Québec through the northern part of Ontario and the eastern portion of Manitoba, and extending south through to Minnesota and the northeastern part of South Dakota.

The Superior Province has been divided into various subprovinces based on lithology, age, genesis, and metamorphism (Thurston, 1991). These subprovinces are also shown on Figure 3.1. The Township of Ignace is situated in the Wabigoon Subprovince, which is part of the western region of the Superior Province. The Wabigoon Subprovince is about 900 km long and 150 km wide and bounded by the Winnipeg River Subprovince to the northwest, the English River Subprovince to the northeast, and the Quetico Subprovince to the south (Blackburn et al., 1991).

The Wabigoon Subprovince is further subdivided into three regions (Western, Central and Eastern) based on the geographic distribution of different lithologic associations. The boundaries between the three regions show interfingering, with greenstone belts extending from one region to another. The Western and Eastern regions, underlain by supracrustal rocks and intravolcanic granitic batholiths, are separated by the Central Wabigoon region, where the Township of Ignace is located and which comprises gneissic domes and granitoid batholiths and minor supracrustal belts (Blackburn et al., 1991).

Figure 3.2 shows the bedrock geology of the Central and Western Wabigoon regions, as well as their main structural features. The central Wabigoon region comprises Ignace, Upsala, Atikokan and Mine Centre and extends 30 to 270 km west of Thunder Bay (Stone, 2009a).

The Central Wabigoon Subprovince is underlain by thin, branched and anastomosed greenstone belts intruded by large felsic plutonic bodies. Greenstone belts in the region are mostly composed of ultramafic volcanic rocks with lesser components of intermediate to felsic volcanic rocks, gabbro and sedimentary rocks. Some of these minor greenstone belts are restricted to the Central Wabigoon region, while others represent extensions of greenstone belts of the adjacent regions.

Intrusive rocks in the Central Wabigoon region vary in age. Among the oldest plutonic rocks are biotite tonalite-gnessic intrusions such as the 3 billion year old Marmion Batholith (Blackburn et al., 1991). A small percentage of intrusive rocks in the Central Wabigoon region are scattered oval to elongated masses of tonalite to granodiorite and small units of granite within the greenstone belts. Late post-tectonic intrusions are the most common rock in the region and occur as massive biotite granite dikes, stocks and batholiths (e.g. White Otter Lake, Indian Lake and Muskeg Batholiths). Other younger post-tectonic rocks are found to a lesser extent (10%) as sanukitoid (high-Mg granitoids) heterogeneous plutons (Stone and Davis, 2006a).

Greenstone belts in the Wabigoon Subprovince often contain long, subconcordant, sinuous shear zones that exhibit complex histories of ductile and brittle deformation. Also, indications of repeated units and layer parallel shearing support the theory that supracrustal assemblages have been tectonically stacked (Blackburn et al., 1991).

With reference to Figure 3.2, there are a number of regional faults in both the Central and Western Wabigoon subprovinces. The closest regional faults to the Township of Ignace are the northeast-trending Finlayson-Marmion Fault Zone and the east-west trending Washeibemaga Lake Fault, approximately 34 km southeast and 45 km west of the Township of Ignace respectively.

3.2 Local Bedrock Geology

3.2.1 Lithologies

The bedrock geology of the Ignace area is shown on Figure 3.3. The Township of Ignace is located on the southwestern edge of the Indian Lake Batholith, an irregularly shaped, granitic intrusion that covers approximately 1,600 km^2 and extends well beyond the boundaries of the Township of Ignace to the north and east (Blackburn et al., 1991).

As shown on Figure 3.3, there are other batholiths in the Ignace area. The closest ones to the Township of Ignace are the White Otter Lake and Revell Batholiths. These are Neoarchean intrusions that were emplaced into the older Raleigh Lake and Bending Lake Greenstone Belts. Other smaller-scale plutons of different compositions and ages also intrude the greenstone belt rocks at specific locations (e.g. the Paddy Lake and Islet Plutons).

Gravity, magnetic and radiometric geophysical surveys for the Ignace area mainly respond to differences in rock type, rock unit thickness and mineralization. The gravity field over the Township of Ignace (Figure 3.4) is generally flat. There is a positive gravity response in the area northwest of Raleigh Lake within the Raleigh Lake Greenstone Belt, and in the area centered on the dioritic Islet Pluton south of Bending Lake. Negative gravity responses are noted over the Basket Lake and White Otter Lake Batholiths. These gravity differences between the major geologic units are due to differences in both rock density and thickness of these units.

Airborne magnetic survey results (Figure 3.5) also reflect the general differences in lithology of the major rock units. The magnetic response over the granitic intrusions of the Ignace area (i.e., the Indian Lake, Revell and White Otter Lake Batholiths) is quite consistent. Slightly elevated magnetic field measurements correspond to the greenstone belt “slivers” located south of the Township of Ignace, while a pronounced magnetic high occurs within the greenstone belt in the vicinity of Bending Lake. These positive magnetic responses are likely the result of mineralization associated with these greenstone formations.

Airborne radiometric data for the Ignace area (presented as equivalent uranium response) is provided on Figure 3.6. Radiometric responses due to the presence of potassium, uranium and thorium related minerals are typically elevated in granitic rocks compared to volcanic rocks, and this relationship is seen in the Ignace area. Three radiometric highs occur within the Indian Lake Batholith: an area between the northwest corner of the Township of Ignace and Basket Lake some 25 km to the northwest; a small area northeast of the Township of Ignace; and a small area northwest of Cecil and Kin Lakes. These highs are likely the result of local variations in mineral composition, but their exact nature is not known.

The main intrusive bodies and the greenstone belts occurring in the Ignace area are further described below.

Indian Lake Batholith

It is estimated that the intrusion of the 1,600 km^2 Indian Lake Batholith took place approximately 2.671 billion years ago during the last tectonic stages of the Kenoran Orogeny (Tomlinson et al., 2004). The Indian Lake Batholith is composed of light grey-white to pale pink biotite granite, typically medium to coarse grained, inequigranular, leucocratic and massive to very weakly foliated. The granite in this intrusion usually contains a few percent of biotite (3-5%) and subequal proportions of quartz, plagioclase and potassium feldspar (Stone et al., 1998). The granite at the Butler Station Quarry, in the Township of Ignace, is composed of about 40% plagioclase, 29% quartz, 28% potassium feldspar, 3% biotite and traces of magnetite, rare epidote and chlorite (Brisbin et al., 2005).

The Indian Lake Batholith contains a large (approximately 35 km^2) inclusion in the southern portion of the Township of Ignace that extends beyond its boundaries. The inclusion is composed of biotite-hornblende tonalite to granite. This rock is usually coarse, granular and mesocratic and, when hornblende granite is present, it is characterized by large potassium feldspar megacrystals that are 1 to 5 cm in size (Stone et al., 1998).

Szewcyk and West (1976), based on gravity data, estimated the thickness of the Indian Lake Batholith to be about 2 km ± 0.5 km. The authors noted the absence of a strong gravity signature beneath the western margin of the batholith in the Ignace area and infer either the presence of a denser rock mass beneath the batholith or the thinning of the intrusion in this area. Everitt (1999) describes the Indian Lake Batholith as a sheet-like intrusion less than 2 km thick.

Brisbin et al. (2005) reported compressive strength values for the Indian Lake Batholith granite in the range of 180 MPa, densities of 2.6 tonnes/m^3 and water contents of 0.28%.

White Otter Lake Batholith

The White Otter Lake Batholith extends south and southwest of the Township of Ignace. It is about 80 km long and 30 km wide and has an approximate surface extension of 2,000 km^2 (Figure 3.2). The negative gravity response associated with this intrusion suggests that it extends to depths greater than 2 km (Szewcyk and West 1976). The White Otter Lake Batholith extends to within about 7 km of the Township of Ignace south of its southern boundary.

This massive late to post- tectonic intrusion is approximately 2.685 billion years old (Stone et al., 1998; Tomlinson et al., 2004; Stone and Davis, 2006a). Typically the granite of this intrusion is light grey-white to pink and contains less than 6% biotite. A large inclusion of biotite-hornblende tonalite to granite similar to that of the Indian Lake Batholith is present in the northeastern edge of the batholith, southeast of the Township of Ignace. The granite becomes locally pegmatitic close to the hornblende inclusion (Stone et al., 2007). Outcrop descriptions have reported some foliation at surface. George Armstrong Co. Limited (1981) drilled a diamond drillhole to a depth of 97 m in the South Grey Trout Lake area of the White Otter Lake Batholith and described the lithology as coarse grained grey-white massive granite.

Revell Batholith

The Revell Batholith is an elongated 45 km long, 15 km wide northwest-trending pre-tectonic intrusive body located approximately 23 km west of the Township of Ignace and surrounded by metavolcanic rocks (Figures 3.2 and 3.3). No information was found on the thickness of this batholith.

The intrusion is comprised of a number of different granitic phases with an approximate age of 2.737 billion years (Larbi et al., 1998). The youngest and most widely spread phase is composed of medium to coarse grained, light grey-white to pink, massive potassium feldspar megacrystic biotite granite to granodiorite. Data from quarries in the northern sector of this batholith show biotite contents from 5 to 10% (Storey, 1986) and local presence of white pegmatite veins. Older tonalitic phases occur along the western margin of the intrusion as elongated units; the oldest phase in the batholith is represented by medium-grained, foliated biotite tonalite (Stone, 2009b).

Greenstone Belts

Both the Raleigh Lake and Bending Lake Greenstone Belts have been interpreted as extensions of the Neoarchean greenstone sequences of the Kakagi Lake – Savant Lake Volcanic Belt in the Western Wabigoon region (Stone, 2009b). These greenstone sequences are interpreted to have developed about 2.745 to 2.712 billion years ago. A metavolcanic rock sample from the Raleigh Lake Greenstone Belt has an age of 2.73 billion years (Stone, 2010). Stone (2009b) suggests that these greenstone formations extend to approximately 3 km depth.

The Raleigh Lake Greenstone Belt stretches in a northwest-trending direction in the area between the Indian Lake, White Otter Lake and Revell Batholiths, to a width of 10 km west of the Township of Ignace. South of the Township of Ignace, a narrow arm of the belt curves eastwards and extends to the Bonheur area.

The most abundant rocks in the Raleigh Lake Greenstone Belt are mafic metavolcanic rocks, usually present as fine grained, dark green to black pillow lavas commonly associated with pyritic iron formation units. In the mafic parts of the greenstone belt gabbroic sills and stocks are present at scattered locations. Intermediate to felsic metavolcanic rocks exist as dacitic to rhyolitic flows, tuffs and breccias, the latter being mostly concentrated west of Raleigh Lake. These rocks show gneissic textures due to moderate levels of strain south and southeast of Raleigh Lake. The more intensely developed foliation in intermediate-felsic metavolcanics may imply that these rocks could be older than the mafic metavolcanic units (Stone, 2009b). Both mafic and intermediate-felsic metavolcanic rocks are intruded by biotite tonalite, which is typically coarse-grained, grey and moderately foliated. Metasedimentary units are concentrated at Balmoral Lake, just south of the Township of Ignace. Although migmatization has obliterated most of the original sedimentary structures, these metasedimentary units are interpreted by Stone (2009b) as turbiditic sandstone-siltstone sequences.

The southwest-trending Bending Lake Greenstone Belt runs south of the Revell Batholith. This belt is mostly composed of mafic metavolcanic rocks, gabbro, intermediate volcanic rocks and clastic metasediments that occur in units of up to 2 km thick extending for almost the full length of the belt.

3.2.2 Deformation and Metamorphism

Neoarchean deformation in the Central Wabigoon region is interpreted to have occurred in multiple deformation stages (Stone, 2010). Although the sequence of deformation events has not yet been established in the Ignace area, in the northern Central Wabigoon region Percival et al. (2002) interpreted the earliest deformation to have occurred 2.913 to 2.835 billion years ago and the late shearing to have developed about 2.677 billion years ago.

No significant faults or deformation zones have been identified within the Township of Ignace. The Indian Lake Batholith (2.671 billion years old) is a late to post-tectonic massive intrusion where only weak magmatic foliations have been recognized (Stone et al., 1998). These non-tectonic foliations are defined by the alignment of igneous minerals that delineate concentric patterns in the granite (Stone et al., 1998). Data from a number of quarries in the Indian Lake Batholith reveals the existence of various joint systems with varied orientations and spacing

(Storey, 1986; Hinz et al., 1994). These joints were identified at surface and it is presently not clear if they extend to depth.

Granitic rocks of the easternmost end of the Indian Lake Batholith about 40 km east of the Township of Ignace are transected by the north-northeastern extension of the Finlayson-Marmion Fault (see Figure 3.2). The fault in this area occurs as a broad zone of plastic deformation and it has been interpreted as a strike-slip fault (Stone and Halle, 1999). No evidence of post-Archean activity (shear-type deformation) along this fault zone has been reported in the available literature.

The White Otter Lake Batholith (2.685 billion years old), south of the Township of Ignace, is also a late to post-tectonic massive intrusion (Stone, 2010) where tectonic deformation is likely negligible. The Revell Batholith is a strongly foliated pre-tectonic intrusion that probably emplaced coincident with volcanism in the Wabigoon Subprovince and was likely affected by a number of deformation events during the Kenoran Orogeny (Stone, 2010; Larbi et al., 1998). Everitt (1999), however, describes the Revell Batholith as a sparsely fractured intrusion, based on information at surface. Data from quarries in the Revell Batholith highlight the existence of joint systems at surface (Storey, 1986; Hinz et al., 1994), but no information was found on the potential fracturing of this intrusion at depth.

The Raleigh Lake and Bending Lake Greenstone Belts at the periphery of the Township of Ignace have probably been folded and faulted over several Archean deformation events. The metavolcanic rocks in the greenstone belts adjacent to the Township of Ignace show intense planar fabrics of tectonic origin with complex curved trajectories that parallel geologic contacts (Stone et al., 1998).

Similar to other greenstone belts in the Wabigoon Subprovince, the Raleigh Lake and Bending Lake Greenstone Belts are likely to include numerous local faults and shear zones (Stone, 2010). The closest mapped faults and shear zones to the Township of Ignace include: a fault running along the contact between metasedimentary and metavolcanic rocks about 4 km southwest of the Township of Ignace, and a northwest-trending shear zone along the edge of the Raleigh Lake belt about 30 km northwest of the Township of Ignace (Stone et al., 1998; Parker, 1989). In the Bending Lake Greenstone Belt, several high strain deformation zones have also been identified at different locations. However, poor exposure has prevented accurate mapping of these faults.

Stone (2010) estimates that, in the Central Wabigoon region, late Neoarchean metamorphism occurred from approximately 2.722 to 2.657 billion years ago and suggests the possibility that older metamorphic events also affected the area. However, evidence of this early metamorphism has been obscured by the latest metamorphic stages. A comprehensive overview of metamorphism across the Superior Province is provided by Easton (2000).

In the Ignace area, metamorphism is mainly restricted to the rocks of the Raleigh Lake and Bending Lake Greenstone Belts and to the Revell Batholith. No information on the metamorphic grade of the latter was found in the readily-available literature. In the Raleigh Lake Greenstone Belt, metamorphic grade varies from moderate to high, reaching the amphibolites facies. Numerous amphibolite and garnet layers and clasts are found in rocks of the belt. In the Balmoral Lake area southwest of the Township of Ignace, metasedimentary sequences are extensively migmatized (Stone et al., 1998; Blackburn and Hinz, 1996).

In the Bending Lake Greenstone Belt, mineral assemblages are indicative of significantly variable metamorphic grade, up to the amphibolites facies. Rocks at the margins and in thin extensions of the belt exhibit higher metamorphic grade than rocks in the core of the belt, implying a degree of contact metamorphism adjacent to the surrounding intrusive bodies (Stone, 2009b).

3.2.3 Neotectonic Activity

Neotectonics refers to deformations, stresses and displacements in the earth's crust of recent age or which are still occurring. The geology of the Ignace area is typical of many areas of the Canadian Shield, which has been subjected to numerous glacial cycles during the last million years (Shackleton et al., 1990; Peltier, 2002).

During the maximum extent of the Wisconsinan glaciation, approximately 21,000 years ago (Barnett, 1992), the earth's crust was depressed by more than 340 m in the Minnesota area (Brevic and Reid, 1999), due to the weight of glacial ice. The amount of crustal depression in the Ignace area would be of a similar magnitude, but slightly greater due to its closer proximity to the main centre of glaciation.

Post-glacial isostatic rebound began with the waning of the continental ice sheets and is still occurring across most of Ontario. The greatest rates of crustal rebound (approximately 12 mm/a) are recorded in the Hudson Bay region, where the thickest glacial ice occurred (Sella et al., 2007). As a result of the glacial unloading, horizontal stresses are created locally in shallow bedrock in many areas of Ontario. Natural stress release features include elongated compressional ridges or pop-ups such as those described in White et al. (1973) and McFall (1993).

No detailed identification and interpretation of neotectonic structures is available in the readily-available literature for the Ignace area. It is therefore useful to review the findings of previous field studies involving fracture characterization and evolution as it may pertain to glacial unloading. McMurry et al. (2003) summarized several studies conducted in a number of plutons in the Canadian Shield and in the crystalline basement rocks in Western Ontario. These various studies found that fractures below a depth of several hundred metres in the plutonic rock were ancient features. Early-formed fractures have tended to act as stress domain boundaries. Subsequent stresses, such as those caused by plate movement or by continental glaciation, generally have been relieved by reactivation along the existing zones of weakness rather than by the formation of large new fracture zones.

In summary, no neotectonic structural features are known to occur within the Ignace area.

3.3 Seismicity

The Township of Ignace lies in the Superior Province of the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). Although Hayek et al. (2009) indicate that the general Western Superior Province has experienced a number of low magnitude, shallow seismic events, all recorded earthquakes in the Ignace area have a magnitude less than 4. Figure 3.7 presents the location of earthquakes with a magnitude greater than 3 that are known to have occurred in Canada from 1627 until 2007 and Figure 3.8 shows the locations and magnitudes of earthquakes recorded in the National Earthquake Database (NEDB) for the period between 1985 and 2010 in the Ignace area (NRC, 2010).

In summary, available literature and recorded seismic events indicate that the Ignace area is located within a region of very low seismicity: the tectonically stable northwest portion of the Superior Province of the Canadian Shield.

3.4 Quaternary Geology

Figure 3.9 illustrates the extent and type of Quaternary deposits in the Ignace area, and the location of the wells from which information on overburden thickness was obtained. The Quaternary cover in the Ignace area mostly comprises different types of glacial deposits that accumulated with the progressive retreat of the ice sheet during the end of the Wisconsinan glaciation. This period of glaciation began approximately 115,000 years ago and peaked about 21,000 years before present, at which time the glacial ice front extended south of Ontario into what is now Ohio and Indiana (Barnett et al., 1991). The northward retreat of the ice sheet in the Ignace area started approximately 12,000 years ago and progressively exposed deposits of the Eagle-Finlayson and Hartmann Moraines. Any earlier deposits in the Ignace area have been largely or entirely removed by glacial erosion which stripped away the pre-existing overburden and eroded the crystalline bedrock.

Mapping of the Quaternary geology in the Ignace area shows that southwest of the TransCanada Highway, the bedrock is either exposed or covered by a thin layer of drift (coarse, heterogeneous sediments). Northeast of the TransCanada Highway the bedrock is discontinuously covered by Quaternary sediments. These are glaciofluvial outwash deposits, glaciofluvial ice-contact deposits comprised of gravel and sand and glaciolacustrine deposits and till (Figure 3.9).

Information on the thickness of Quaternary deposits in the Ignace area was obtained from a small number of water well records along the shores of Agimak Lake and from diamond drillholes mostly concentrated southwest of Highway 17 at the periphery of the Township of Ignace (see Figure 3.9). Recorded depths to bedrock in the Township of Ignace range from 0 to 15 m, although greater thicknesses have been recorded in a few locations. The thickness of the Quaternary deposits southwest of the highway in the periphery of the Township of Ignace is typically less than 5 m.

4.0 HYDROGEOLOGY

Information concerning groundwater in the Ignace area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database. The locations of known water wells are shown on Figure 4.1. Until recently, the Township of Ignace obtained its municipal water supply from two overburden water wells which supplied the normal demands of the municipality and a third well which provided fire flows (AMO, 2008). The municipality has recently constructed an upgraded water supply system, sourcing water from a new surface water intake structure. A number of scattered wells serving individual private residences exist mostly along the shores of Agimak Lake.

Water wells in the Ignace area obtain water from the overburden or the shallow bedrock. The Ministry of the Environment water well database contains 112 discrete water well records in the Ignace area (Figure 4.1), 75 of which provided useful information regarding aquifer, yield, etc., as noted in the table below.

Table 4.1: Water Well Record Details

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[1]	38	4.5 to 42	0.3 to 12.1	9.5 to 930	N/A
Bedrock	37	6 to 154	0 to 22.5	0 to 006	0 to 22

[1] – Inferred for some records which were lacking stratigraphic descriptions

4.1 Overburden Aquifers

There are 38 water well records in the Township of Ignace that can be confidently assigned to the overburden aquifer. These wells generally are 4 to 42 m deep and have pumping rates of 9.5 L/min to 930 L/min. These well yields reflect the purpose of the wells (private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from the aquifer.

The limited number of well records and their concentration along the main roadways and Agimak Lake limits the available information regarding the extent and characteristics of the overburden aquifers in the Ignace area.

4.2 Bedrock Aquifers

No information was found on deep bedrock groundwater conditions in the Ignace area at a typical repository depth of approximately 500 m. In the Township of Ignace there are 37 well records that can be confidently assigned to the shallow bedrock aquifer. These wells range from 6 to 154 m in depth, with most wells between 20 and 40 m deep. Measured pumping rates in these wells are variable and range from 0 L/min to 206 L/min, with yields typically between 30 and 40 L/min. These well yields reflect the purpose of the wells (in many cases private residential supply with limited water demand) and do not necessarily reflect the maximum sustained yield that might be available from the shallow bedrock aquifers. Long-term groundwater yield in fractured bedrock will depend on the number and size of fractures, their connectivity, transmissivity, storage and on the recharge properties of the fracture network in the wider aquifer.

The Ministry of the Environment Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the Ignace area or anywhere else in Northern Ontario. 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 (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth (Everitt et al., 1996).

The low topographic relief of the Canadian Shield tends to result in low hydraulic gradients for groundwater movement in the shallow active region (McMurry et al., 2003). In deeper regions, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al., 1996; McMurry et al., 2003). Increased vertical and horizontal stresses at depth tend to close or prevent fractures thereby reducing permeability and resulting in diffusion-dominated groundwater movement (Stevenson et al., 1996; McMurry et al., 2003).

4.3 Hydrogeochemistry

No information on groundwater hydrogeochemistry was found for the Ignace area. Existing literature, however, has shown that groundwater within the Canadian Shield can be subdivided into two main hydrogeochemical regimes: a shallow, generally fresh water flow system, and a deep, saline water flow system (Singer and Cheng, 2002).

Gascoyne et al. (1987) investigated the saline brines found within several Precambrian plutons and identified a chemical transition at around 300 m depth marked by a uniform, rapid rise in total dissolved solids and chloride. This was attributed to advective mixing at above 300 m, with a shift to diffusion-controlled flow below that depth. It was noted that major fracture zones within the bedrock can, where present, extend the influence of advective processes to greater depths.

In the deeper regions, where groundwater transport in unfractured or sparsely fractured rock tends to be very slow, long residence times on the order of a million years or more have been reported (Gascoyne, 2000; 2004). Groundwater research carried out in AECL's Whiteshell Underground Rock Laboratory (URL) in Manitoba found that crystalline rocks from depths of 300 to 1,000 m have total dissolved solids (TDS) values ranging from 3 to 90 g/L (Gascoyne et al. 1987; Gascoyne 2000; 2004). However, total dissolved solids exceeding 250 g/L have been reported in some regions of the Canadian Shield at depths below 500 m (Frape et al., 1984).

5.0 ECONOMIC GEOLOGY

5.1 Petroleum Resources

The Township of Ignace is located in a crystalline geological setting where the potential for petroleum resources is negligible and where no hydrocarbon production or exploration activities are known to occur.

5.2 Metallic Mineral Resources

In the Township of Ignace there is no record of metallic mineral production in the past and no exploration potential for metallic minerals has been identified within the township boundaries. The periphery of the Township of Ignace, however, has seen past production of metallic resources and exploration potential for different metals has been recognized. The Ignace area is part of the Kenora Mining District, where mining history is closely related to the exploration for gold, which was produced in the past at a number of mines. Figure 5.1 shows the areas of active exploration interest based on active mining claims, as well as known mineral occurrences identified in the Ontario Geological Survey's Mineral Deposit Inventory Version 2 (OGS, 2004).

Metallic mineralization occurrences in the Ignace area include: rare metals and radioactive element-enriched pegmatites; iron formations; cobalt-copper-nickel-platinum group metals; and gold.

Gold, Iron and Base Metals

There are currently no producing mines in the Ignace area. The potential for economically exploitable mineralization remains, however. Gold, iron and base metals exploration activities in the Ignace area date from the late 1800's and have continued sporadically to date, with most exploration efforts focusing on the Raleigh Lake and Bending Lake Greenstone Belts. As noted on Figure 5.1, the nearest metallic mineral occurrences are in the Raleigh Lake Greenstone Belt to the immediate south and west of the Township of Ignace.

The Sakoose Mine, 45 km northwest of the Township of Ignace, intermittently produced gold and associated base metals from 1899 to 1947 down to a total depth of approximately 60 m. Gold was produced from a quartz vein system at a mafic volcanic/metasediment contact, intruded by a felsic dike. During this period, the mine produced a total of 3,669 ounces of gold, at an average grade of 0.41 ounces/ton (Titan Resources International Corporation, 2010).

In 1935 minor gold and silver production also occurred at the Tabor Lake Mine (45 km northwest of the Township of Ignace), which contains non NI43-101 compliant indicated reserves of 50,000 tons at 0.50 ounces Au/ton (Norontex Exploration Ltd., 1983). These gold deposits are found in the metavolcanic rocks along the northwestern contact of the Revell Batholith. Gold-bearing quartz veins here are controlled by northeast-trending shear and fracture zones associated with a major northeast-trending deformation zone that extends across Melgund Township (Parker, 1989). Exploration efforts have intensified in recent years and a 2008 drilling program by King's Bay Gold identified new gold zones below and to the east of the old Sakoose mine. Exploration by companies, such as Titan Resources International and Laurentian Goldfields, continues along this mineralized shear zone in the greenstone belt.

Gold potential has also been identified in association with a northwest-trending shear zone that extends northwest of Raleigh Lake within the greenstone belt. In 2008, Amador Gold Corp. acquired eight exploration claims in the Revell and Hyndman townships about 30 to 35 km northwest of the Township of Ignace to assess the gold and base metal potential of the area (Amador Gold Corp., 2008).

Gold, base metals, molybdenum, and platinum group element (PGE) occurrences have been reported in the greenstone “slivers” south of Agimak Lake and exploration efforts in the area continue today (MNDM, 2009).

In the Bonheur area, to the southwest of the Township of Ignace, pyrite mineralization has been identified in gossan zones of gneissic metavolcanic rocks, which probably represent thin metamorphosed iron formation beds. Greenschist alteration mineralized with gold is characteristic of the Marmion Fault in the Atikokan area. In the Bonheur area, the extension of this same fault is underexplored and offers a new exploration target for gold (Stone and Hall, 1999).

The Bending Lake Greenstone Belt has the potential to host iron, base metals and gold deposits. In the Bending Lake area an iron formation was investigated by Jalore Mining Co., Algoma Steel Ltd. and Steep Rock Iron Mines Ltd. during the 1950's and 1970's. Currently, the iron deposit is being explored by Bending lake Iron Group Ltd., which has estimated 249 Million tons of iron ore assuming an average grade of 28% iron. In the company's property, five mineral showings (Cu, Zn or Au) related to volcanogenic massive sulphides (VMS) have also been identified (Stone, 2009b).

Base metal potential exists in the volcanic rocks in the Bending Lake area, where a garnet-bearing alteration zone with characteristics typical of volcanogenic massive sulphide environments has been identified. In the 1990's Noranda Ltd. carried out extensive exploration for base metals in the area (Stone, 2009b).

Uranium

No economic deposits of uranium have been identified in the Ignace area.

Rare Metals

Rare metals mineralization has been reported in the pegmatitic dikes of the Raleigh Lake Pegmatite field, 15 km west of the Township of Ignace (Pedersen, 1999). Previous exploration in the area by Breaks and Bond (1993) led to findings of spodumene and beryl. Abaddon Resources Inc. is currently actively exploring lithium and rare metals pegmatite dikes in the volcanic rocks flanking the Raleigh Lake granite intrusion; previous and current drilling work in the property has confirmed the existence and extension of the mineralization. Other companies, such as King's Bay Gold Corp. and Mainstream Minerals Corp. are also exploring pegmatite dikes in the Raleigh Lake area. Additionally, two-mica granite on the northeast side of the Revell Batholith and the metasedimentary rocks at Balmoral Lake provide favourable environments for rare metals mineralization (Stone et al., 1998).

5.3 Non-Metallic Mineral Resources

Known non-metallic mineral resources in the Ignace area include sand and gravel, stone, and peat. During the first half of the twentieth century a number of non-metallic deposits were developed from the Indian Lake and Revell Batholiths both in the Township of Ignace and in its periphery, as described below.

The Indian Lake Batholith has been the site of periodic extraction of ornamental stone at four quarries from 1888 until 1952. The Bannerman & Horne Quarry, and the Gummeson deposit and Horne Granite Quarries extracted granite along the TransCanada Highway within the Township of Ignace. In the Bonheur area, 22 km southeast of the Township of Ignace, the Bonheur Quarry operated prior to 1932. In the Revell Batholith, a small quarry of unknown history exists at the intersection of Highway 17 and Basket Lake Road. Potential was also recognized in the Twin River Road prospect, 55 km west of the Township of Ignace, but no production is known from it (Brisbin et al., 2005; Storey, 1986; Farrow, 1996; Hinz et al., 1994; Gerow and Bellinger, 1990).

In 1984 the Proctor and Redfern Group Ltd, on behalf of the Ontario Geological Survey, carried out an evaluation of a number of peatlands in the Ignace area. Some of the examined peatlands showed potential for supporting conventional peat operations, with peat quality excellent for horticultural applications. Despite the commercial potential of some of these deposits in the Ignace area, no peat extraction is known to have occurred (The Proctor and Redfern Group Ltd., 1984).

No kimberlites or lamproites that could be diamond bearing have been identified in the Ignace area, although the potential for the Canadian Shield to host economic diamond deposits has been demonstrated by a number of mines in the Northwest Territories and Ontario.

6.0 INITIAL SCREENING EVALUATION

This section provides an evaluation of each of the five initial screening criteria (NWMO, 2010) for the Ignace area based on the readily-available information presented in Sections 2 to 5. The intent of this evaluation is not to conduct a detailed analysis of all available information or identify specific potentially suitable sites, but rather to identify any obvious conditions that would exclude the Township of Ignace from further consideration in the site evaluation process.

Initial screening criteria (NWMO, 2010) require that:

1) The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

2) This available land must be outside of protected areas, heritage sites, provincial parks and national parks.

3) This available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

4) This available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.

5) This available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the outlined safety factors in Section 6 of the site selection document (NWMO, 2010).

For cases where readily-available information is limited and where the assessment of some of the criteria is not possible at the initial screening stage, the area would be advanced to the feasibility study stage for more detailed evaluation, provided the community remains interested in continuing to participate in the siting process.

6.1 Screening Criterion 1: Land Availability

The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

Surface facilities associated with the deep geological repository will require a surface land parcel of about 1 km by 1 km (100 ha) in size, although some additional space may be required to satisfy regulatory requirements. The underground footprint of the repository is about 1.5 km by 2.5 km (375 ha) at a typical depth of about 500 m.

This criterion was evaluated by assessing whether the Ignace area contains parcels of land that are large enough to accommodate the surface facilities and whether there is a sufficient volume of rock at depth to accommodate the underground facilities. The available land areas should be accessible for the construction of surface facilities and for the various field investigations that are necessary to characterize the rock volume required to accommodate the footprint of the repository (e.g. drilling of boreholes).

Availability of land was assessed by identifying areas where surface facilities are unlikely to be built due to constraints such as the presence of natural features (e.g. large water bodies, topographic constraints), land use (e.g. developed areas, infrastructure), accessibility and construction challenges based on the information presented in Section 2.

Review of available mapping and satellite imagery shows that the Township of Ignace contains limited constraints that would prevent the development of the repository's surface facilities (Figures 2.2 and 6.1). These would mainly include permanent water bodies such as Agimak Lake, Michel Lake, Fox Lake and portions of Osaquan Lake, which account for approximately 25% of the area of the Township of Ignace. Also, a very small portion of the Township of Ignace is covered by residential and industrial infrastructure, with developments limited mainly to roadways and the settlement area itself (Figure 6.1). The remainder of the Township of Ignace is largely forested. The areas at the periphery of the Township of Ignace are also largely undeveloped, with limited natural or physical constraints such as major infrastructure or permanent water bodies. Therefore, the Ignace area contains sufficient land to potentially accommodate the repository surface facilities.

As discussed in Section 2, topography is variable across the Ignace area. However, no obvious topographic features that would prevent construction and characterization activities have been identified. Most of the Ignace area could be accessed from the two main roads: TransCanada Highway (Highway 17) and Highway 599 (Figure 6.1).

As discussed in Section 6.5, readily-available information suggests that the Ignace area has the potential of containing sufficient volumes of host rock to accommodate underground facilities associated with a deep geological repository. This would have to be confirmed in subsequent site evaluation stages.

Based on the review of readily available information, the Ignace area contains sufficient land to accommodate the repository's surface and underground facilities.

6.2 Screening Criterion 2: Protected Areas

Available land must be outside of protected areas, heritage sites, provincial parks and national parks.

The assessment of this criterion is needed to assure that the remaining available land, after excluding protected areas, is large enough to allow for the construction of the repository's facilities. For the purpose of this initial assessment protected areas are considered to be ecologically sensitive or significant areas, as defined by provincial or federal authorities.

The Ignace area was screened for federal, provincial and municipal parks, conservation areas, nature reserves, national wildlife areas and archaeological and historic sites using available data from the Ontario Ministry of Natural Resources (Land Information Ontario) and the Ontario Ministry of Tourism and Culture.

With reference to Figure 2.1 and Figure 6.1, there are no known protected areas within the Township of Ignace with the exception of a small (less than 1 km^2) section of the Sandbar Lake Provincial Park in the northeast corner of the Township. As shown in Figure 6.1 there are three other Provincial Parks and two conservation reserves in the Ignace area. These protected areas occupy a small portion of the land within the Township of Ignace and its periphery.

As discussed in Section 2.4, most of the land in the Ignace area is free of known heritage constraints. Known archaeological sites are small and generally concentrated around Agimak Lake and some lakes and rivers mainly to the north of the Township of Ignace (Figure 2.1). There are no National Historic Sites in the Ignace area.

The absence of locally protected areas would need to be confirmed in discussion with the community and Aboriginal peoples in the area during subsequent site evaluation stages if the community remains interested in continuing with the site selection process.

Based on the review of readily available information, the Ignace area contains sufficient land outside of protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities.

6.3 Screening Criterion 3: Known Groundwater Resources at Repository Depth

Available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

In order to minimize the future risk of human intrusion during the long post-closure period, the repository should be sited in a host rock formation that does not contain significant groundwater resources at repository depth (typically 500 m) that may encourage future generations to access those resources and potentially compromise the long-term performance of the repository.

The review of available information did not identify any known groundwater resources at repository depth for the Ignace area. As discussed in Section 4.2, the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database shows that all water wells known in the Ignace area obtain water from overburden or shallow bedrock sources at depths ranging from 4 to 154 m, with most wells between 4 to 40 m deep.

Experience from other areas in the Canadian Shield has shown that active groundwater flow is generally confined to shallow fractured localized systems (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth (Everitt et al., 1996). In deeper regions, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al. 1996; McMurry et al., 2003).

MOE Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the Ignace area or anywhere else in Northern Ontario. Groundwater at such depths is generally saline and very low groundwater recharge at such depths limits the potential yield, even if suitable water quality were to be found. The absence of groundwater resources at repository depth in the Ignace area would, however, need to be confirmed during subsequent site evaluation stages if the community remains interested in continuing with the site selection process.

The review of available information did not identify any known groundwater resources at repository depth for the Ignace area. Experience in similar geological settings suggests that the potential for deep groundwater resources at repository depths is low throughout the Ignace area. The absence of groundwater resources at repository depth would need to be confirmed during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

6.4 Screening Criterion 4: Known Natural Resources

Available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.

As with the assessment of groundwater resources, the need to minimize the risk of future human intrusion requires that the repository be sited in a host rock formation having a low potential for economically exploitable natural resources. Readily-available information on past and potential future occurrence for natural resources such as oil and gas and metallic and non-metallic mineral resources was reviewed in Section 5.

The review indicates that there is no evidence of past or present exploration or development activities associated with oil and gas resources. Given the geological setting (i.e. Canadian Shield), the potential for activities associated with these resources in the Ignace area is negligible.

There are currently no operating mines or quarries within the Township of Ignace. There has not been any production of metallic minerals in the past within the Township of Ignace and the potential for such resources remains low. In the periphery of the Township of Ignace, metallic mineral potential is limited to the metavolcanic and metasedimentary rocks of the Raleigh and Bending Lake Greenstone Belts. While there are currently no producing mines in the area, exploration efforts continue today. No metallic mineralization has been identified to date in the granitic intrusions in the Ignace area.

The Ignace area is known for its past exploitation of and potential for (non-metallic) industrial stone, such as granite, at specific locations in the Indian Lake and Revell Batholiths. However, the risk that these resources pose for future human intrusion is negligible, as quarrying operations for granite would be limited to very shallow depths. Commercial potential for peat exists in some low-lying areas but no peat extraction has occurred in the Ignace area (Figure 5.1). In summary, in the Ignace area the potential for natural resources is limited and mostly associated with the greenstone belts outside of the granitic intrusions.

Based on the review of readily-available information, the Ignace area contains sufficient land, free of known economically exploitable natural resources, to accommodate the required repository facilities. The absence of natural resources would need to be confirmed during subsequent site evaluation stages if the community remains interested in continuing with the site selection process.

6.5 Screening Criterion 5: Unsafe Geological or Hydrogeological Features

Available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the outlined safety factors in Section 6 of the site selection document (NWMO, 2010).

The site should not be located in an area of known geological or hydrogeological features that would make the site unsafe, as per the following five geoscientific safety-related factors identified in the site selection process (NWMO, 2010):

1) <u>Safe containment and isolation of used nuclear fuel</u>. Are the characteristics of the rock at the site

appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances?

2) Long-term resilience to future geological processes and climate change. Is the rock formation at the site geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially affected by natural disturbances and events such as earthquakes and climate change?

3) Safe construction, operation and closure of the repository. Are conditions at the site suitable for the safe construction, operation and closure of the repository?

4) Isolation of used fuel from future human activities. Is human intrusion at the site unlikely, for instance, through future exploration or mining?

5) Amenable to site characterization and data interpretation activities. Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

At this early stage of the site evaluation process, where limited data at repository depth exist, the five safety-related geoscientific factors are assessed using readily-available information, with the objective of identifying any obvious unfavourable hydrogeological and geological conditions that would exclude the Township of Ignace from further consideration. These factors would be gradually assessed in more detail as the site evaluation process progresses and more site specific data is collected during subsequent site evaluation phases, provided the community remains interested in continuing with the site selection process.

As discussed below, the review of readily-available geoscientific information did not identify any obvious geological or hydrogeological characteristics that would exclude the Township of Ignace from further consideration in the site selection process at this stage.

Safe Containment and Isolation

The geological and hydrogeological conditions of a suitable site should promote long-term containment and isolation of used nuclear fuel and retard the movement of any potentially released radioactive material. This requires that the repository be located at a sufficient depth, typically around 500 m, in a sufficient rock volume with characteristics that limit groundwater movement.

Readily-available information on the local and regional geology and hydrogeology was reviewed in Sections 3 and 4, respectively. The Township of Ignace is underlain by the Indian Lake Batholith, which is one of several massive granitic intrusions that dominate the geology in the Ignace area (Figure 3.3). Two other intrusions, the White Otter Lake and the Revell Batholiths, lie to the south and west of the Township of Ignace, respectively. These batholiths have intruded the older metamorphosed volcanic rocks of the Raleigh Lake and Bending Lake Greenstone Belts. There are other smaller-scale plutons in the Ignace area, such as the Paddy Lake and Islet Plutons.

The granitic Indian Lake Batholith extends significantly beyond the boundaries of the Township of Ignace mainly to the north and northeast. The thickness of this intrusion has been estimated to be approximately 2 km, although some uncertainty exists about the extent to which the intrusion thins out towards its western margin, where the Township of Ignace is located. The review of the Indian Lake Batholith geological characteristics indicated that it is, at surface, texturally and structurally homogeneous. Furthermore, the batholith is post-tectonic and has probably experienced limited deformation events. Therefore, the Indian Lake Batholith might be considered potentially suitable for hosting a deep geological repository, except in the area covered by the Sandbar Lake Provincial Park immediately northeast of the Township of Ignace.

At the periphery of the Township of Ignace, examples of potentially suitable host rocks include the granitic White Otter Lake and Revell Batholiths. The White Otter Lake Batholith has sufficient lateral extent and depth (estimated at 2 km) to host a repository. However, the portion of this batholith that is immediately south of the Township of Ignace would not be suitable as it is covered by the Turtle River – White Otter Lake Provincial Park and the Campus Lake Conservation Reserve. The Revell Batholith has sufficient extent to accommodate a repository, although further studies would be required to assess the thickness of this intrusion and its homogeneity at depth.

As discussed in Section 3.2.2, deformation zones in the Ignace area are mostly associated with the Raleigh Lake and Bending Lake Greenstone Belts. The closest mapped fault to the Township of Ignace is 4 km southwest and runs along the contact between two units in the Raleigh Lake Greenstone Belt. The closest regional fault is located about 34 km southeast of the Township of Ignace (Figure 3.3).

From a hydrogeologic point of view, the review of readily-available information did not reveal the existence of known deep fracture systems or deep aquifers in the Ignace area (see Section 4.2). The presence of active deep groundwater flow systems in crystalline formations is controlled by the frequency and interconnectivity of fractures at depth. Experience from other areas in the Canadian Shield, particularly for granitic intrusions (plutons and batholiths), indicates that active groundwater flow tends to be generally limited to shallow fractured systems, typically less than 300 m. In deeper rock, fractures are less common and less likely to be interconnected, leading to very slow groundwater movement with residence times that could reach a million years or more (McMurry et al., 2003; Gascoyne, 2004; 2000).

In summary, the review indicates that the Township of Ignace and its periphery contain areas with no obvious geological and hydrogeological conditions that would fail the containment and isolation requirements. This would need to be confirmed through subsequent evaluation phases. Other geoscientific characteristics that may have an impact on the containment and isolation functions of a deep geological repository such as the mineralogy of the rock, the geochemical composition of the groundwater and rock porewater, the thermal and geomechanical properties of the rock would also need to be assessed during subsequent site evaluation stages, provided the community remains interested in continuing with the site selection process.

Long-term Stability

A suitable site for hosting a repository is a site that would remain stable over the very long-term in a manner that will ensure that the performance of the repository will not be substantially altered by future geological and climate change processes, such as earthquakes or glaciation. A full assessment of this geoscientific factor requires detailed site specific data that would be typically collected and analyzed through detailed field investigations. The assessment would include understanding how the site has responded to past glaciations and geological processes and would entail a wide range of studies involving disciplines such as seismology, hydrogeology, hydrogeochemistry, paleohydrogeology and climate change.

At this early stage of the site evaluation process, the long-term stability factor is evaluated by assessing whether there is any evidence that would raise concerns about the long-term hydrogeological and geological stability of the Ignace area. As discussed below, the review of readily-available information did not reveal any obvious characteristics that would raise such concerns.

The Township of Ignace is located in the Superior Province of the Canadian Shield, where large portions of land have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). As discussed in Sections 3.1 and 3.2, no major regional faults or smaller scale local faults or shear zones have been identified within the Township of Ignace. Although fault and shear zones have been identified in the periphery of the Township of Ignace, there is no evidence to suggest that these fault zones have been tectonically active within the past 2 billion years.

The geology of the Ignace area is typical of many areas of the Canadian Shield, which has been subjected to numerous glacial cycles during the last million years. Glaciation is a significant past perturbation that could occur in the future. However, findings from studies conducted in other areas of the Canadian Shield suggest that deep crystalline formations, particularly the plutonic intrusions, have remained largely unaffected by past perturbations such as glaciation. Findings of a comprehensive paleohydrogeological study of the fractured crystalline rock at the Whiteshell Research Area, located within the Manitoba portion of the Canadian Shield (Gascoyne, 2004) indicated that the evolution of the groundwater flow system was characterized by periods of long-term hydrogeological and hydrogeochemical stability. Furthermore, there is evidence that only the upper 300 m have been affected by glaciations within the last million years. McMurry et al. (2003) summarized several studies conducted in a number of plutons in the Canadian Shield and in the crystalline basement rocks of Western Ontario. These various studies found that fractures below a depth of several hundred metres in the plutonic rock were ancient features. Subsequent geological processes such as plate movement and continental glaciation have caused reactivation of existing zones of weakness rather than the formation of large new zones of fractures.

In summary, the review did not identify any obvious geological or hydrogeological conditions that would clearly fail to meet the long-term stability requirement for a potential repository within the Township of Ignace and its periphery. As mentioned above, the long-term stability factor would need to be further assessed through detailed multidisciplinary geoscientific and climate change site investigations, if the community remains interested in continuing with the site selection process.

Potential for Human Intrusion

The site should not be located in areas where the containment and isolation functions of the repository are likely to be disrupted by future human activities such as exploration or mining. Therefore, the repository should not be located within rock formations containing exploitable groundwater resources (aquifers) at repository depth and economically exploitable natural resources and other valuable commodities as known today.

This factor has already been addressed in Sections 6.3 and 6.4, which concluded that the potential for deep groundwater resources at repository depths and known economically exploitable natural resources is low throughout the Ignace area.

Amenability to Construction and Site Characterization

The characteristics of a suitable site should be favourable for the safe construction, operation, closure and long-term performance of the repository. Beside the requirement for space discussed in Section 6.1, this requires that the strength of the host rock and in-situ stress at repository depth are such that the repository could be safely excavated, operated and closed without unacceptable rock instabilities; and that the soil cover depth over the host rock should not adversely impact repository construction and site investigation activities. Similarly, the host rock geometry and structure should be predictable and amenable to site characterization and interpretation activities.

From a constructability perspective, limited site specific information is available on the local rock strength characteristics and in-situ stresses for the Ignace area. However, there is abundant information at other locations of the Canadian Shield that could provide insight into what should be expected for the Ignace area in general. Available information suggests that crystalline rock formations within the Canadian Shield, particularly within plutonic intrusions, generally possess geomechanical characteristics that are good to very good and amenable to the type of excavation activities involved in the development of a deep geological repository for used nuclear fuel (McMurry et al., 2003; Chandler et al., 2004; Arjang and Herget, 1997; Everitt, 1999).

The review of readily available information on the bedrock geology and Quaternary geology for the Ignace area (Sections 3.2 and 3.4) did not indicate any obvious conditions which could make the rock mass difficult to characterize, although such conditions may exist in localized areas. The degree to which these factors such as geologic variability and overburden thickness might affect the characterization and data interpretation activities is unknown at this stage and would require further assessment during subsequent site evaluation stages of the site selection process, provided the community remains interested in continuing with the site selection process.

Based on the review of readily available geological and hydrogeological information, the Ignace area comprises portions of land that do not contain obvious known geological and hydrogeological conditions that would make the area unsuitable for hosting a deep geological repository.

7.0 INITIAL SCREENING FINDINGS

This report presents the results of an initial screening to assess the potential suitability of the Ignace area against five initial screening criteria using readily-available information. As per discussions between the NWMO and the Township Council, the initial screening focused on the Township of Ignace and its periphery, which are referred to as the "Ignace area". As outlined in NWMO's site selection process (NWMO, 2010), the five initial screening criteria relate to: having sufficient space to accommodate surface facilities, being outside protected areas and heritage sites, absence of known groundwater resources at repository depth, absence of known natural resources and avoiding known hydrogeologic and geologic conditions that would make an area or site unsuitable for hosting a deep geological repository.

The review of readily available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Township of Ignace from further consideration in the NWMO site selection process. The initial screening indicates that there are areas within the boundaries of the Township of Ignace that are potentially suitable for hosting a deep geological repository. The geology of these areas is dominated by the granitic Indian Lake Batholith. The review has also revealed that there are areas at the periphery of the Township of Ignace that are potentially suitable. These include the Indian Lake Batholith, as well as the White Otter Lake and Revell Batholiths. Potential suitability of these areas would need to be further assessed during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

It is important to note that at this early stage of the site evaluation process, the intent of the initial screening was not to confirm the suitability of the Ignace area, but rather to identify whether there are any obvious conditions that would exclude it from further consideration in the site selection process. Should the community of Ignace remain interested in continuing with the site selection process, several years of progressively more detailed studies would be required to confirm and demonstrate whether the Ignace area contains sites that can safely contain and isolate used nuclear fuel.

The process for identifying an informed and willing host community for a deep geological repository for Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future.

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9.0 REPORT SIGNATURE PAGE

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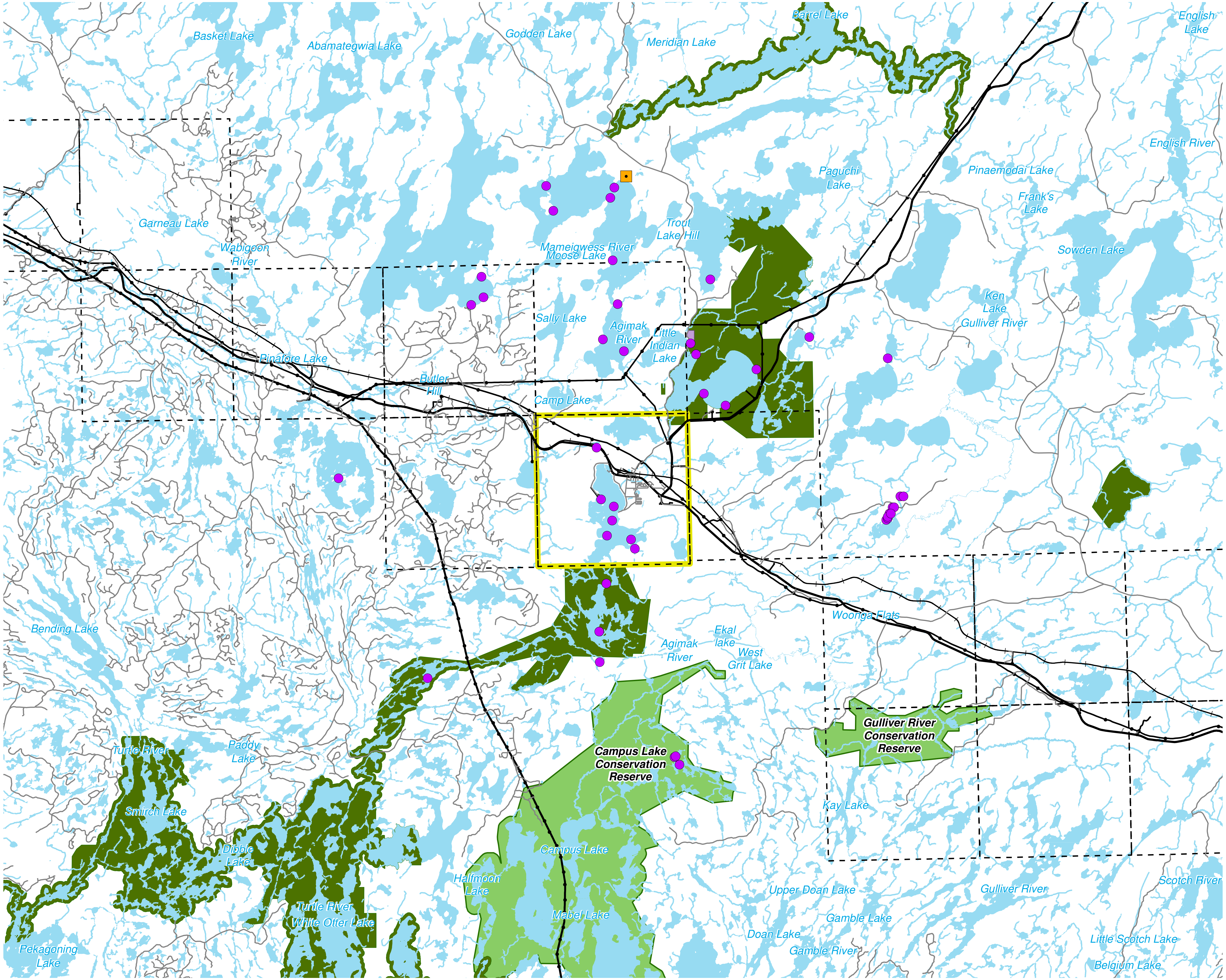
FIGURES



Basket Lake
Abamategwia Lake
Godden Lake
Meridian Lake
Barrel Lake
English Lake
English River
Garneau Lake
Wabigoon River
Paguchi Lake
Pinaemodai Lake
Frank's Lake
Trout Lake Hill
Mameigwess River
Moose Lake
Sowden Lake
Ken Lake
Gulliver River
Sally Lake
Agimak River
Little Indian Lake
Pinafore Lake
Butler Hill
Camp Lake
Woonga Flats
Bending Lake
Ekal lake
Agimak River
West Grit Lake
Gulliver River Conservation Reserve
Turtle River
Paddy Lake
Campus Lake Conservation Reserve
Smirch Lake
Kay Lake
Dibble Lake
Campus Lake
Halfmoon Lake
Upper Doan Lake
Gulliver River
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White Otter Lake
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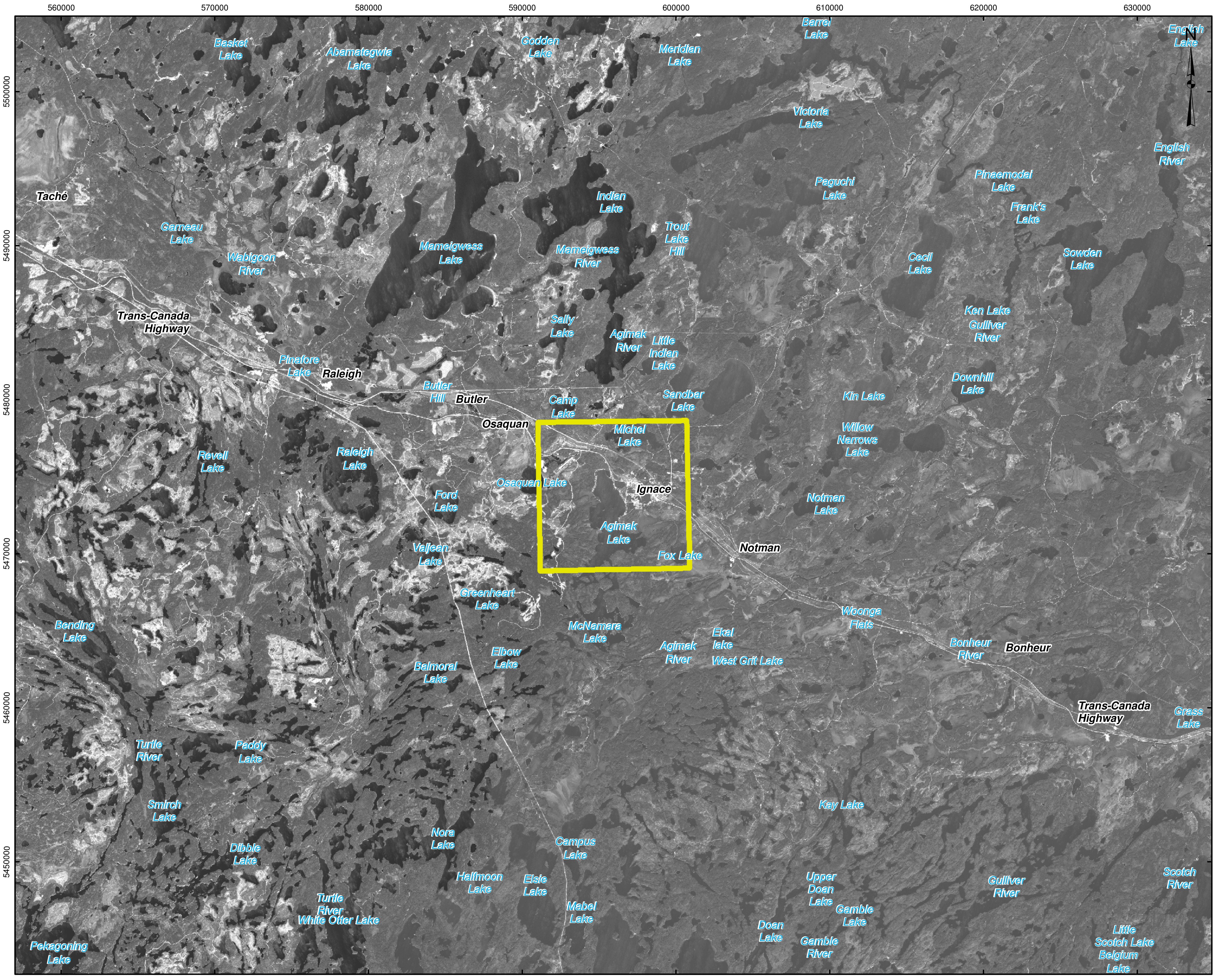
Gamble Lake
Doan Lake
Little Scotch Lake
Pekagoning Lake
Gamble River
Belgium Lake



LEGEND

Municipal Boundary (Township of Ignace)

REFERENCE

Imagery: Spot 5 , Obtained from Geobase (2006, 10m resolution)
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15
SCALE 1:250,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Satellite Imagery of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	30 Aug. 2010	**FIGURE: 2.2**	
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

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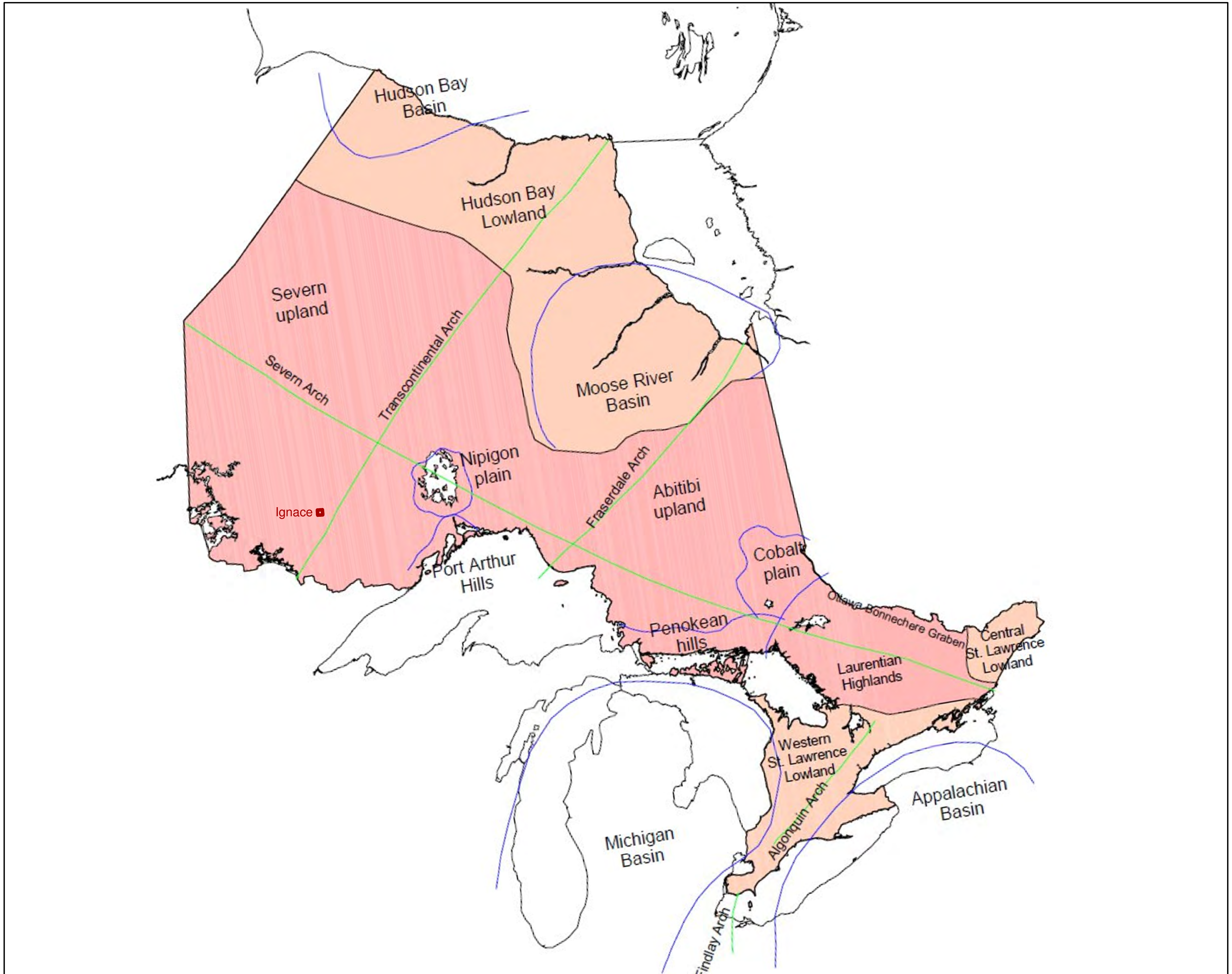

LEGEND

- Phanerozic Borderlands
- Precambrian Canadian Shield
- Township of Ignace

REFERENCE

Base Data - ESRI Digital Chart of the World, 2010
Physiography: Physiographic regions in Ontario based on Bostock (1970)
(from Thurston et al. 1991)
Projection:NA

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Physiographic Regions of Ontario

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	30 Aug. 2010	FIGURE: 2.3	
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

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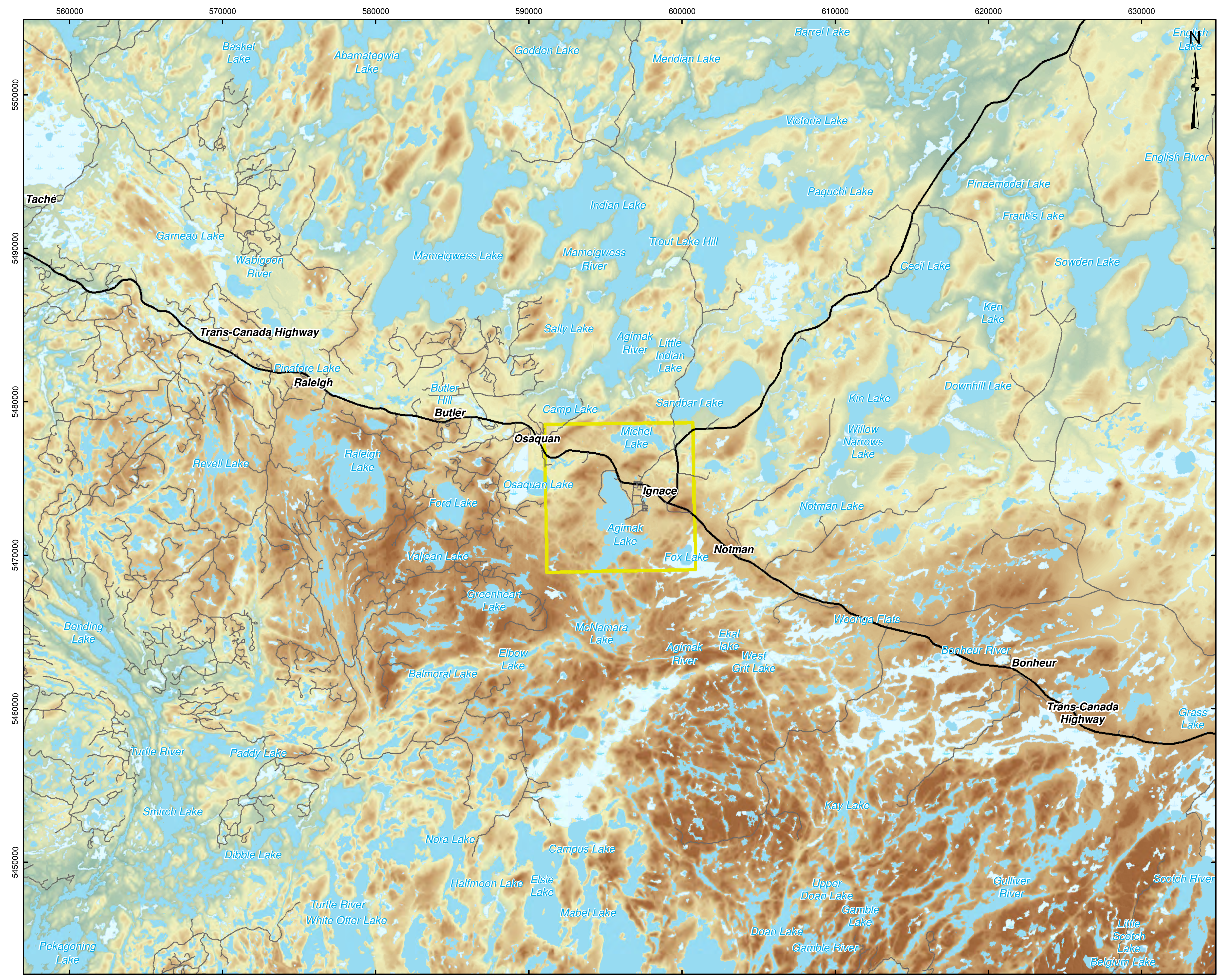

LEGEND

- Main Road
- Local Road
- Water Area, Permanent
- Wetland, Permanent
- Municipal Boundary (Township of Ignace)

Elevation (masl)

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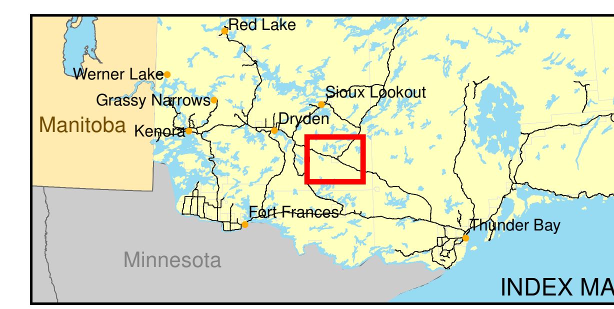
- 516.286
- 491.286
- 466.286
- 441.286
- 416.286
- 391.286



REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15

SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

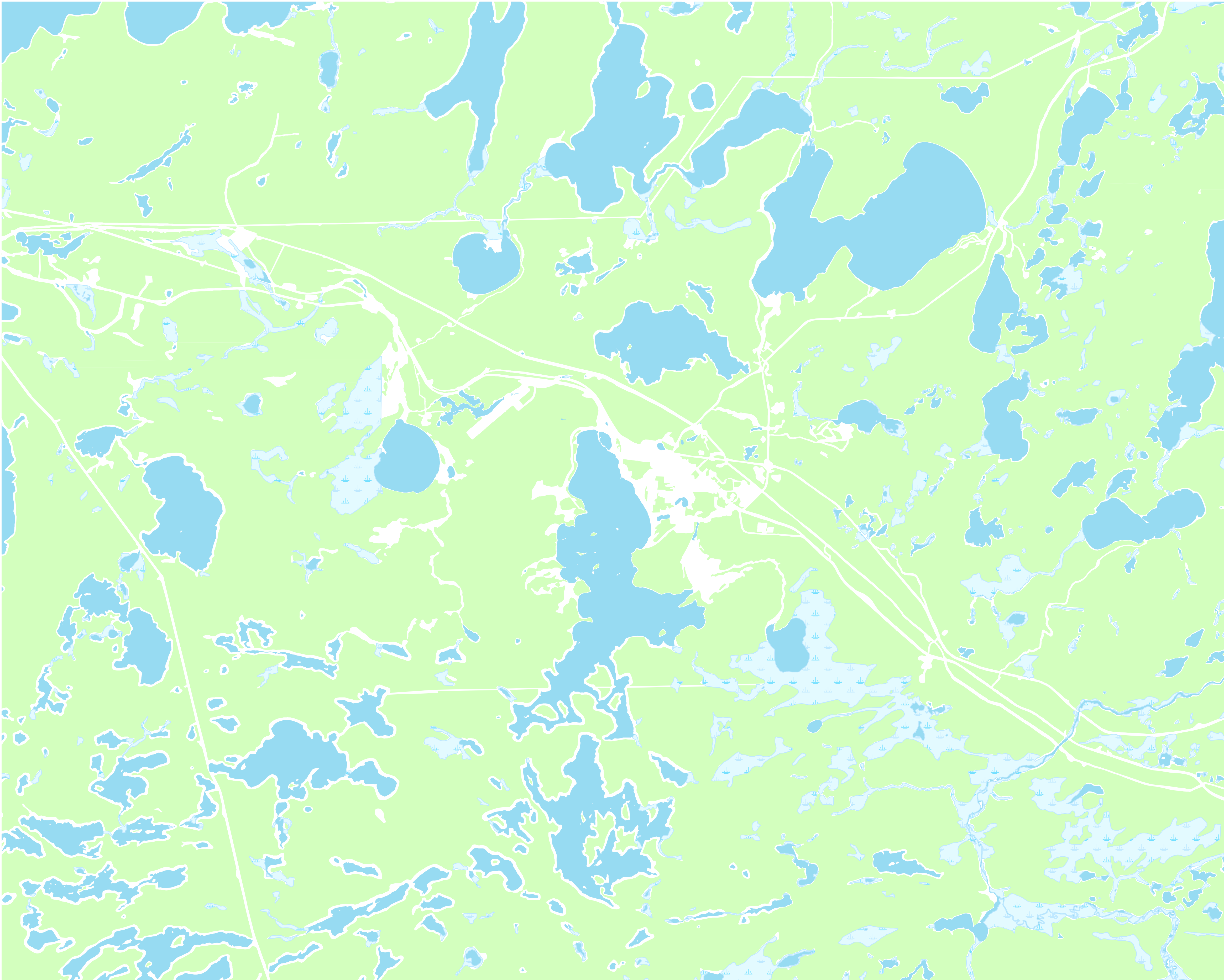
TITLE

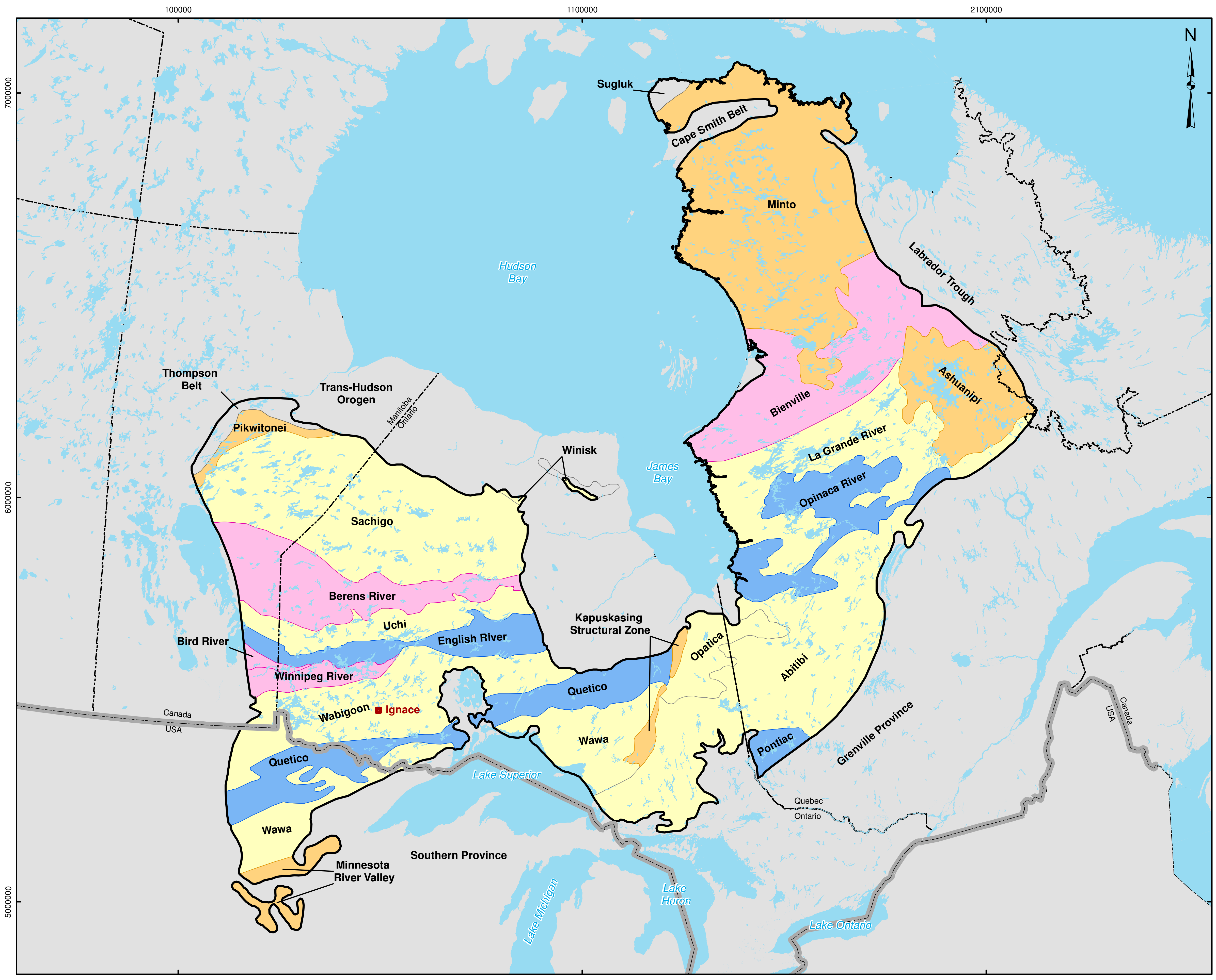
Digital Elevation Model (DEM) of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	30 Aug. 2010	FIGURE: 2.4	
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

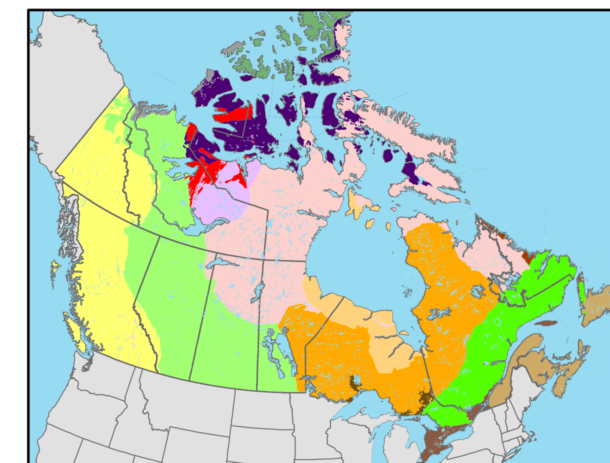
G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\DigitalElevationModelIgnace.mxd





LEGEND

- Provincial Boundary
- International Boundary
- Limit of Exposed Archean Rock
- Township of Ignace



Geological Regions of Canada

Appalachian Orogen	Cordilleran Orogen	Pacific Continental Shelf
Arctic Continental Shelf	Grenville Province	Slave Province
Arctic Platform	Hudson Bay Lowlands	Southern Province
Atlantic Continental Shelf	Innuitian Orogen	St. Lawrence Platform
Bear Province	Interior Platform	Superior Province
Churchill Province	Nain Province	Oceanic crust

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Physiographic Regions of Ontario - Thurston, P. C. 1991 Geology of Ontario: Introduction in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, p.26-57
Geology: Geological Map of Canada 1996, Map D1860A
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

200 100 0 200 400
SCALE 1:9,500,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

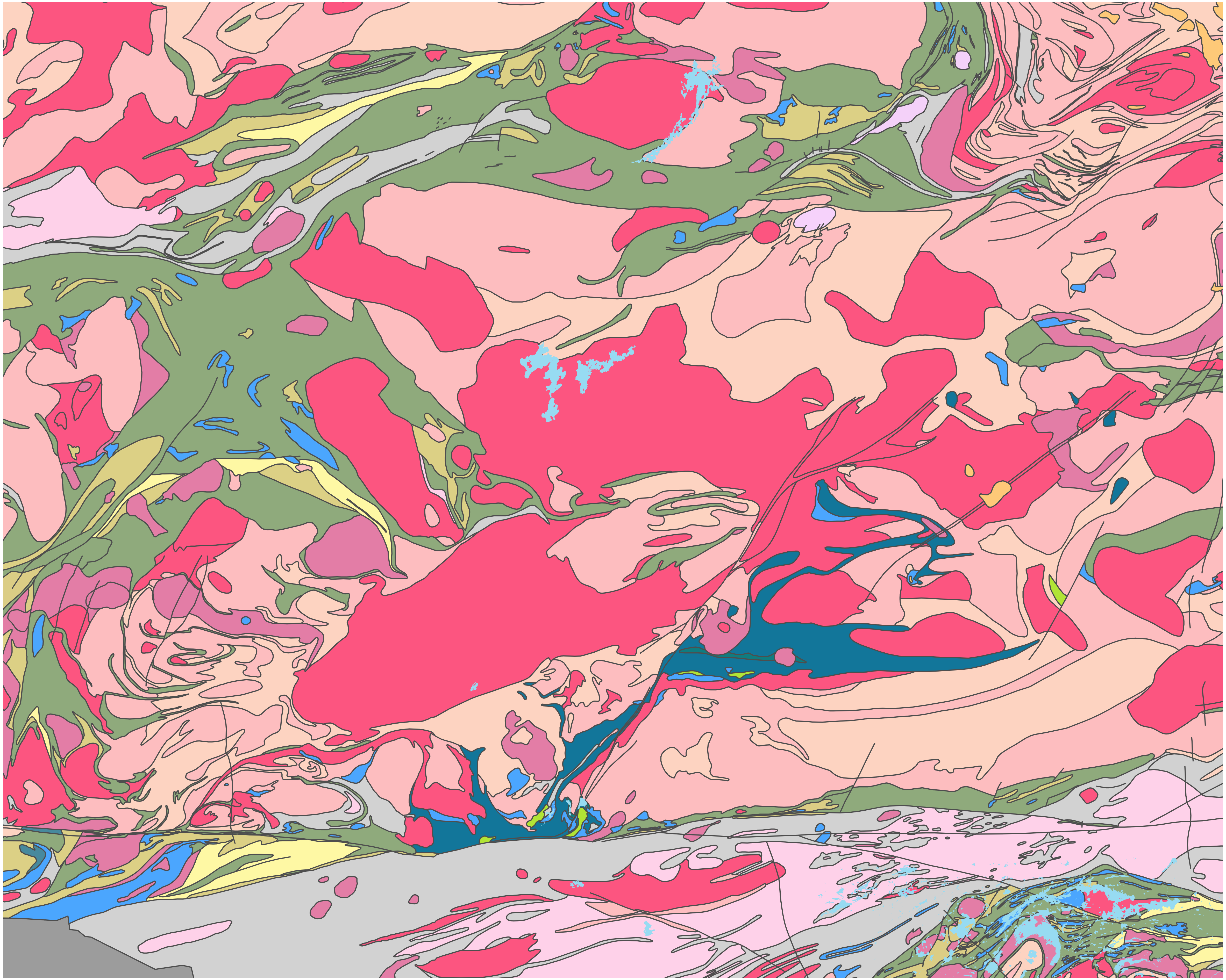
TITLE

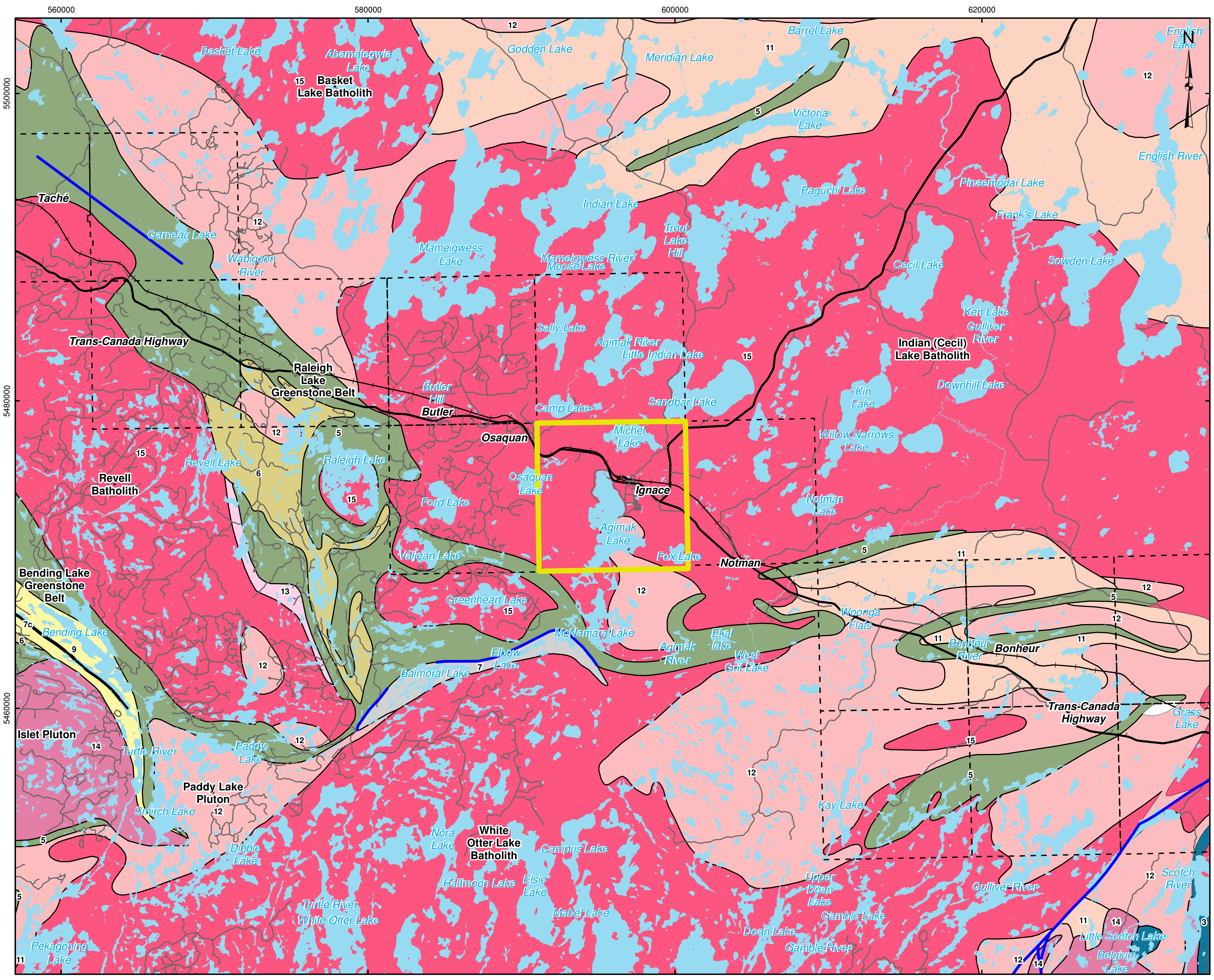
Subdivision of the Superior Province of the Canadian Shield

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	30 Aug. 2010	**FIGURE: 3.1**	
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\SubdivisionSuperiorProvinceCanadianShield.mxd





LEGEND

- Main Road
- Local Road
- Railway
- Water Area, Permanent
- Geographic Township
- Geological Fault
- Geological Contact
- Iron Formation
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 2 Felsic to intermediate metavolcanic rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks
- Municipal Boundary (Township of Ignace)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Geology: MRD126-Bedrock Geology of Ontario, 2007
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15

SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

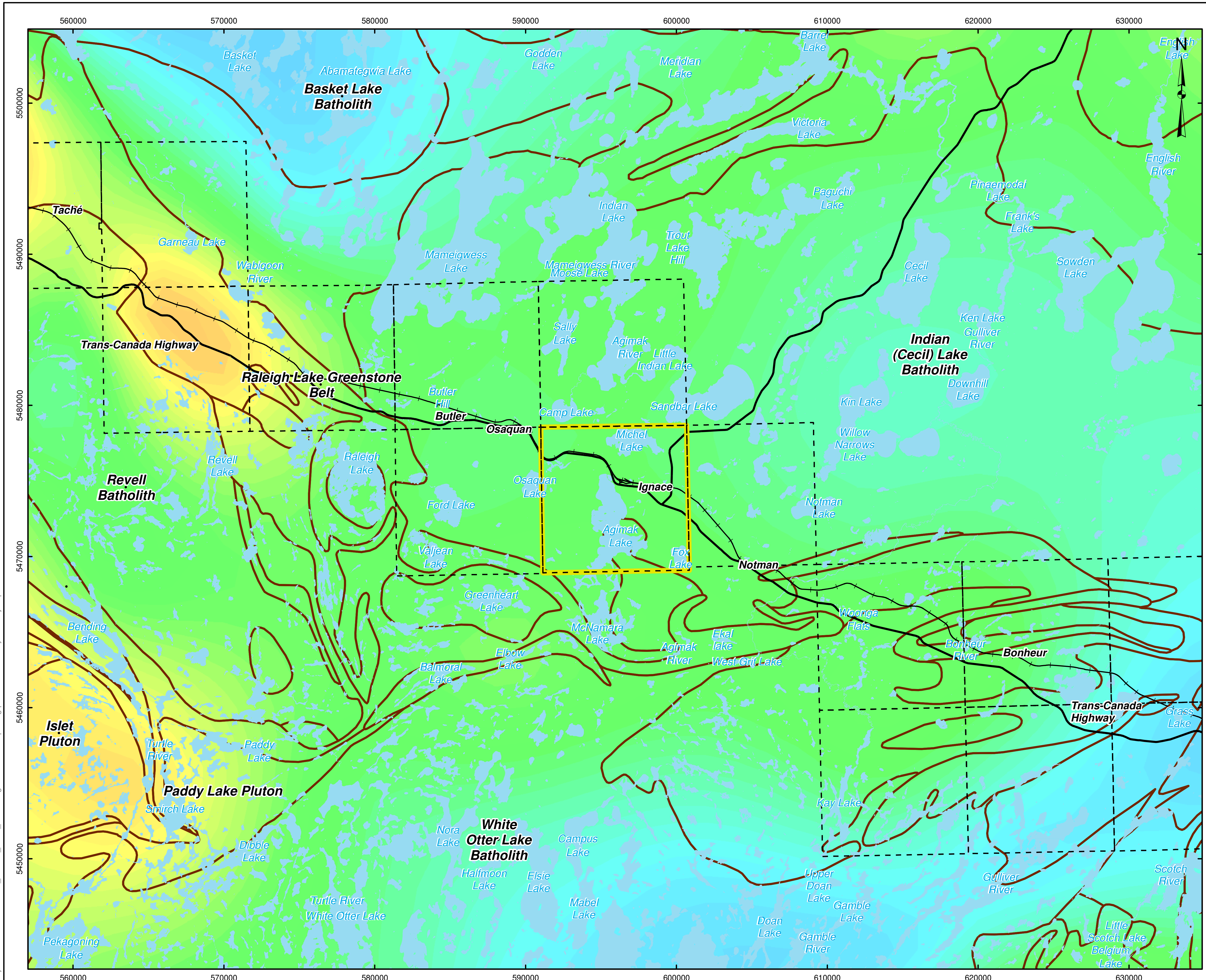
Bedrock Geology of the Ignace Area

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

Golder Associates
Mississauga, Ontario

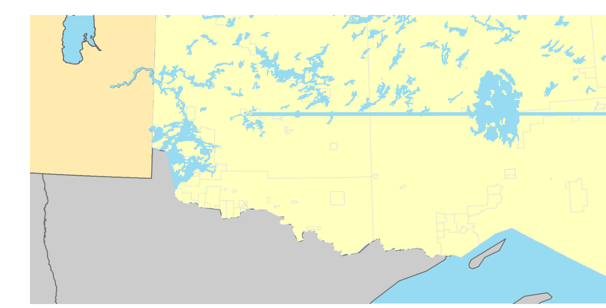
FIGURE: 3.3

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\BedrockGeology.mxd



G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\GravityAnomalyMap.mxd

LEGEND



Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geophysics: GSC Canada - 2km resolution - Gravity Anomalies, 2010;
Canadian Aeromagnetic Data Base,Airborne Geophysics Section, GSC - Central Canada
Division,Geological Survey of Canada,Earth Sciences Sector,Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario, 2007
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

PROJECT

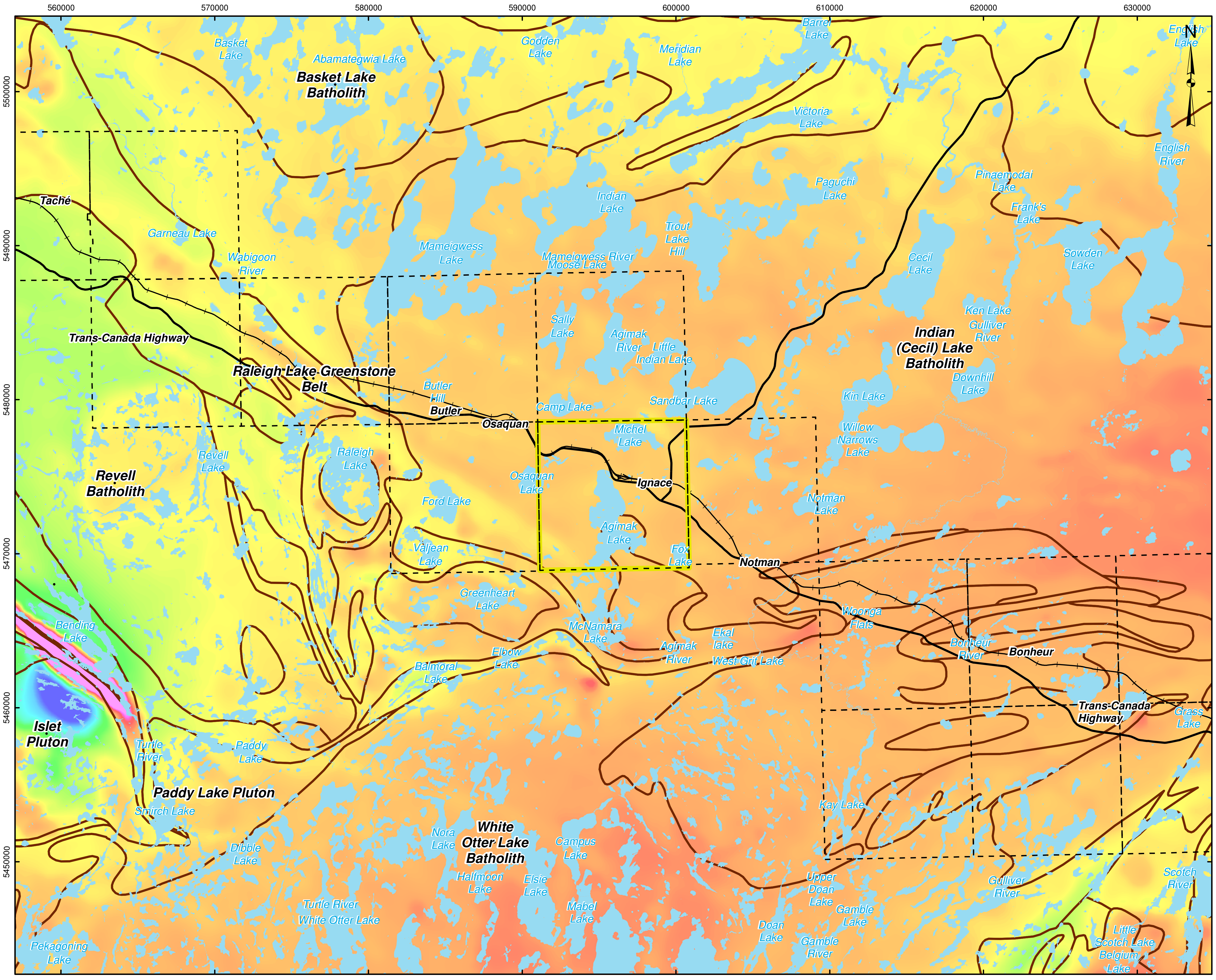
NWMO Desktop Level Initial Screening

TITLE

Gravity Map of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010	**FIGURE: 3.4**	
GIS	PRM	25 Feb. 2011		
CHECK	JF	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		



LEGEND

- Main Road
- Railway
- Water Area, Permanent
- Geological Contact
- Geographic Township
- Municipal Boundary (Township of Ignace)

Residual Total Magnetic Field (nT)

1000, 900, 800, 700, 600, 500, 400, 300, 200, 100, 0, -100, -200, -300, -400, -500, -600, -700, -800, -900, -1000

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geophysics: GSC Canada - 200m - Magnetic - Residual Total Field, 2008;
Canadian Aeromagnetic Data Base,Airborne Geophysics Section, GSC - Central Canada
Division,Geological Survey of Canada,Earth Sciences Sector,Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario, 2007
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15

SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

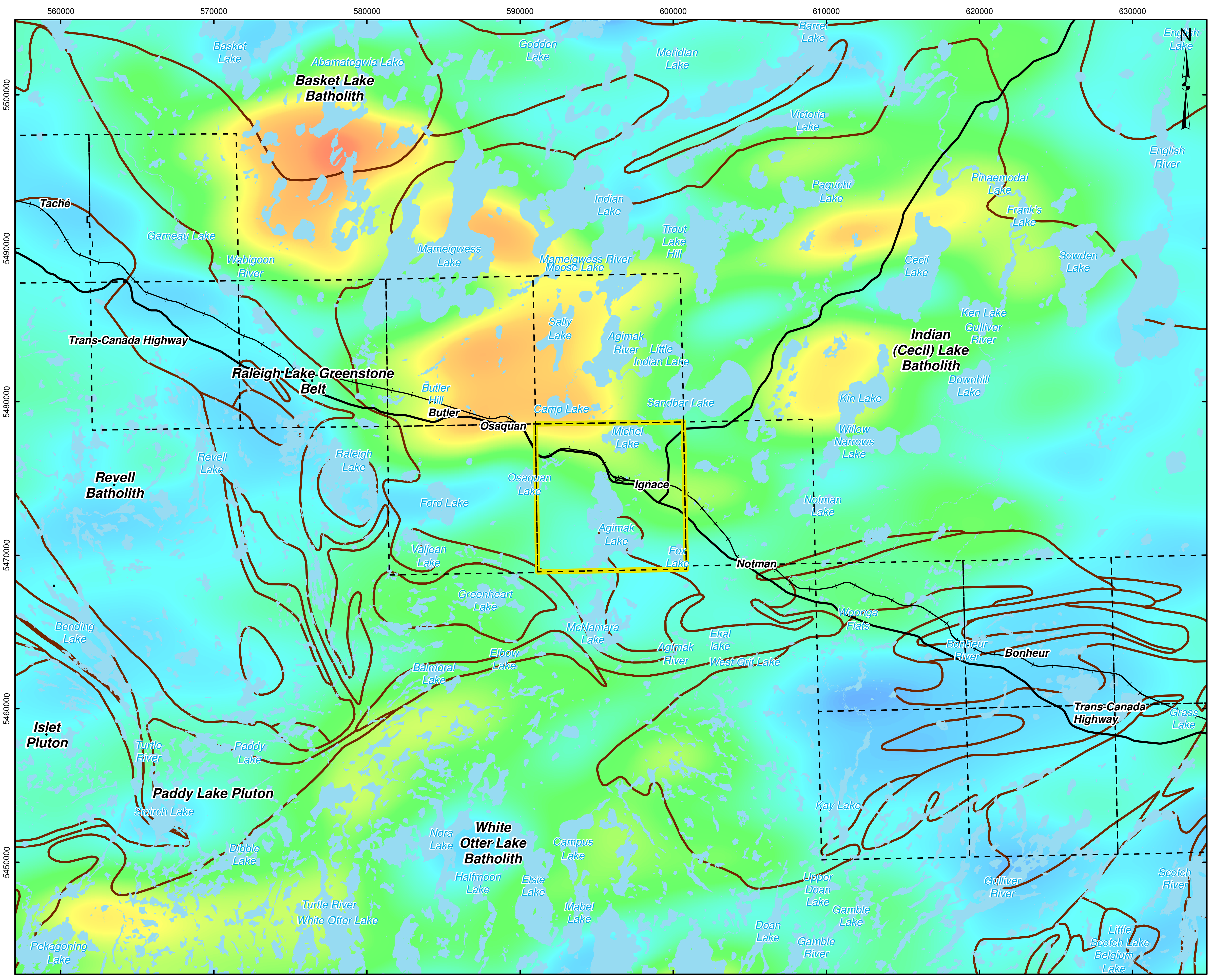
Residual Total Magnetic Field of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

FIGURE: 3.5

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\ResidualMagneticTotalField.mxd



LEGEND

- Main Road
- Railway
- Water Area, Permanent
- Geological Contact
- Geographic Township
- Municipal Boundary (Township of Ignace)

Equivalent Uranium (ppm)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Radiometrics: GSC Canada - 250m -Equivalent Uranium, 2010;
National Gamma-Ray Spectrometry Program Data Base, Airborne Geophysics Section,GSC -
Central Canada Division, Geological Survey of Canada, Earth Sciences Sector,Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario, 2007
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15

SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

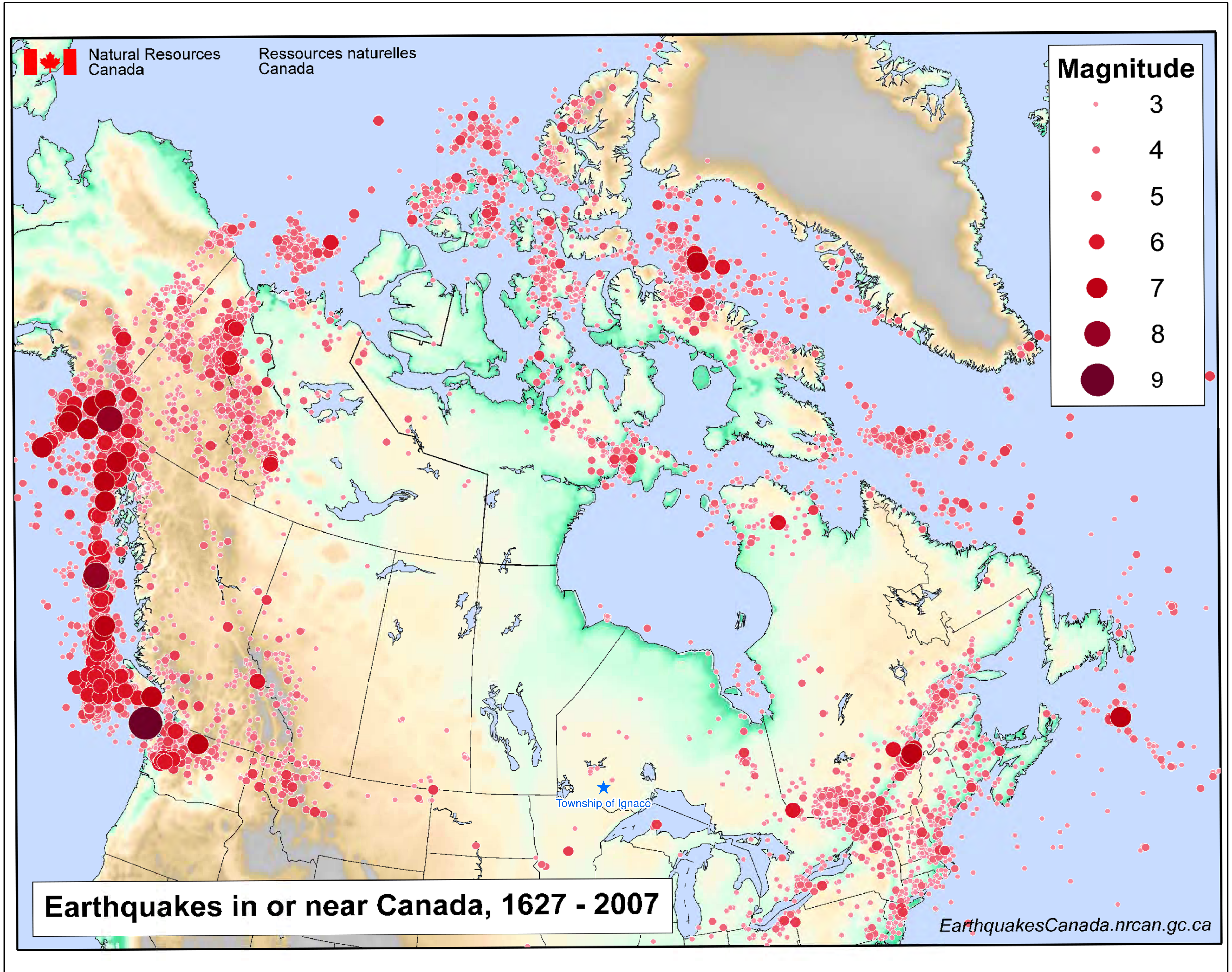
TITLE

Equivalent Uranium of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010	**FIGURE: 3.6**	
GIS	PRM	25 Feb. 2011		
CHECK	JF	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\EquivalentUranium.mxd



LEGEND

★ Township of Ignace

REFERENCE

Base Data - ESRI Digital Chart of the World,2010
Seismic: NRCAN, Earthquake Map of Canada 1627-2007
Projection:NA

PROJECT

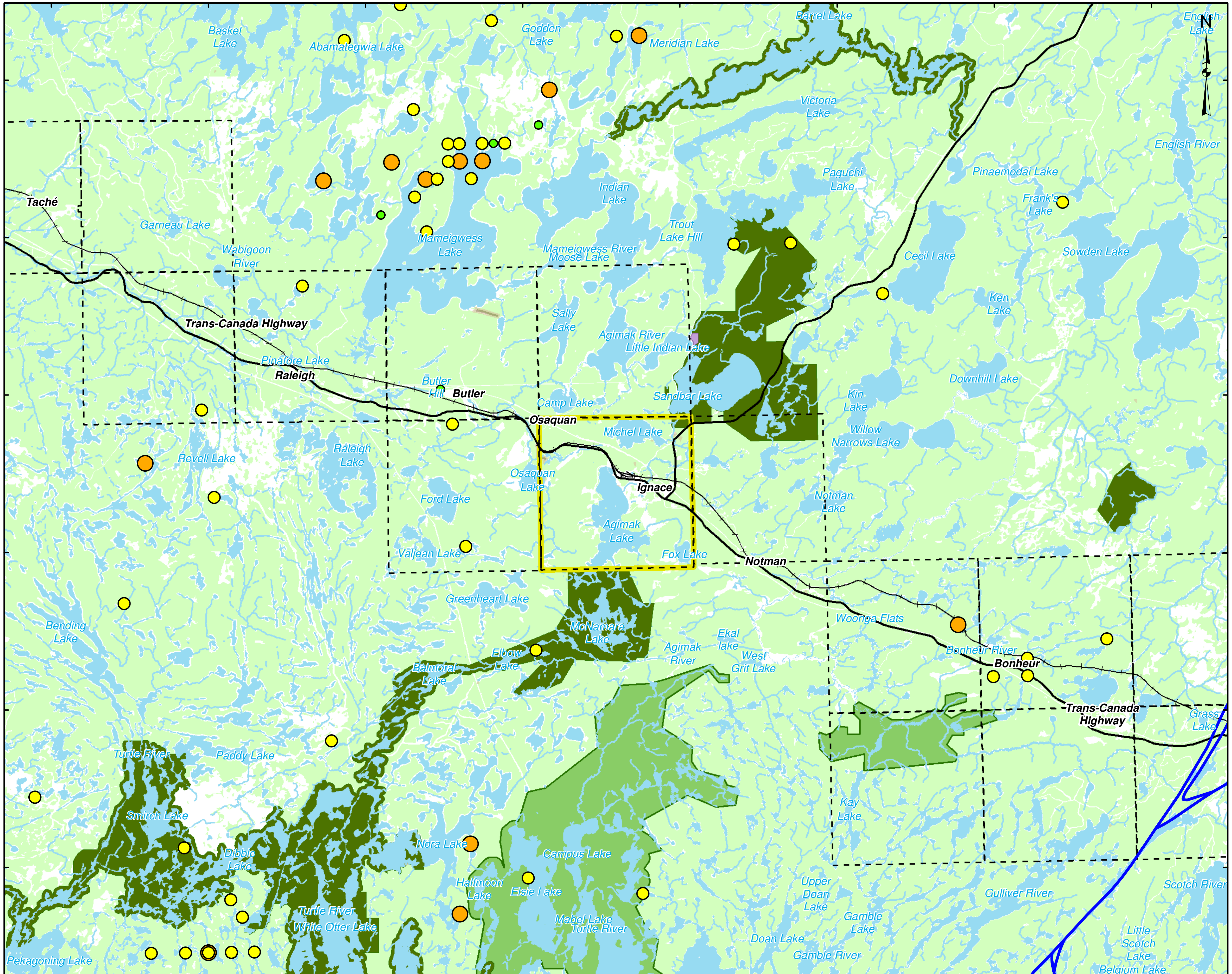
NWMO Desktop Level Initial Screening

TITLE

Earthquakes Map of Canada 1627-2007

Golder Associates, Mississauga, Ontario	PROJECT NO. 10-1152-0110			SCALE AS SHOWN / REV. 1.0
	DESIGN	PRM	30 Aug. 2010	**FIGURE: 3.7**
	GIS	PRM	25 Feb. 2011	
	CHECK	CM	25 Feb. 2011	
	REVIEW	GS	25 Feb. 2011	

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\EarthquakesMap\Canada1627to2007.mxd



LEGEND

Seismic Events (Magnitude)

- < 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- > 3.0

- Geological Fault
- Main Road
- Railway
- Watercourse, Permanent
- Watercourse, Intermittent
- Water Area, Permanent
- Wooded Area
- Forest Reserve
- Conservation Reserve
- Provincial Park
- Crown Leased Land
- Geographic Township
- Municipal Boundary (Township of Ignace)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Seismic:Earthquakes Canada, GSC, Earthquake Search (On-line Bulletin), Sept 2010
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15

SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

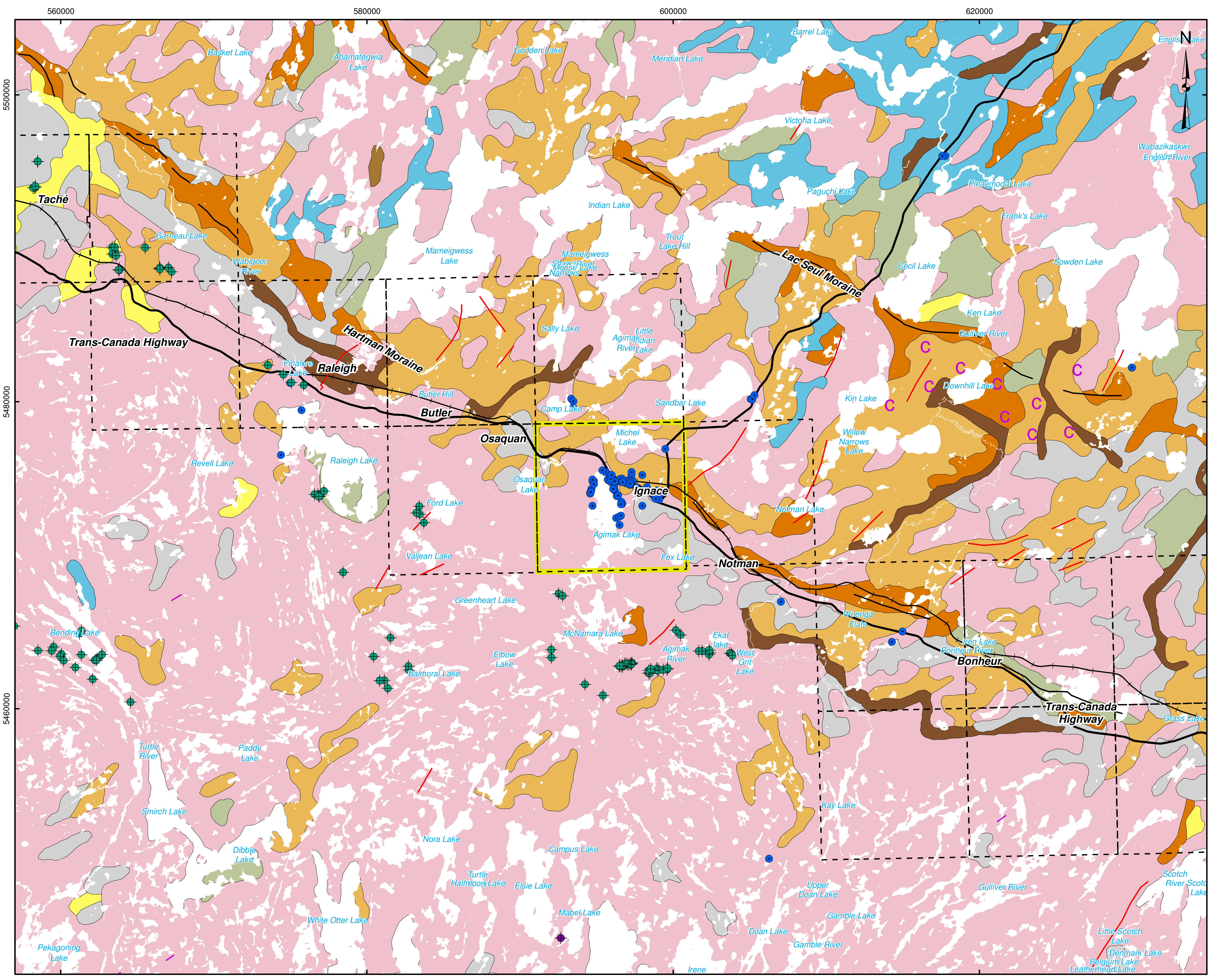
Historical Earthquake Records for the Ignace Area 1985-2010

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	JF	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

FIGURE: 3.8

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\HistoricalEarthquakeRecordsfortheIgnaceArea.mxd



LEGEND

- Diamond Drill Hole
- Overburden Drill Hole (Auger,Wacker)
- Percussion Drill Hole
- Wedged Diamond Drill Hole
- MOE Well Location
- Dunes
- Main Road
- Railway
- Drumlin or area of drumlins
- Esker or area of eskers; direction of flow know or assumed
- Terrace escarpment (abandoned shore bluff)
- Terrace escarpment; fluvial
- Trend of end moraine crest
- Area of DeGeer or minor moraine forms
- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice
- 23: Glaciofluvial Outwash deposits
- 24: Glaciolacustrine deposits
- 25: Glaciolacustrine deposits
- 28: Fluvial deposits
- 31: Fluvial deposits
- 32: Organic deposits
- 33: Lakes
- Geographic Township
- Municipal Boundary (Township of Ignace)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geology: EDS014-Surficial Geology of Ontario 1:1,000,000, 2000
Wells: Ministry of the the Environment , 2010
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

4 2 0 4 8 12
SCALE 1:250,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

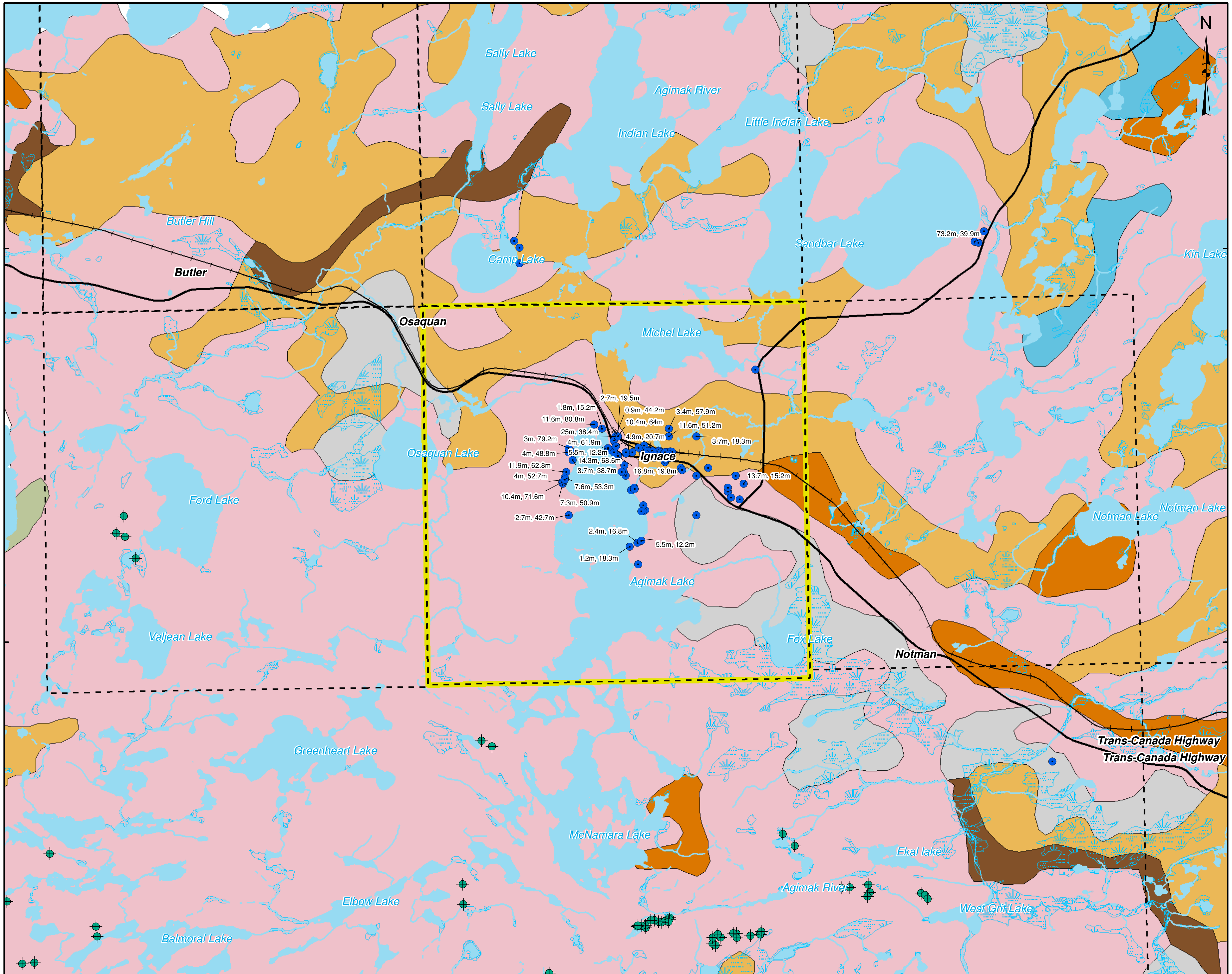
TITLE
Quaternary Geology of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

FIGURE: 3.9

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\QuaternaryGeology.mxd



LEGEND

- MOE Well (Depth to Bedrock, Depth to Water)
- Diamond Drill Hole
- Overburden Drill Hole (Auger,Wacker)
- Percussion Drill Hole
- Wedged Diamond Drill Hole
- Main Road
- Railway
- Watercourse, Permanent
- Watercourse, Intermittent
- Water Area, Permanent
- Wetland, Permanent
- Geographic Township
- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice
- 23: Glaciofluvial Outwash deposits
- 24: Glaciolacustrine deposits
- 25: Glaciolacustrine deposits
- 28: Fluvial deposits
- 31: Fluvial deposits
- 32: Organic deposits
- 33: Lakes
- Municipal Boundary (Township of Ignace)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Wells: Ministry of the Environment, 2010
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

2 1 0 2 4 6

SCALE 1:100,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

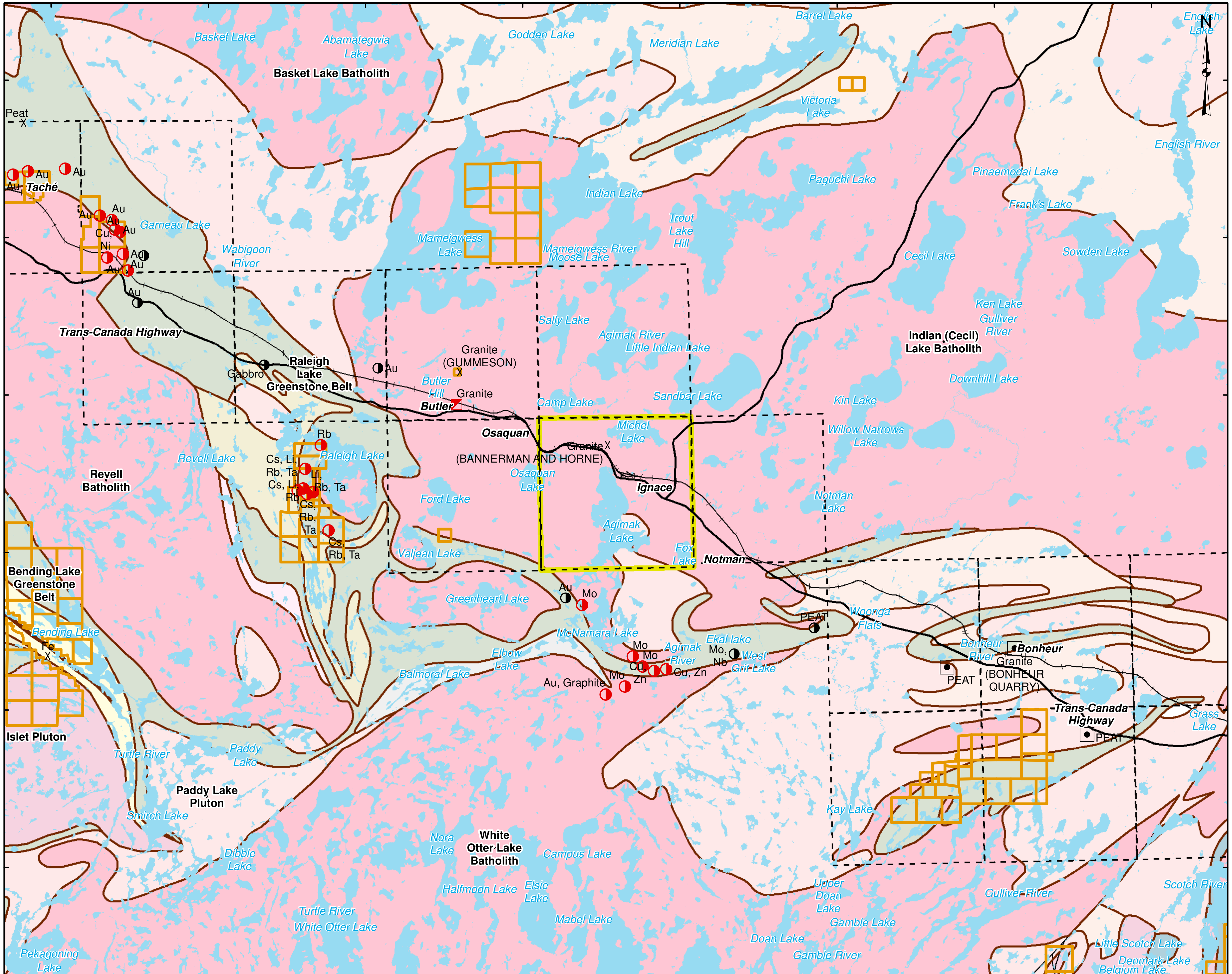
Water Well and Diamond Drillhole Records of the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

FIGURE: 4.1

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\WaterWellRecords.mxd



LEGEND

- X Developed Prospect with Reserves
- Discretionary Occurance
- Occurance
- Past Producing Mine with Reserves
- Past Producing Mine without Reserves
- Prospect
- Main Road
- Railway
- Water Area, Permanent
- Geographic Township
- Municipal Boundary (Township of Ignace)
- Geological Contact
- Active Mining Claims
- 15 Massive granodiorite to granite
- 14-Diorite-monzodiorite-granodiorite suite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 9 Coarse clastic metasedimentary rocks
- 7 Metasedimentary rocks
- 7c Marble, chert, iron formation, minor metavolcanic rocks
- 6 Felsic to intermediate metavolcanic rocks
- 5 Mafic to intermediate metavolcanic rocks
- 3 Mafic metavolcanic and metasedimentary rocks
- 2 Felsic to intermediate metavolcanic rocks
- 1 Metasedimentary rocks and mafic to ultramafic metavolcanic rocks

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009
Claims: Ministry of Northern Mines and Development July 2010
Mineral Inventory: Mineral Deposit Inventory of Ontario v2, 2004
Geology: MRD126-Bedrock Geology of Ontario, 2007
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

5 2.5 0 5 10 15
SCALE 1:250,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

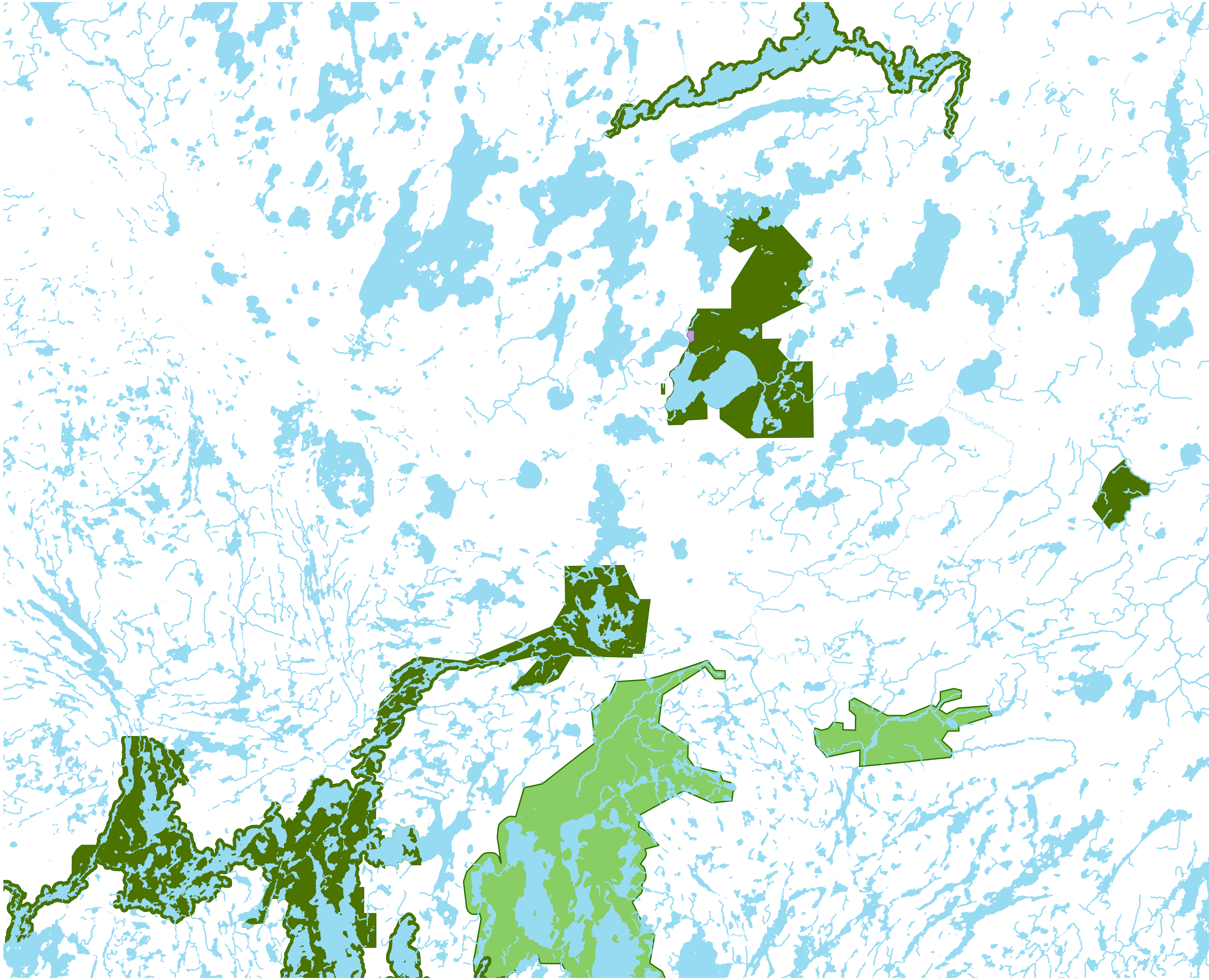
Mining Claims and Mineral Potential in the Ignace Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	25 Feb. 2011		
CHECK	CM	25 Feb. 2011		
REVIEW	GS	25 Feb. 2011		

FIGURE: 5.1

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\phase2000\MiningClaimsandMineralPotential.mxd



At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. 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 now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

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Mississauga, Ontario, L5N 5Z7
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Golder Associates