nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

February 21, 2012

Township of Nipigon
52 Front St
Box 160
Nipigon, ON P0T 2J0

Attn: Mr. Lindsay Mannila, CAO

Re: **Adaptive Phased Management Initial Screening – The Township of Nipigon**

Dear Mr. Mannila,

Further to the Municipality of Nipigon's 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 Nipigon 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 Nipigon from further consideration in the NWMO site selection process. The initial screening suggests that the Nipigon area contains portions of lands 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 Nipigon 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, Nipigon 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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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

c. Mayor Richard Harvey

REPORT

A world of capabilities delivered locally

February 2012

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

Township of Nipigon, Ontario

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

Report Number: 10-1152-0110 (9000)
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Golder Associates

EXECUTIVE SUMMARY

On November 9, 2011, the Township of Nipigon 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 presents the findings of an initial screening, conducted by Golder Associates Ltd., to evaluate the potential suitability of the Nipigon area against five initial 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 Nipigon from further consideration in the site selection process. The initial screening focused on the Township of Nipigon and its periphery, which are referred to as the "Nipigon area". Areas within or in closer proximity to neighbouring townships were not included in the initial screening.

The five initial screening criteria are defined in the site selection process document (NWMO, 2010), and 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 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 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 Nipigon from being further considered in the NWMO site selection process. The initial screening indicates that there are large areas within the Township of Nipigon and its periphery that are potentially suitable for hosting a deep geological repository. The geology of these areas is dominated by metasedimentary rocks that extend to the northwest and north of the township boundaries. There are also several sufficiently large granitic intrusions to the north and northwest of the township that are also potentially suitable. 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 the intent of this initial screening is not to confirm the suitability of the Nipigon 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 Nipigon remain interested in continuing with the site selection process, more detailed studies would be required to confirm and demonstrate whether the Nipigon area contains sites that can safely contain and isolate used nuclear fuel.

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 Nipigon area contains limited constraints that would prevent the development of the repository's surface facilities. The Nipigon 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 Nipigon area contains sufficient land outside protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities. There are two provincial parks, two conservation reserves, two

forest reserves and one recommended conservation reserve in the Nipigon area. These parks and reserves only occupy a small portion of the Nipigon area. Small portions of two provincial parks are within the Township of Nipigon boundaries. A small portion of Black Sturgeon River Provincial Park falls within the southwest corner of the township, while a small portion of Ruby Lake Provincial Park lies within the southeast corner of the township.

There are several known archaeological sites in the Nipigon area and the potential for archaeological and historical sites along the Nipigon River and its associated tributaries, as well as Nipigon Bay and Helen Lake, is considered to be high, as these watercourses were used as part of a major transportation route for both Aboriginal and Euro-Canadian people. National Historic sites in the Nipigon area include a series of French trading posts from the mid to late 17th century along the Nipigon River. These archaeological and historic sites occupy a small portion of the Nipigon area.

The presence of other locally protected areas and heritage sites 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 Nipigon area. The Ontario Ministry of the Environment Water Well Record database indicates that no potable water supply wells are known to exploit aquifers at typical repository depths in the Nipigon area or anywhere else in Northern Ontario. Water wells in the Nipigon area obtain water from overburden or shallow bedrock sources at depths ranging from 1 to 159 m, with most wells between 30 to 60 m deep. Experience in similar geological settings across the Canadian Shield suggests that the potential for deep groundwater resources at repository depths is low throughout the Nipigon 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 Nipigon area contains sufficient land, free of known economically exploitable natural resources, to accommodate the required repository facilities. The Nipigon area generally has a low potential for oil and gas resources. There are no current or past mining operations in the Nipigon area, and the potential for metallic minerals resources remains low and generally associated with localized geological formations in the area. A number of peat deposits exist in the area, but no peat extraction has occurred.

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

Based on the review of readily-available geoscientific information, the Nipigon area comprises portions of land that do not contain known unsafe geological and hydrogeological conditions. The Nipigon area is largely underlain by metasedimentary rocks that are potentially suitable for hosting a deep geological repository. The Nipigon area also contains a number of granitic intrusions to the north and northwest of the township that are potentially suitable.

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1.0 INTRODUCTION

On November 9, 2011, the Township of Nipigon 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 Nipigon area against five screening criteria using readily available information. The initial screening focused on the Township of Nipigon and its periphery, which are referred to as the "Nipigon area" in this report. Areas within or in closer proximity to neighbouring townships were not considered in the initial screening.

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, social, economic and cultural factors as identified through dialogue with Canadians including 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 Nipigon is located on the western shore of Lake Superior's Nipigon Bay, approximately 85 km northeast of Thunder Bay, and immediately north of the Township of Red Rock, as shown on Figure 2.1. The Township of Nipigon is approximately 116 km^2 in area extending from the mouth of the Nipigon River on Nipigon Bay westward to the Black Sturgeon River. The settlement area of Nipigon is accessed by the Trans Canada Highway (Highway 17) as well as rail and secondary roads. Satellite imagery for the Nipigon area (Spot 5, taken between 2005 and 2008 at 10 m resolution) is presented on Figure 2.2.

2.2 Topography

The Township of Nipigon is located in the Canadian Shield physiographic region, a low-relief, dome-like, gently undulating land surface with an elevation of about 150 masl (metres 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 Port Arthur Hills, the Abitibi Upland and the Laurentian Highlands.

The Township of Nipigon lies in the Port Arthur Hills physiographic subdivision, which borders the shores of Lake Superior and comprises a rugged terrain dominated by plateaux, ridges and cuestas defined by the underlying folded bedrock sequence (Thurston, 1991).

The Digital Elevation Model (DEM) for the Nipigon area is presented on Figure 2.4. The terrain in the Nipigon area is dominated by a number of ridges, plateaux and hills, including a prominent cuesta, which rises some 200 m higher than the surrounding lands and reaches an elevation of more than 400 masl in the south central portion of the township. One of the most prominent topographic features of the Nipigon area is the Black Sturgeon River canyon which confines the Black Sturgeon River between cliff faces as high as 200 m in height and partly runs along the extreme southwestern corner of the Township of Nipigon. Topography in the eastern portion of Nipigon Township is gentler in relief, with elevations averaging approximately 200 to 300 masl.

The highest elevations within the Township of Nipigon occur in the northwest along the eastern flanks of a prominent diabase plateau named Moseau Mountain and in the southeast portion of the township where elevations exceed 450 masl. The balance of the township ranges between approximately 350 and 300 masl except for the northeastern quadrant where the terrain falls away to between 250 and 200 masl. The lowest elevations in the area occur along the Lake Superior shoreline at an elevation of approximately 183 masl.

2.3 Drainage

Surface water drainage for the Nipigon area is shown on Figure 2.5. Drainage is generally easterly to southeasterly into Lake Superior from the watershed along the north side of Lake Nipigon and extending west as far as the Lac Des Iles area (approximately 100 km west of Nipigon). This height of land separates the Atlantic Watershed (via Lake Superior) from the Arctic Watershed (via Hudson Bay).

In the Nipigon area, the most prominent drainage features are the Nipigon and Black Sturgeon Rivers which flow along the east and west portions of the township, respectively. The Nipigon River drains the lake of the same name to the north of the Nipigon area from which it flows in a southerly course for approximately 25 km to Lake Helen and then to Nipigon Bay in Lake Superior. The settlement area of Nipigon is located along the west bank of the Nipigon River downstream from Lake Helen. The Black Sturgeon River originates in Black Sturgeon Lake near the southern margin of Lake Nipigon. The river flows in a southeasterly direction for a distance of

approximately 70 km before entering Black Bay on Lake Superior. For most of its length, the river follows a meandering path within a river valley occasionally bounded by steep cliffs. Approximately 10 km to the south of the Township of Nipigon, the river makes an abrupt 90-degree turn and flows in a southwesterly direction to its outlet into Black Bay. A number of small creeks are tributary to the Black Sturgeon River including Moseau Creek, which flows in a southeasterly direction to its confluence with the Black Sturgeon River south of the Township of Nipigon. Little and Big Trout Rivers flow in a generally parallel direction to Moseau Creek until their confluence to the south of Nipigon Township. In addition to these larger drainage systems, much of the land bordering Lake Superior drains directly to the lake via a number of small and generally unnamed creeks.

2.4 Protected Areas

Parks and Reserves

There are two provincial parks and several conservation reserves in the Nipigon area. Figure 2.1 shows the location of these protected areas. Only small portions of Black Sturgeon River Provincial Park and Ruby Lake Provincial Park occur within the township boundaries on the southwest and southeast corners respectively.

The Black Sturgeon River Provincial Park is some 72 km in length and covers 244 km^2 in area. The park extends from the north end of Black Sturgeon Lake and generally follows the Black Sturgeon River. A small portion (approximately 0.04 km^2) of this park falls within the extreme south-western corner of the township.

The Ruby Lake Provincial Park covers an area of 27 km^2 on the east side of the mouth of the Nipigon River, bordering the extreme northeast of the Township of Nipigon. The portion of the Park within Nipigon Township is approximately 0.27 km^2.

The Black Bay Bog Conservation Reserve covers an area of approximately 18.8 km^2 to the south of the Townships of Nipigon and Red Rock while the Lake Superior Archipelago Conservation Reserve includes all of the Crown Islands in the large archipelago in northern Lake Superior from the western end of Black Bay Peninsula to Schreiber. The 28.7 km^2 Nipigon River Conservation Reserve extends from the southeast corner of Lake Nipigon and follows the Nipigon River to Lake Helen in the south.

Heritage Sites

The cultural heritage screening examined known archaeological and historic sites in the Nipigon area. Information on archaeological sites in Ontario is provided by the Ontario Ministry of Tourism and Culture, through their Archaeological Sites Data Base (Ontario Ministry of Tourism and Culture, Pers. Comm., December 6, 2011).

There are 10 known archaeological sites in the Nipigon area (Figure 2.1). For two of these sites, aside from their location, no information is contained in the database (e.g., time period or cultural affiliations are not provided). Of the remaining eight sites, three are identified as pre-contact (prior to European arrival) Aboriginal sites. Two sites have been identified as pre-contact Aboriginal activity sites: potentially camping or hunting sites. The other site is a pictograph.

The remaining five sites are Euro-Canadian sites. One site contained a single gunflint while another site contained the remains of a late 19th to early 20th century foundation. Of the other sites, two are related to the fur trade – a Hudson's Bay Company post and possibly a French post and portage. One site is identified as the remains of a railway lodge while the last site is a logging camp. The logging camp site also contains two burials that may be Aboriginal but are of undetermined age.

All sites are located near a watercourse. The sites have been recorded along the Black Bay Peninsula on Nipigon Bay, along the shores of the Nipigon and Wolf Rivers, and along the shoreline of Helen Lake. These nine sites demonstrate the long duration of occupation by both Aboriginal and Euro-Canadian people in the area.

The potential for archaeological and historical sites along the Nipigon River and its associated tributaries, as well as Nipigon Bay and Lake Helen, is considered to be high, as these watercourses were used as part of a major transportation route for both Aboriginal and Euro-Canadian people. Archaeological potential is the likelihood that archaeological resources may be present on a subject property. In archaeological potential modelling, a distance to water criterion of 300 m is generally employed for watercourses, including lakeshores, rivers and large creeks (Government of Ontario, 2011).

A search for National Historic Sites in the Nipigon area determined that there are a series of mid- to late 17th century French trading posts along the Nipigon River. They were designated in 1944 but there are no plaques commemorating these posts and there is no current mapping showing the location of these posts. Figure 2.1 illustrates the approximate location of some of these posts based on mapping from the 1930's (Voorhis, 1930).

A search for Provincial Historic Sites through the Ontario Heritage Trust resulted in three locations where plaques have been placed to commemorate a historic event of provincial significance. The first plaque, located at the Nipigon River lookout along Highway 11/17, commemorates the Jesuit Mission to the Nipissings in 1667. The second plaque is located on a scenic lookout on Highway 11 near Orient Bay (41 km north of Nipigon) and commemorates the Palisades of the Pijitawabik. These palisades are pillar-like features of the sheer-rising cliffs at several points along the Lake Nipigon shoreline and are the dramatic result of erosion that began more than a billion years ago. The final plaque is located in Five Mile Park on Lake Helen, on Highway 11, 7 km north of Highway 17, and commemorates a historic canoe route connecting Lake Superior with James Bay via Lake Nipigon and the Albany River.

The presence of other locally protected areas and heritage sites 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.

3.0 GEOLOGY AND SEISMICITY

3.1 Regional Bedrock Geology

The geology of the Nipigon area consists of Mesoproterozic-aged sedimentary rocks and unconsolidated Quaternary deposits overlying 3 to 2.5 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 over a period of more than 2 billion years.

As shown on Figure 3.1, the Township of Nipigon is situated on the boundary between the Superior and Southern Provinces of the Canadian Shield. The Superior Province has been divided into various subprovinces, based on lithology, age, genesis and metamorphism (Thurston, 1991). It 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 Southern Province borders the Superior Province on the south from the Sudbury area through to Thunder Bay and is comprised of younger volcanic and sedimentary basins of Proterozoic age, deposited over the Archean basement.

The Township of Nipigon is situated on the boundary of the Quetico Subprovince of the Superior Province and the Southern Province. Figure 3.2 shows the general bedrock geology and mapped geological faults of the Nipigon area and surroundings, with topography added as “shaded relief” over top of the bedrock geology.

The Quetico Subprovince consists primarily of Archean clastic metasedimentary rocks that underwent regional melting and recrystallization (migmatization), and are intruded by 2.70 to 2.65 billion year old granitic intrusive rocks (Williams, 1991). In the southern and western portions of the Nipigon region (Figure 3.2), the Proterozoic sedimentary rocks of the Sibley and possibly Animikie Groups unconformably overlie the Archean metasedimentary rocks of the Quetico Subprovince.

A generalized geologic sequence for the Nipigon Area is presented in Table 3.1. The geological history of the Nipigon area can be summarized as follows: the metasedimentary rocks of the Quetico Subprovince were deposited approximately 2.698 to 2.690 billion years ago, and were deformed and metamorphosed prior to about 2.66 billion years ago with the subsequent emplacement of ultramafic dikes and sills, and discrete large granitic bodies. Rocks of the Quetico Subprovince were unconformably overlain by sedimentary rocks of the Sibley Group approximately 1.5 to 1.3 billion years ago (Heaman et al., 2006). The metasedimentary rocks of the Quetico Subprovince and the sedimentary rocks of the Sibley Group in the Nipigon area were intruded by Nipigon diabase sills and dykes related to the failed intracontinental rifting event approximately of approximately 1.115 billion years ago and localized ultramafic intrusions, such as the Hele Intrusion, (Hart, 2005), approximately 1.115 to 1.105 billion years ago (Heaman et al., 2006). Osler Group tholeiitic flood basalts were emplaced slightly later than the Nipigon sills (Sutcliffe, 1991) and underlie most of the St. Ignace Island chain to the south and east of the Nipigon area.

A major structural feature in the region is the Black Sturgeon River Fault Zone (Figure 3.2), which comprises a series of northwest-trending faults following coincident with the Black Sturgeon River, and forms the northeastern border of a graben structure (Hart, 2005). Rock units to the southwest of the fault zone are downthrown by several hundred metres compared to rocks to the northeast. The fault zone is marked by a steep valley, approximately 1 km wide and 200 m deep, through which the Black Sturgeon River flows in the northwest part of the Nipigon Area. The dip and the width of the fault zone are unknown. Northeast-trending

faults are also present, but they are not as well defined and appear to parallel the fabric of the rocks of the Quetico Subprovince (Hart, 2005). The DEM for the Nipigon area shows lineaments in the rocks of the Quetico Subprovince, and these are discussed further in the local bedrock geology (Section 3.2).

Table 3.1: Generalized Stratigraphic Column (not to scale) – Nipigon Area, Ontario

Eon	Lithology	Group/Formation		Description
Proterozoic			Osler Volcanic Group (Keweenawan Supergroup)	Mafic metavolcanics
			Diabase Sills	Diabase
		Sibley Group	Nipigon Bay Formation	Sandstone
			Outan Island Fm. – Hele Member	Sandstone/siltstone
			Outan Island Fm. – Lyon Member	Siltstone/mudstone
			Kama Hill Fm.	Red shale with minor sandstone
			Rossport Fm. – Fire Hill Member	Conglomerate overlain by mudstone
			Rossport Fm. – Middlebrun Bay Member	Stromatolitic limestone
			Rossport Fm. – Channel Island Member	Dolomitic mudstone
			Pas Lake Fm. – Fork Bay Member	Sandstone
			Pas Lake Fm. – Loon Lake Member	Conglomerate
			English Bay Complex (north of Nipigon area)	Granite/rhyolite
		Animikie Group	Rove Fm.	Black shale–sandstone
Achaean	X X X X X X X		Quetico Subprovince	Metasedimentary rocks Granitic intrusions

3.2 Local Bedrock Geology

The bedrock geology of the Nipigon area is shown on Figure 3.3 with topography added as shaded relief. More recent mapping by Hart (2005) has been used where it is available (i.e., west of the white line on Figure 3.3). The Township of Nipigon is located on the boundary between the metasedimentary rocks of the Quetico Subprovince of the Superior Province and the sedimentary rocks of the Sibley Group of the Southern Province of the Canadian Shield.

There are five distinct geologic units in the Nipigon area (Figure 3.3): the metasedimentary rocks and granites of the Quetico Subprovince, sedimentary rocks of the Sibley Group, Nipigon diabase sills and the ultramafic Hele Intrusion.

Archean metasedimentary rocks and migmatites of the Quetico Subprovince comprise the bedrock at surface over the majority of the Township of Nipigon (covering approximately 95% of the township area). These metasedimentary rocks extend beyond the township boundaries to the north and over an extensive area east of the Black Sturgeon River Fault Zone. To the south and to the west of the Black Sturgeon River Fault Zone the metasedimentary rocks of the Quetico Subprovince are unconformably overlain by the unmetamorphosed, undeformed sedimentary rocks of the Sibley Group. The sedimentary rocks of the Sibley Group are found to the south of the township, and northeast along the Lake Superior shoreline. An approximately 11 km^2 body of Archean granite of the Quetico Subprovince comprises the bedrock at surface in a small portion along the southern boundary of the township.

Other granitic intrusive bodies occur along the west boundary of the township and north and northwest of the township (Figure 3.3). These include elongate or lensoid bodies mapped as massive granodiorite to granite located in the west central portion of the Township of Nipigon and further to the northwest along the east side of the Black Sturgeon River. They are small in width (typically about 1 km wide), concordant with the strike of the metasedimentary rocks of the Quetico Subprovince, and they lack any characteristic geophysical signature that would suggest a potential in-situ migmatization origin. Hart (2005) considered the lack of well-developed gneissic textures along with the presence of xenoliths to be indicative of an intrusive origin.

Other granitic bodies include two irregular granitic bodies along the east side of the Black Sturgeon River in the area south of Mound Lake approximately 10 km northwest of the Township of Nipigon. The more southerly of these is an approximately 20 km^2 body of biotite-bearing massive granodiorite to granite bordered on the north by a slightly larger 38 km^2 muscovite-bearing granite intrusion. Both of these granitic bodies are accompanied by distinct magnetic and radiometric geophysical signatures, supporting an intrusive origin.

A separate muscovite granite body occurs crossing Lake Helen some 5 km north of the Township of Nipigon. This unit is approximately 10 km long and 2 km wide. It is concordant to the ductile fabric within the regional metasedimentary rocks and lacks any distinct geophysical signature, raising the possibility of a migmatitic origin.

In a number of places in the Nipigon area there are localized outcrops of mafic intrusions, diabase sills and dikes, including the Nipigon Sill Complex, which intrude both Archean metasedimentary rocks and the Proterozoic sedimentary rocks of the Sibley Group (Figure 3.3). Within the township, Nipigon Sills occur at surface along a diagonal trend from the northwest corner of the township to the southeast. This exposure of the Nipigon Sill Complex extends north of the township as a north to north-east striking 500 m wide linear feature to the Purdom Lake area where it broadens in areal extent to approximately 5 km width. Immediately west of the Black Sturgeon River Fault Zone, approximately 1 km southwest of the Township of Nipigon, is the ultramafic Hele Intrusion.

The gravity response (Figure 3.4) for the Nipigon area shows a gradual transition from a relative gravity high to the north and northwest associated with the Superior Province, to a relative gravity low to the south and east, reflecting the change in lithology associated with the Southern Province. The highest gravity response is associated with the metasedimentary rocks and migmatites of the Quetico Subprovince northwest of the Township of Nipigon and immediately east of the Black Sturgeon River Fault Zone. There is very little difference in gravity response across the Black Sturgeon River Fault Zone, consistent with the displacement across this zone being only on the order of a few hundreds of metres (Coates, 1972; Hart, 2005). There is no significant gravity response associated with the ultramafic Hele Intrusion, suggesting that it does not extend to significant depths.

The airborne magnetic and radiometric survey data for the Nipigon area, shown on Figures 3.5 and 3.6, include high resolution data recently acquired to support the mapping work by Hart (2005), covering the western half of the Township of Nipigon, as well as areas to the north and west. The remaining magnetic and radiometric data shown on the figures was acquired at significantly lower resolution.

The magnetic responses of the metasedimentary rocks and migmatites of the Quetico Subprovince and the sedimentary rocks of the Sibley Group are generally seen to be subdued (Figure 3.5). By contrast, intrusive bodies such as the Archean granites of the Quetico Subprovince and the Hele Intrusion show distinct positive magnetic responses. The positive magnetic response over the Hele Intrusion shows criss-crossing linear features striking approximately 25^{o} and 100^{o}, coincident with prominent topographic lineaments. These linear features have been interpreted to be faults (Coates, 1972; Hart, 2005) as are a number of similar lineaments elsewhere in the Nipigon Area. The Nipigon Sills have a distinctly low magnetic response in comparison to their surrounding host rocks as a result of their remnant magnetization from the time of emplacement.

The radiometric data presented on Figure 3.6 (presented as equivalent uranium response) also appears to correlate to the lithologies of the Nipigon area. The sedimentary rocks of the Sibley Group are seen to have a relatively low radiometric response in comparison to the Archean metasedimentary rocks of the Quetico Subprovince to the north. Within the Archean metasedimentary rocks, there are several radiometric highs to the north and northwest of the Township of Nipigon corresponding to granitic intrusives and possibly to mineralizing structural trends in the metasedimentary rocks of the Quetico Subprovince. The Hele Intrusion has a low radiometric response, owing to its gabbroic composition. The Nipigon intrusions are also generally seen to have relatively low radiometric responses.

The main geological units in the Nipigon area are further described below.

3.2.1 Lithologies

Archean Metasedimentary Rocks

Archean metasedimentary rocks of the Quetico Subprovince (Figure 3.3) underlie the largest portion of the Township of Nipigon and constitute the uppermost bedrock unit to the north of the Township of Nipigon and east of the Black Sturgeon River. Metasedimentary rocks of the Quetico Subprovince also extend beneath the sedimentary rocks of the Sibley Group to the south of the Township of Nipigon and in the area west of the Black Sturgeon River. Hart (2005) classified the major portion of the metasedimentary rocks of the Quetico Subprovince in the Nipigon area as migmatites. Migmatites in the Nipigon area formed by partial melting of precursor sedimentary rocks, resulting in the formation of rocks (migmatites) composed of two or more petrographically distinct components. Partial melting has been suggested by Hart (2005), to be due to the intrusion of felsic granitic intrusive rocks, mostly of biotite granite composition, either as thin layers interspersed

with the sedimentary rocks or as discrete metre-scale irregular dike swarms. Depositional ages of the original sediments of the Quetico Subprovince are dated circa 2.698 to 2.690 billion years (Percival et al., 2006).

Migmatitic rocks in the Nipigon area are mostly comprised of a gneissic and a granitic component. The gneissic component predominantly consists of amphibolite, which is a black to medium grey rock composed of fine- to medium-grained hornblende, plagioclase and quartz. These rocks show weak to moderate foliation. In the Nipigon area, however, amphibolites are most often found mixed with leucocratic quartz-feldspar granite dikes in the form of irregular interbanding to chaotic mixtures of the two rock types (Hart, 2005).

Although the thicknesses of the metasedimentary rocks and related migmatites in the Nipigon area are not reported in the literature, a regional thickness of up to 18 km has been interpreted from regional geophysical studies (Culshaw et al., 2006; Percival et al., 2006). A number of lineaments have been mapped as faults in the metasedimentary rocks to the east of the Black Sturgeon River Fault Zone (Hart, 2005). Most of these lineaments follow a north or northwest trend and are spaced about 1.5 to 3 km apart.

Archean Granites

The metasedimentary migmatites of the Quetico Subprovince in the Nipigon area have been intruded by several irregular shaped granitic bodies, mapped by Hart (2005) as metamorphosed biotite granite within the Township of Nipigon and in the area to the northwest of the township bordering the Black Sturgeon River valley. Biotite granite intrusions in the Nipigon area consist of light pinkish, grey to light pink granite composed of quartz and feldspar with less than 10% biotite. These rocks are massive and medium to coarse grained, with rare very coarse grained to pegmatitic sections. Often these granitic intrusions contain xenoliths of the surrounding amphibolites, which are a few metres in diameter. These granitic bodies are in some places cut by pegmatitic dikes.

Muscovite-bearing granitic intrusions are also mapped to the north of the Township of Nipigon in the form of an approximately 10 km long and 2 km wide body crossing Lake Helen some 5 km north of the township, and an unnamed approximately 38 km^2 subcircular body located south of Mound Lake, approximately 10 km to the northwest of the township (Figure 3.3). The muscovite granite is described as light grey, pinkish grey, to white, massive, and medium to very coarse grained with occasional pegmatitic sections. Xenoliths of metasedimentary and gneissic rocks are present throughout the intrusion, and pegmatitic muscovite granite dikes intrude the granite body and the surrounding gneisses.

Based on conceptual regional geological cross-sections by Hart (2005) shown on Figure 3.7, the granitic intrusion within the Township of Nipigon seems to extend to at least 300 m depth. Such interpretation is based on sparse diamond drillhole information and on airborne geophysical data over the region. Four major lineaments mapped as faults by Hart (2005) cut across the gneiss and biotite granite occurring in the southwest portion of the township (Figure 3.3), having a northwest trend and an approximate spacing of 1 to 2 km. The dip and depth of these structures is unknown. Interpreted faults also crosscut the biotite and muscovite granite intrusions northwest of the township to the east of the Black Sturgeon River Fault Zone and to the south of Mound Lake. The absence of mapped faults along the Nipigon River and in the area to the northeast of the township likely reflects the scale of mapping for these areas, rather than the absence of such structural features.

Sedimentary Rocks of the Sibley Group

The Sibley Group is an unmetamorphosed, relatively flat-lying sedimentary rock sequence that unconformably overlies the Archean rocks of the Quetico Subprovince. It occurs over a small portion of the Township of

Nipigon, large areas to the south and southwest of the township, to the northeast along the Lake Superior shoreline and extending northward in the area east of the Nipigon River (Figure 3.3).

The rocks of the Sibley Group in the Nipigon area range from approximately 1.5 to 1.3 billion years in age and have been divided into five formations (Rogala et al., 2005; Hart, 2005), three of which are known to be present in the Township of Nipigon. According to Rogala et al. (2005), the lowermost unit, the Pass Lake Formation, consists of conglomerates overlain by sandstones; the middle unit, the Rossport Formation, consists of dolomite-siltstone layers on the bottom, stromatolites in the middle and mudstone on the top; and the uppermost unit, the Kama Hill Formation, is composed of shales and siltstones. Younger members of the Sibley Group, the Outan Island and Nipigon Bay Formations, have not been mapped within the Township of Nipigon but these units are known to be present beneath portions of Nipigon Bay (Rogala et al., 2005).

As noted on the conceptual geological cross-sections developed by Hart (2005) and shown on Figure 3.7, the complete sequence of sedimentary rocks of the Sibley Group are estimated to reach up to approximately 200 m in thickness where they occur in the Nipigon area. These cross-sections were developed using geological mapping by Hart (2005), sparse diamond drillhole information and airborne geophysical data.

The Hele Intrusion

The Hele Intrusion covers a total area of approximately 40 km^2 and is located adjacent to the west side of the Black Sturgeon River Fault Zone approximately 1 km to the southeast of the Township of Nipigon (Figure 3.3). The Hele Intrusion is underlain by sedimentary rocks of the Sibley Group and has a reported maximum thickness of approximately 130 m (Hart, 2005), based on diamond drillhole information and modelling of available airborne magnetic data.

The Hele Intrusion was emplaced about 1.106 billion years ago (Heaman et al., 2006), related to a failed intracontinental rifting event, and is composed of altered peridotite interlayered with olivine gabbro and feldspathic peridotite. The peridotite is a high weathered and serpentinized rock containing numerous, subparallel serpentine and chlorite-rich fractures (Hart, 2005). A few major lineaments, mapped by Hart (2005) as faults, cut across the Hele Intrusion in north and east-southeast orientations, the latter with spacings of 1 to 2.5 km (Figure 3.3).

Nipigon Diabase Sill Complex

Nipigon diabase sills are relatively thin (<200 m) generally flat-lying mafic rocks that intrude and sometimes overlie the other rock types in the Nipigon area. Within the township, several small diabase sills occur at surface along a diagonal trend from the northwest corner of the township to the southeast. The outcrops of diabase are typically less than 1 km^2 in size and less than 100 m thick (Hart, 2005), as seen on Figure 3.7. Larger diabase occurrences are mapped beyond the township limits and Nipigon diabase sills often intrude the older rocks in the area at depth and occur as extensive, relatively flat and thin (less than 50 m) intrusive layers (Hart, 2005).

There are no obvious textural or mineralogical differences between the sills; the diabase is commonly medium brown to brownish grey, massive, medium to coarse-grained feldspar and pyroxene with trace olivine and magnetite (Hart and Magyarosi, 2004). Their emplacement is interpreted by Coates (1972), Sutcliffe (1991) and others to be related to the Midcontinent Rift event (Section 3.1). The intrusion of these sill bodies has been constrained to have occurred in the period 1.115 to 1.105 billion years (Heaman et al., 2006).

Lineaments mapped by Hart (2005) as faults (Figure 3.3) cut across a few of the sills located southwest of the township boundary, with either northeast, east or northwest orientations and either intersecting each other or spaced about 5 km apart.

3.2.2 Deformation and Metamorphism

Deformation in the Nipigon area is interpreted to have occurred in four stages, from approximately 2.698 to 2.667 billion years ago (Valli et al., 2004). Deformation initially produced folding and faulting as well as development of schistosity in the metasedimentary rocks of the Quetico Subprovince. Syndeformational high grade metamorphism to amphibolites facies was reached during the second stage. Emplacement of metamorphosed, weakly to strongly-deformed granite bodies (e.g., granitic intrusion within the Township of Nipigon) (Williams, 1991) would have been coeval with the fourth deformation stage. Sedimentary rocks of the Sibley Group are unmetamorphosed except for contact metamorphism with the Nipigon Sills and related intrusive rocks.

Major faulting has occurred in the Nipigon area, with the Black Sturgeon River Fault Zone being the most noticeable structural feature. Major lineaments in the Nipigon area, mapped as faults by Hart (2005), consist of a series of subparallel, north-trending faults, and a series of northwest-trending faults, as exhibited by the Black Sturgeon River Fault itself (Figure 3.3). These two major regional fault trends define the Black Sturgeon River Fault Zone (Coates, 1972; Hart 2005). The Black Sturgeon River Fault Zone follows a northwest trend, giving direction to the river of the same name and has produced a canyon that is, on average, approximately 1 km wide. North-trending faults are spaced from approximately 2.5 to 6.5 km apart, whereas northwest-trending faults are spaced as close as approximately 1.5 km apart. An east-trending subset of faults with spacings from 1.5 to 2 km has been identified in the Hele Intrusion and similarly oriented features are likely present elsewhere in the Nipigon area although the scale of mapping in the northeast portion of Figure 3.2 has been completed at a lower resolution with the frequency of mapped faults commensurately lower in this portion of the Nipigon area.

Hart and Magyarosi (2004) and Hart (2005) found little lateral displacement on the north- and northwest-trending faults based on the correlation of the iron formations across Black Sturgeon Lake. Vertical displacement across north-trending faults in some areas has been up to 350 m, as is the case of the Black Sturgeon River Fault as shown on Figure 3.7. Elsewhere, the vertical displacement on these faults is variable and often uncertain. These faults may have controlled the emplacement of ultramafic intrusions.

Timing and magnitude of displacement of the faults in the Nipigon area is poorly constrained. North- and northwest-trending faults appear to have been active approximately 1.100 billion years ago, based on stratigraphic relationships between faults and geological units. In particular, relationships between the Black Sturgeon River Fault and rocks of the Sibley Group suggest that the fault is either as old as the Sibley Group rocks, or is older and was still active during sedimentation, or that the fault was reactivated after sedimentation (Hart, 2005).

3.3 Quaternary Geology

The Quaternary geology of the Nipigon area (Figure 3.8) comprises different types of glacial deposits including tills, glaciofluvial sands, and glaciolacustrine sediments deposited during late Pleistocene Wisconsinan glaciations, as well as more recent fluvial and organic deposits. 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 Ohio and Indiana (Barnett et al., 1991). Partial retreat of glacial ice from the Superior basin began approximately 10,000 years ago with the final deglaciation of the Nipigon area beginning approximately

9,500 years ago (Burwasser, 1977). Over the next 500 years, water levels fluctuated through a series of glacial lake stages as different drainage outlets became activated.

Figure 3.8 shows the distribution of Quaternary deposits in the Nipigon area and the location of the wells from which information on overburden thickness was obtained. Most of the Township of Nipigon comprises bedrock with only a thin mantle of unconsolidated material. Glaciofluvial deposits of sand and gravel occur in the north central part of the township and fine textured glaciolacustrine deposits of silt and clay occur in the settlement area of Nipigon. Similar fine textured deposits underlie a large portion of the low-lying lands to the south of the Township of Nipigon extending over the Black Bay peninsula. North and west of the township the bedrock is mostly exposed.

Information on the thickness of Quaternary deposits in the Nipigon area was obtained from a number of water well records in the Nipigon area. Figure 3.8 shows the locations of wells from the Ministry of Environment (MOE) and diamond drill holes from the Ministry of Northern Development and Mines (MNDM). Overburden thicknesses within the area typically range from 15 to 40 m, with the greatest thickness reported to be 99 m.

3.4 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 Nipigon 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). The most recent of these glacial cycles (referred to as the Wisconsinan glaciation) occurred between approximately 115,000 and 10,000 years ago.

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/North Dakota area (Brevic and Reid, 1999), due to the weight of glacial ice. The amount of crustal depression in the Nipigon area would be of a somewhat greater magnitude due to its closer proximity to the main centre of glaciation located over Hudson's Bay.

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 amplified locally in shallow bedrock in many areas of Ontario. Natural stress release features include elongated compressional ridges or pop-ups such as those described by White et al. (1973), McFall (1993), and Karrow and White (2002).

Although no information regarding in situ stress conditions have been reported in the available literature for the Nipigon area, studies at a number of sites in northern Ontario (Herget and Arjang, 1997) indicate that major horizontal compressional stress direction of northeast-southwest with the magnitudes of horizontal stresses generally exceeding the vertical stress component.

No detailed identification and interpretation of neotectonic structures were found in readily available literature for the Nipigon 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 are often 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 in the Nipigon area.

3.5 Seismicity

The Township of Nipigon lies on the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). Hayek et al. (2009) indicated that this area of the Canadian Shield has experienced a number of low magnitude, shallow seismic events. Figure 3.9 presents the location of earthquakes with a magnitude 3 or greater that are known to have occurred in Canada from 1627 until 2010. Figure 3.10 shows the locations and magnitudes of seismic events recorded in the National Earthquake Database (NEDB) for the period between 1985 and 2011 in the Nipigon area (NRC, 2011b). In the last 25 years there have been three recorded seismic events within 20 km of the Township of Nipigon and eight events within 75 kilometres. Note that these events occurred along the Lake Superior shoreline and that none of these seismic events measured greater than a magnitude of 3.

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

4.0 HYDROGEOLOGY

Information concerning groundwater in the Nipigon area was obtained from the MOE Water Well Record (WWR) database. The Township of Nipigon obtains its municipal water supply from the Nipigon Bay on Lake Superior, however, a large number of wells exist in the Nipigon area serving individual private residences. Most of these are located along the Trans Canada Highway and obtain water from the overburden or the shallow bedrock. Figure 4.1 shows the location of water wells in the Nipigon area although only depths are shown for only a fraction of the water wells in the settlement area of Nipigon since the density of wells would otherwise render the figure illegible. The MOE Water Well Record database contains a total of 459 water well records for the Nipigon area. A summary of these wells is provided in the table below.

Table 4.1: Summary of Water Well Records – Nipigon Area, Ontario

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	199	1 to 99	0 to 30	1 to 100	N/A
Bedrock	260	5 to 159	0 to 46	1 to 200	0 to 100

4.1 Overburden Aquifers

There are 199 water well records in the Nipigon area that can be confidently assigned to the overburden aquifer, which is generally found in the sand and gravel deposits above bedrock and at the base of the glaciolacustrine deposits that form the most widespread surficial soil materials. The overburden wells are generally 5 to 40 m deep, but depths of up to 99 m have been recorded. Well yields are variable with recorded values ranging from 1 L/min to 100 L/min. These values 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.

4.2 Bedrock Aquifers

In the Nipigon area, there are 260 well records that can be confidently assigned to the shallow bedrock aquifer. These wells range from 5 to 159 m in depth, with most wells between 30 to 60 m deep. Measured pumping rates in these wells are variable and range from 1 L/min to 200 L/min with yields typically between 3 to 5 L/min. These values reflect the purpose of the wells (private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from the 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.

Metasedimentary rocks of the Canadian Shield are present at repository depth (approximately 500 m) in the Nipigon area. The review of readily available information did not identify any known groundwater resources at repository depth in the Nipigon area or anywhere else in the Ontario part of the Canadian Shield. Experience from other areas in the Canadian Shield has shown that active groundwater flow is generally confined to shallow fractured localized systems. In these 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). At greater depths, 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 Nipigon 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.

At greater depths, where groundwater movement 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 Nipigon is located in a largely crystalline geological setting with Mesoproterozoic sedimentary rocks overlying the crystalline rocks in some areas. There are no known hydrocarbon exploration activities in the Nipigon area and the potential for petroleum resources is considered to be negligible.

5.2 Metallic Mineral Resources

Figure 5.1 shows the areas of active mineral exploration interest in the Nipigon area based on active mining claims, as well as known mineral occurrences identified in the Ontario Geological Survey's (OGS) Mineral Deposit Inventory Version 2 (OGS, 2004). There is no record of metallic mineral production in the past in the Nipigon area. A few mineral occurrences have been identified at the periphery of the Township of Nipigon, but their economic potential has not been proven. As shown on Figure 5.1 there are currently a number of active exploration claims west of the Township of Nipigon.

Metallic mineral occurrences in the Nipigon area include: cobalt-copper-nickel-platinum group metals, silver-lead-zinc, rare metals and radioactive element-enriched pegmatites. All of the occurrences are considered to be sub-economic.

Platinum Group Elements (PGE)

The Hele Intrusion in the southwest corner of the Township of Nipigon is mineralogically similar to the Seagull Intrusion (about 40 km northwest of the Township of Nipigon), which contains sub-economic platinum group element (PGE) mineralization (Hart and Magyarosi, 2004). The potential feeder zones to the Hele Intrusion have been suggested to have potential for PGE and nickel-copper mineralization (Hart, 2005). Anomalous concentrations of PGE have been identified in the Foxden Occurrence (described under 'Nickel and Copper' below). HTX Minerals Corp. is currently exploring the Hele Intrusion for PGE-Ni-Cu (HTX, 2011).

Nickel and Copper

The Foxden Cu-Ni Occurrence is located west of the Hele Intrusion, approximately 10 km west of the Township of Nipigon (Figure 5.1). The occurrence is contained within an extension of the Hele Intrusion and is hosted in medium-grained pyroxenite in contact with dolostone of the Rossport Formation. A grab sample collected by OGS staff yielded 412 ppm Cu, 1,011 ppm Ni, 36 ppb Pt, and 27 ppb Pd (Schnieders et al., 2002).

The Hughes Point Copper Occurrence is located on the west side of Hughes Point, approximately 4 km east of the Township of Nipigon. Calcareous sedimentary rocks of the Sibley Group host a number of narrow, Cu-mineralized calcite veinlets near the upper contact with a flat lying diabase sill.

Silver, Lead, and Zinc

The Nipigon Silver Occurrence is located along the west side of the Nipigon River approximately 3.5 km south of Highway 17 and consists of sub-economic traces of argentiferous galena and sphalerite. Sub-economic silver, lead and zinc mineralization is also reported at the Gordon and Ozone siding occurrences to the east of the Nipigon River and north of the Trans Canada Highway near the eastern limit of the area.

Uranium

The Hele Uranium Occurrence is located along the east side of the Black Sturgeon River, approximately 6 km west of the Township of Nipigon. It consists of a number of granitic dikes in granite gneisses. The main dike

strikes east-west and dips 40 degrees north. A grab sample assayed 0.096% U_3O_8 (Robertson and Gould, 1983). Hart (2005) reported that a number of properties in the Nipigon area were explored for uranium between 1977 and 1980 including the Eagle Mountain, and Fog Lake deposits along the west side of the Black Sturgeon River Fault Zone approximately 10 km to the northwest of the Township of Nipigon. No economic uranium mineralization was reported from this work.

Narrow but high grade veins of pitchblende occur in the Eagle Mountain area and east of Black Sturgeon Lake (approximately 50 km northwest of Nipigon). Grades of up to 12% U have been reported (Scott, 1987) in the Black Sturgeon Lake area, although this occurrence was in a relatively small zone and the zone is not considered to have economic potential. Rocks of the Quetico Subprovince are anomalously high in uranium, and the uranium has been remobilized into faults and geochemical traps and veins associated with the unconformity between the Archean basement and the Sibley Group.

5.3 Non-Metallic Mineral Resources

Known non-metallic mineral resources within the Nipigon area include sand and gravel, stone, amethyst, barite and peat. Quarrying for stone and/or manufactured aggregate has been carried out at a number of locations in the Nipigon area, including the Nipigon River Marble Quarry. Small sand and gravel pits are also present within the Nipigon area, although there is no available inventory of sites. A barite deposit is recorded along the west shore of Kama Bay to the east of the Nipigon area while the Stenlund Amethyst Occurrence (which also contains minor barite) is located approximately 5 km east of the Highway 11 turnoff at Nipigon.

A number of peat deposits are identified within the wetlands of the Black Bay Peninsula south of the Township of Nipigon, however no commercial peat extraction is known to have occurred in the 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, no diamond occurrences have been identified in the Nipigon area.

6.0 INITIAL SCREENING EVALUATION

This section provides an evaluation of each of the five initial screening criteria (NWMO, 2010) for the Nipigon 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 Nipigon 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.

The assessment focussed mainly on the areas east west and north of the Township of Nipigon (Figure 2.1). The other areas are closer or within the Township of Red Rock, which is not included in this initial screening.

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 Nipigon 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 Nipigon contains limited constraints that would prevent the development of the repository's surface facilities (Figure 2.1 and 2.2). These would mainly include rugged terrain in the central portion of the township and development along the east portion of the township in the vicinity of the settlement area of Nipigon. Residential and industrial infrastructure occupies a small portion of the township, with developments limited mainly to roadways and the settlement area. The areas to the north and west of the township are largely undeveloped, with limited natural or physical constraints such as major infrastructure or permanent water bodies. Therefore, the Nipigon area contains sufficient land to potentially accommodate the repository surface facilities.

As discussed in Section 2, topography is variable in the Nipigon area, but no obvious topographic features that would prevent construction and characterization activities have been identified. Most of the Nipigon area could be accessed by the Trans Canada Highway (Highway 11/17) and a series of logging roads to the north and west (Figures 2.1 and 2.2).

As discussed in Section 6.5, readily-available information suggests that the Nipigon 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 Nipigon 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 include protected areas, heritage sites or parks, as defined by provincial or federal authorities.

The Nipigon 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.

Figure 2.1 shows that the two provincial parks and two conservation reserves present within the Nipigon area occupy only small portions of land. The Black Sturgeon River Provincial Park is some 72 km in length and covers 244 km^2 in area, but only a very small portion of the park (0.04 km^2) occurs within the township boundaries. The Ruby Lake Provincial Park covers an area of 27 km^2 on the east side of the mouth of the Nipigon River, bordering the northeast of the Township of Nipigon. Only 0.27 km^2 occurs within the boundary of the Township of Nipigon.

As discussed in Section 2.4, most of the land in the Nipigon area is free of known heritage constraints. There are 10 known archaeological sites in the Nipigon area and the potential for archaeological and historical sites along the Nipigon River and its associated tributaries as well as Nipigon Bay and Helen Lake is considered to be high, as these watercourses were used as part of a major transportation route for both Aboriginal and

Euro-Canadian people. National Historic sites in the Nipigon area include a series of French trading posts from the mid to late 17th century along the Nipigon River. The known archaeological and historic sites occupy a small portion of the Nipigon area.

The absence of locally protected areas or heritage sites 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 Nipigon area contains sufficient land outside 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 Nipigon area. As discussed in Section 4, the MOE WWR database shows that all water wells known in the Nipigon area obtain water from overburden or shallow bedrock sources at depths ranging from 1 to 159 m, with most wells between 30 to 60 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). At greater depths, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al., 1996; McMurry et al., 2003).

MOE WWRs indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the Nipigon 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 Nipigon 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 Nipigon area. Experience in similar geological settings suggests that the potential for deep groundwater resources at repository depths is low throughout the Nipigon area. The absence of groundwater resources at repository depth in the Nipigon area would, however, 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 and illustrated on Figure 5.1 along with the location of currently active mining claims.

The review indicates that there is no evidence of past or present exploration or development activities associated with oil and gas resources and the potential for petroleum hydrocarbon resources in the Nipigon area is negligible. There are no current or past mining operations in the Nipigon area. The potential for metallic minerals resources remains generally low and associated with localized geological formations in the area, such as the Nipigon and the Hele Intrusions, and the contact between the Sibley Group and the underlying gneissic rocks of the Quetico Subprovince. Identified metallic mineralization occurrences in the Nipigon area include: uranium, cobalt-copper-nickel-platinum group metals, silver-lead-zinc, rare metals and radioactive element-enriched pegmatites. All of the known occurrences are considered to be sub-economic. Commercial potential for peat exists in some low-lying areas but no peat extraction has occurred in the Nipigon area (Figure 5.1).

Based on the review of readily available information, the Nipigon 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) Safe containment and isolation of used nuclear fuel. 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 Nipigon 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.

As discussed below, the review of readily available geoscientific information did not identify any obvious geological or hydrogeological conditions that would exclude the Township of Nipigon 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. As shown on Figure 3.3, the Township of Nipigon is largely (about 90%) underlain by Archean metasedimentary gneisses and migmatites of the Quetico Subprovince. The other major rock types in the Nipigon area include mafic intrusives such as the Hele Intrusion and the Nipigon Diabase sills, as well as the sedimentary rocks of the Sibley Group and several granitic bodies. Potential suitability of these various rock types within and at the periphery of the township is assessed in the sections below.

Metasedimentary Rocks (gneisses and migmatites)

In addition to underlying most of the Township of Nipigon, the Archean metasedimentary rocks extend to the north, west and east of the Township of Nipigon and have an estimated thickness of up to 18 km (Culshaw et al., 2006; Percival et al., 2006). While there is no information on the degree of homogeneity of these metasedimentary rocks at repository depth, the high degree of metamorphism and partial melting they have experienced in the past would suggest that their physical characteristics could be similar to those of granitic rock. Therefore, the metasedimentary rocks, except in the vicinity of major mapped faults, such as the Black Sturgeon River Fault Zone, warrant further consideration as potentially suitable for hosting a deep geological repository.

Granitic Intrusions

There are a number of granitic intrusions in the Nipigon area occurring mostly along the eastern side of the Black Sturgeon River to the east and northeast of the Nipigon area (Figure 3.3). They are either biotite-bearing granodiorite to granite intrusions or Musocovite-bearing intrusions. They vary in size from elongated bodies with typical width of only 1 km to massive irregularly shaped bodies with areas up to 38 km^2. One of these intrusions, approximately 10 km long and 2 km wide, occurs further east of the Black Sturgeon River some 5 km north of the Township of Nipigon. Some of these granitic intrusions warrant further consideration as potentially suitable host formations, as they seem to have favourable geological characteristics and sufficient lateral extent away from mapped faults. However, further studies would be needed to assess whether they have sufficient thicknesses to accommodate a deep geological repository.

The Hele Intrusion and the Nipigon Diabase Sills

The Hele Intrusion occurs southwest of the Township of Nipigon and extends to the west. It has an estimated maximum thickness of approximately 130 m and does not extend to repository depth. A deep geological repository in this area would necessarily have to be developed in the underlying metasedimentary rocks, which would be difficult to adequately characterize due to the overlying Hele Intrusion. Therefore, the area of the Hele Intrusion is also excluded from further consideration. The Nipigon Sills in the Nipigon area are mapped in several localized areas at surface (Figure 3.3). These are approximately 100 m thick layers of intrusive rocks. The mafic intrusives are considered unsuitable as a potential host rock as they generally do not extend to repository depths.

Sedimentary Rocks of the Sibley Group

The Sibley Group sedimentary rocks occur in the south-central part of the Township of Nipigon and to the south, west and northeast outside the township. They overlay the metasedimentary rocks that form most of the rock at repository depth in the Nipigon area (Figure 3.3). The sedimentary rocks of the Sibley Group are estimated to be approximately 200 m thick in the Nipigon area. An approximately 500 m deep geological repository in these areas would necessarily have to be developed in the underlying metasedimentary rocks. One of the key criteria in assessing the suitability of a site relates to having a host rock that is amenable to site characterization in order to develop a good understanding of the geoscientific characteristics of the site and a robust safety case. Because of the nature of the structural characteristics of these metasedimentary rocks (e.g., fracture geometry and frequency), the presence of the overlying 200 m thick sedimentary rocks would greatly reduce the ability to adequately characterize them at repository depth. Therefore, all the areas within and outside the township that are covered by the sedimentary rocks of the Sibley Group are excluded from further consideration.

From a hydrogeological point of view, the review of readily available information did not reveal the existence of known deep fracture systems or deep aquifers in the Nipigon area. 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, 2000, 2004).

Summary

In summary, the review indicates that the Township of Nipigon and its periphery contain areas with no known obvious geological and hydrogeological conditions that would fail the containment and isolation requirements.

This would need to be confirmed through subsequent evaluation phases. The Nipigon area is largely (about 90%) underlain by metasedimentary rocks (gneisses and migmatites) that are potentially suitable for hosting a deep geological repository. The Nipigon area also contains a number of granitic intrusions to the north and northwest of the township that are potentially suitable. 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 Nipigon area. As discussed below, the review of readily available information did not reveal any obvious characteristics that would raise such concerns.

The Township of Nipigon is located within the Superior Province of the Canadian Shield, where large portions of land have remained tectonically stable for more than two billion years (Percival and Easton, 2007). As discussed in Sections 3.1 and 3.2, fault zones have been identified in the Nipigon area; however, there is no evidence to suggest these faults have been tectonically active within the past 1.1 billion years. Although a number of low magnitude seismic events have been recorded in the area over the past 25 years, there are no earthquakes on record of magnitude greater than 3 occurring in the region dating back to 1627.

The geology of the Nipigon 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 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 approximately 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 typically ancient features. Subsequent geological processes such as plate movement and continental glaciations 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 Nipigon 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 Nipigon 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 Nipigon area. However, there is abundant information at other locations of the Canadian Shield that could provide insight into what should be expected for the Nipigon area in general. Available information suggests that granitic and gneissic crystalline rock formations within the Canadian Shield generally possess good geomechanical characteristics that are 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). As such, it is expected that the gneissic metasedimentary and granitic intrusive rocks of the Nipigon area have good potential to meet the constructability requirements.

The review of readily available information on the bedrock geology and Quaternary geology for the Nipigon area (Sections 3.2 and 3.5) did not indicate any obvious conditions which could make the rock mass unusually difficult to characterize, although such conditions may exist in localized areas. The degree to which these factors such as overburden thickness might affect the characterization and data interpretation activities would require further assessment during subsequent site evaluation stages, provided that the community remains interested in continuing with the site selection process.

Based on a review of readily available geological and hydrogeological information, the Nipigon 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 Nipigon area against five initial screening criteria using readily-available information. The initial screening focused on the Township of Nipigon and its periphery, which are referred to as the "Nipigon area" in this report. Areas within or in closer proximity of neighbouring townships were not included in the initial screening. 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 Nipigon from further consideration in the NWMO site selection process. The initial screening indicates that there are large areas within the Township of Nipigon and its periphery that are potentially suitable for hosting a deep geological repository. The geology of these areas is dominated by metasedimentary rocks that extend to the northwest and north of the township boundaries. There are also several sufficiently large granitic intrusions to the north and northwest of the township that are potentially suitable. 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 Nipigon area, but rather to identify whether there are any obvious conditions that would exclude it from the site selection process. Should the community of Nipigon 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 Nipigon 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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Voorhis, E. 1930. Historic Forts and Trading Posts of the French Regime and of the English Fur Trading Companies. Canadian Department of the Interior Natural Resources Intelligence Branch, Ottawa.

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Williams, H. R. 1991. Quetico Subprovince; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, pp. 383-403.

9.0 REPORT SIGNATURE PAGE

GOLDER ASSOCIATES LTD.

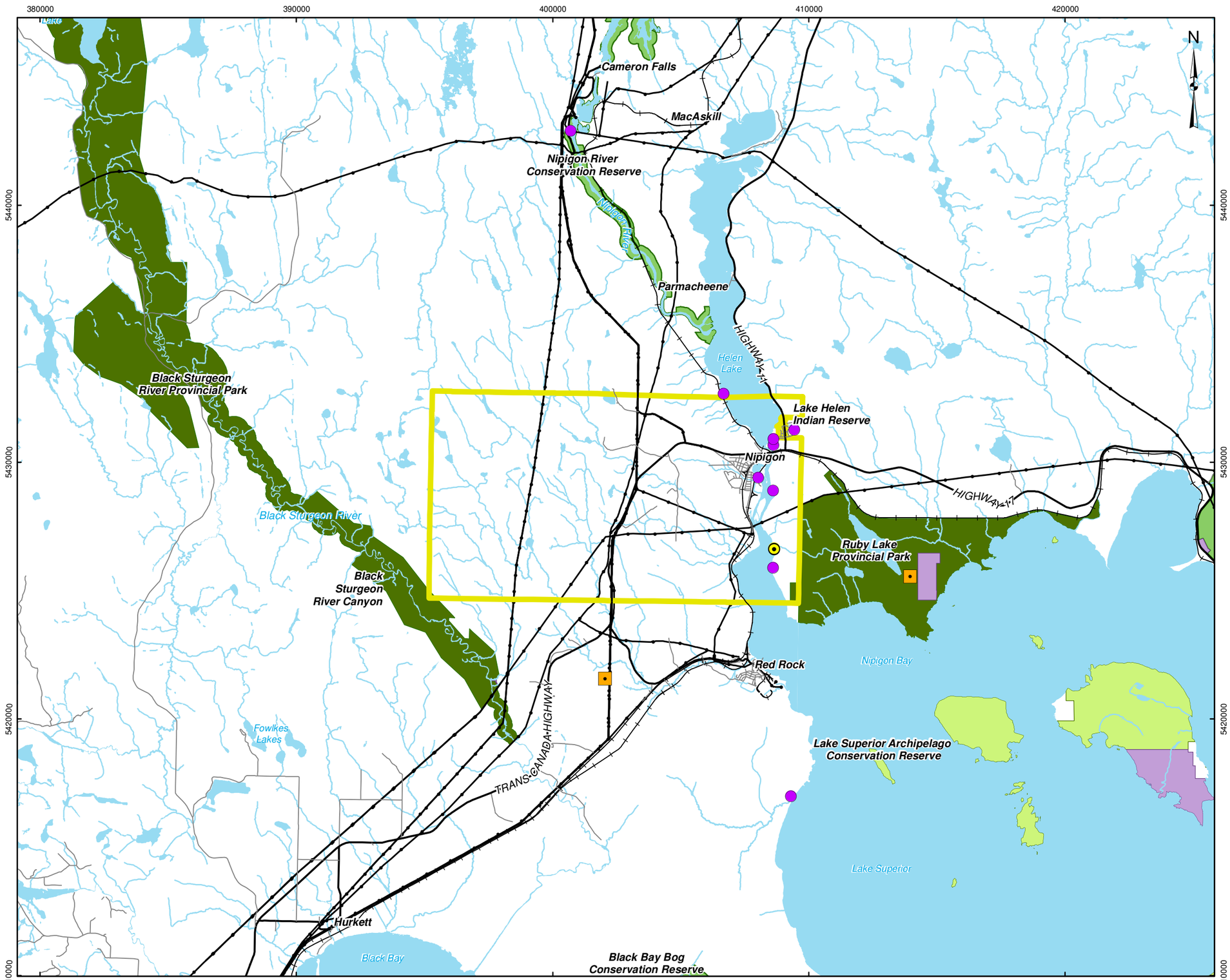
Charles Mitz, M.Eng., P.Geo.
Senior Geoscientist

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

CWM/GWS/wlm

c:\gws-work\1 - active\10-1152-0110 nwmo-initial screenings-on gws\9000 nipigon\07 final report\10-1152-0110 9000 rpt final nipigon 2 feb 2012 r2.docx

FIGURES



LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Watercourse, Permanent
- Watercourse, Intermittent
- Water Area, Permanent
- Registered Archaeological Site
- Pictograph Site
- Approximate Historic Post Location
- Recommended Conservation Reserve
- Forest Reserve
- Conservation Reserve
- Provincial Park

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Heritage Data - Historic Sites of Canada - Ontario Ministry of Tourism and Culture; Ontario Archaeological Sites Database; Ontario Heritage Trust
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 16N

2.5 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011	FIGURE: 2.1	
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

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LEGEND

- Township of Nipigon
- Road
- Water Area, Permanent

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
Imagery: Spot 5 , Obtained from Geobase (2005 to 2008, 10 m resolution)
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 16N

2.5 1.25 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Satellite Imagery of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 2.2

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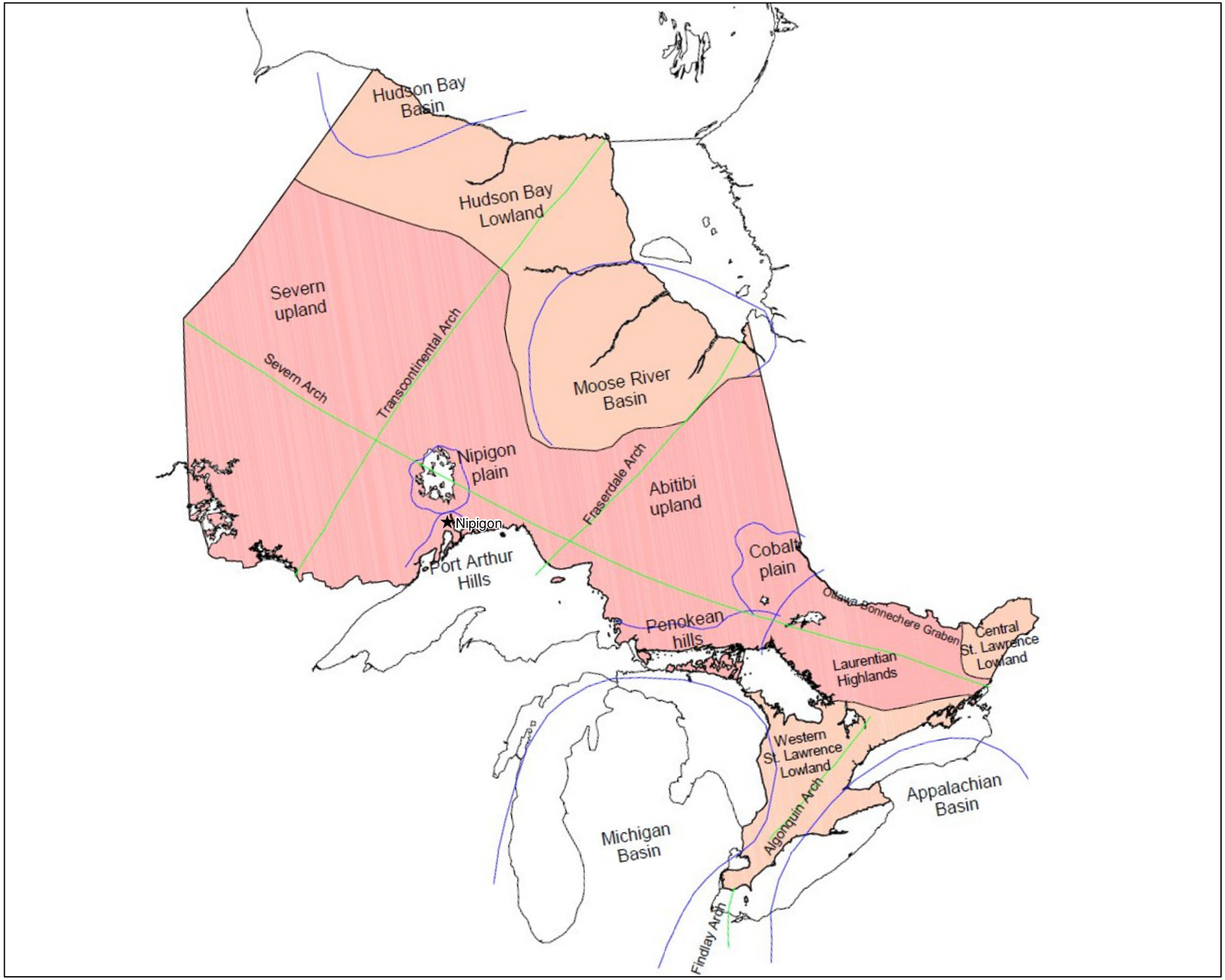

LEGEND

- ★ Township of Nipigon
- Arch
- Basin Boundary
- Phanerozic Borderlands
- Precambrian Canadian Shield

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	PB	30 Aug. 2010	**FIGURE: 2.3**	
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

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380000 390000 400000 410000 420000

5440000 5430000 5420000 5410000

Eskwanonwatin Lake
Mound Lake
Purdom Lake
Cameron Falls
HIGHWAY 11
Nipigon River
Helen Lake
Eagle Mountain
Moseau Mountain
Lake Helen Indian Reserve
Nipigon
HIGHWAY 11
Black Sturgeon River
Black Sturgeon River Canyon
Nipigon Bay
Red Rock
TRANS CANADA HIGHWAY
Fowlkes Lakes
Lake Superior
Wolf Lake
Hurkett
Black Bay

N

LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Water Area, Permanent
- Wetland, Permanent

Elevation Model (masl)

585
500
400
300
200
180

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 16N

2.5 1.25 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Digital Elevation Model (DEM) of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
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REVIEW	GS	1 Feb. 2012		

FIGURE: 2.4

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380000 390000 400000 410000 420000

5440000 5430000 5420000 5410000

Eskwanonwatin Lake
Mound Lake
Purdom Lake
Cameron Falls
HIGHWAY-11
Eagle Mountain
Helen Lake
Lake Helen Indian Reserve
Moseau Mountain
Nipigon
HIGHWAY-17
Black Sturgeon River
Moseau Creek
Little Trout River
Big Trout River
Nipigon River
Red Rock
Nipigon Bay
Fowlkes Lakes
TRANS-CANADA-HIGHWAY
Lake Superior
Wolf Lake
Hurkett
Black Bay

N

LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Watercourse, Permanent
- Watercourse, Intermittent
- Water Area, Permanent
- Wetland, Permanent
- Wooded Area
- Surface Water Flow Direction
- Minor Contour (10m)
- Major Contour (50m)
- Subcatchment Boundary

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 16N

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SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Drainage Features of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011	FIGURE: 2.5	
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

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100000
1100000
2100000
7000000
6000000
5000000

N

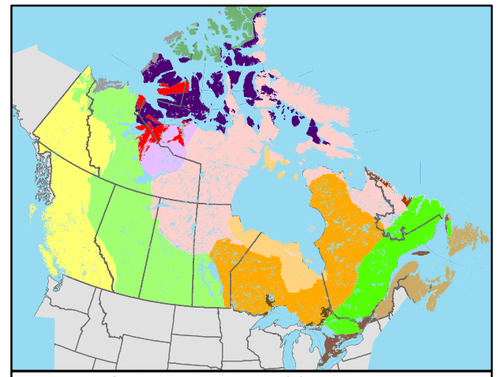
SUGLUK
CAPE SMITH BELT
LABRADOR TROUGH
Minto
Hudson Bay
James Bay
Thompson Belt
TRANS-HUDSON OROGEN
Manitoba
Ontario
Pikwitonei
Winisk
Sachigo
SUPERIOR PROVINCE
Berens River
Uchi
English River
Bird River
Winnipeg River
Wabigoon
Canada
USA
Quetico
Wawa
Minnesota River Valley
Kapuskasing Structural Zone
Opatica
Abitibi
Bienville
Ashuanipi
La Grande River
Opinaca River
Nipigon
SOUTHERN PROVINCE
Lake Superior
Lake Michigan
Lake Huron
Lake Ontario
Pontiac
GRENVILLE PROVINCE
Quebec
Ontario
Canada
USA

LEGEND

- Township of Nipigon
- Provincial Boundary
- International Boundary
- Limit of Exposed Archean Rock
- Southern Province

Superior Province (Archean)

- Sub-Province Gneissic - Plutonic
- Sub-Province Plutonic
- Sub-Province Metasedimentary
- Sub-Province Volcanic - Plutonic



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

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SCALE 1:9,500,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Subdivisions of the Superior Provinces of the Canadian Shield

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.1

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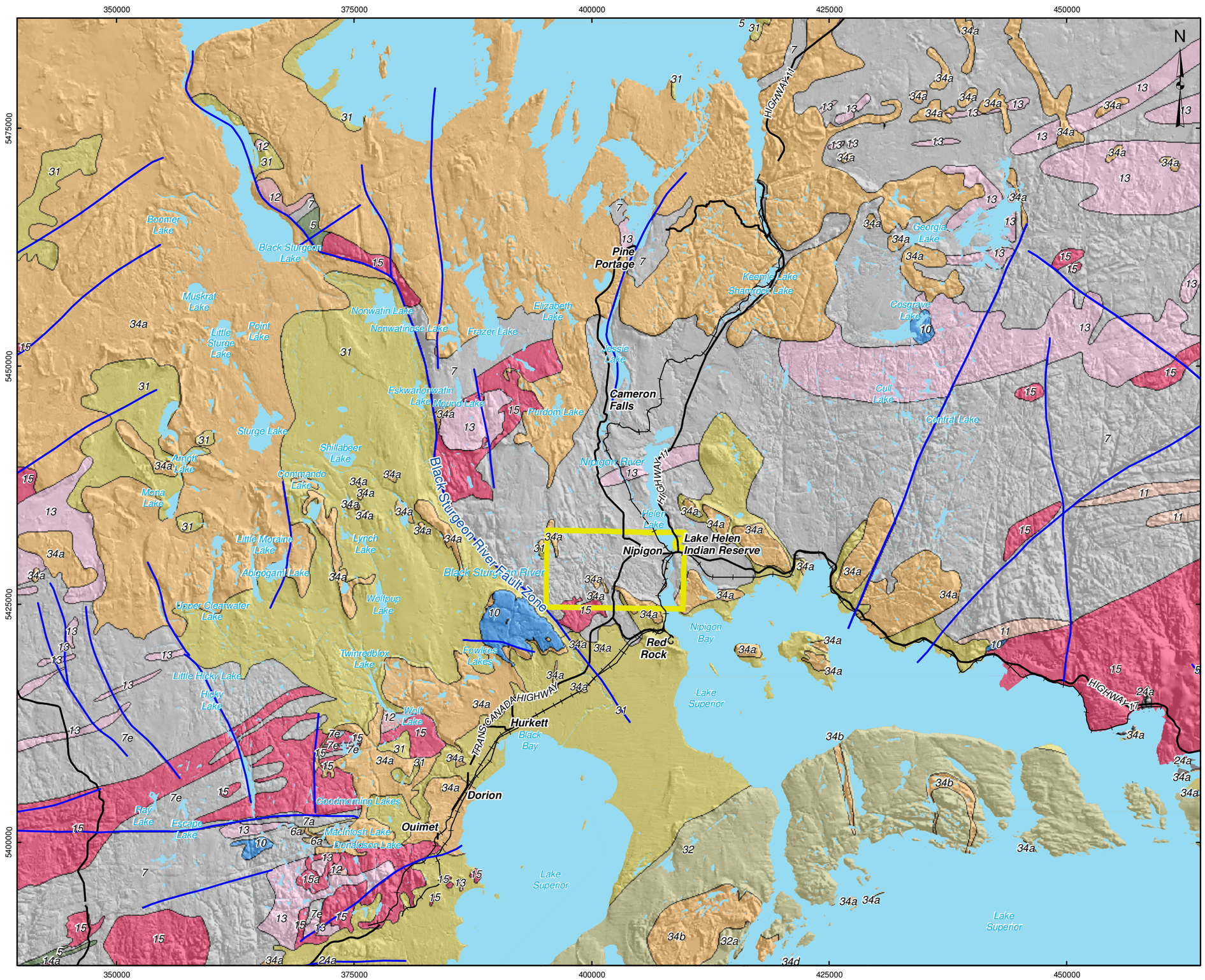

LEGEND

- Township of Nipigon
- Main Road
- Railway
- Utility Line
- Water Area, Permanent
- Geological Fault

Southern Province

- 34 Mafic and related intrusive rocks (Keweenawan age)
  - 34a Logan and Nipigon sills (1109 Ma): diabase sills
  - 34b Pigeon River and Pukaskwa swarms: diabase dikes
- 32 Osler Gp., Maminse Point Fm., Michipicoten Island Fm.
  - 32a Basalt and associated conglomerate and arkose
- 31 Sibley Gp.

Superior Province (Quetico Subprovince)

- 15 Massive granodiorite to granite
  - 15a Potassium feldspar megacrystic units
- 14-Diorite-monzodiorite-granodiorite suite
  - 14a Diorite, monzonite, quartz monzonite
- 13 Muscovite-bearing granitic rock
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 7 Metasedimentary rocks (Paragneisses and Migmatites)
- 6 Felsic to intermediate metavolcanic rocks
  - 6a Dacitic and Andesitic flows, tuffs and breccias
- 5 Mafic to intermediate metavolcanic rocks

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4;
DEM - MRN LIO Digital Elevation Model Version 1.1.0 - 2005
Geology: 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 modified based on detailed mapping published by Hart (2005)
Produced by Golder Associates Ltd under licence from
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

10 5 0 10 20
SCALE 1:400,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Regional Bedrock Geology of Nipigon and Surrounding Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.2

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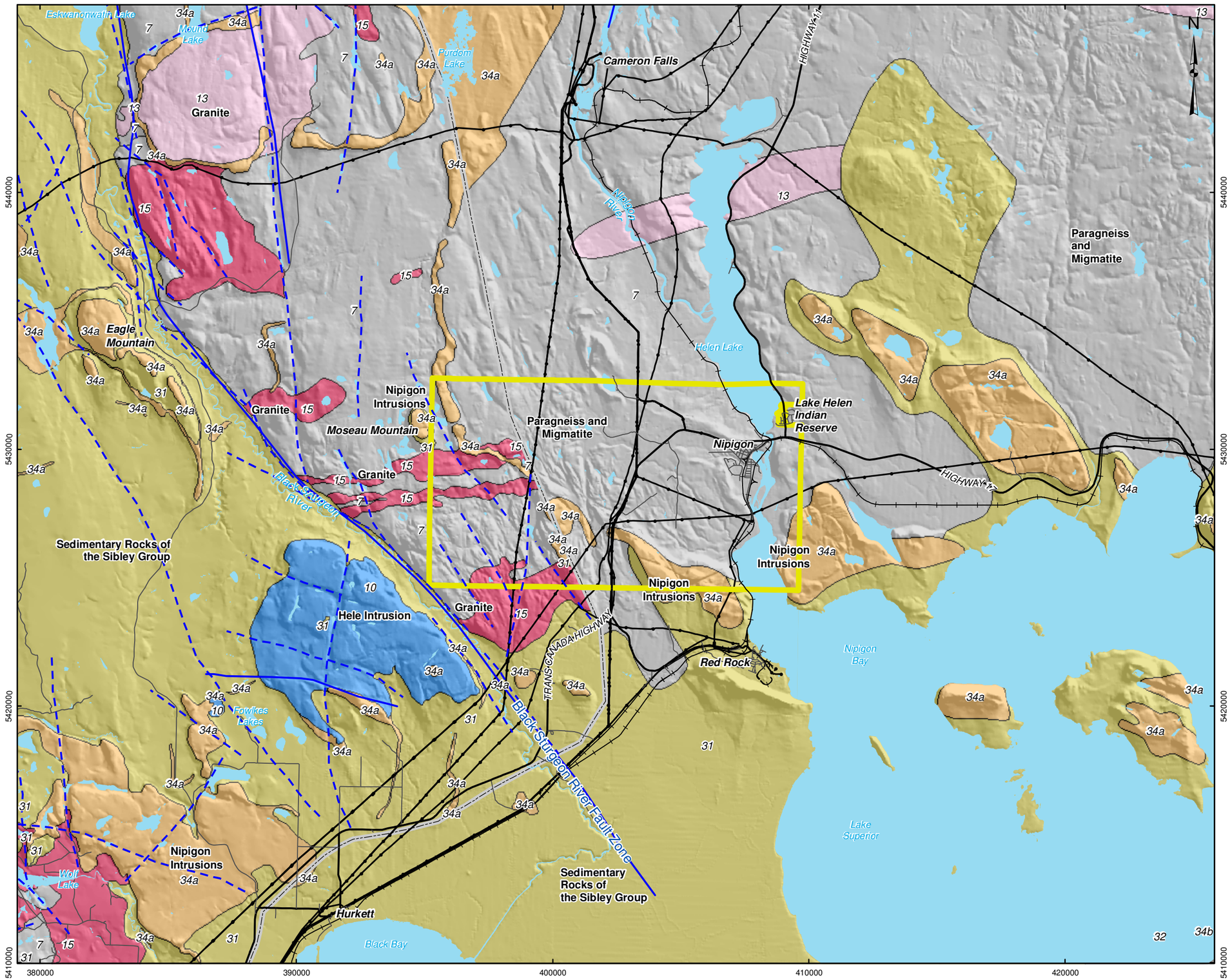

LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Water Area, Permanent
- Geological Fault
- Lineament / Fault (Hart, 2005)
- Eastern Limit of Mapping by Hart (2005)

Southern Province

- 34 Mafic and related intrusive rocks (Keweenawan age)
- 34a Logan and Nipigon sills (1109 Ma): diabase sills
- 31 Sibley Gp.

Superior Province (Quetico Subprovince)

- 15 Massive granodiorite to granite
- 15a Potassium feldspar megacrystic units
- 13 Muscovite-bearing granitic rock
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 7 Metasedimentary rocks (Paragneisses and Migmatites)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
DEM - MRN LIO Digital Elevation Model Version 1.1.0 - 2005
Geology: Modified 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 - incorporating detailed mapping published by Hart (2005)
Produced by Golder Associates Ltd under licence from
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

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SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Bedrock Geology of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.3

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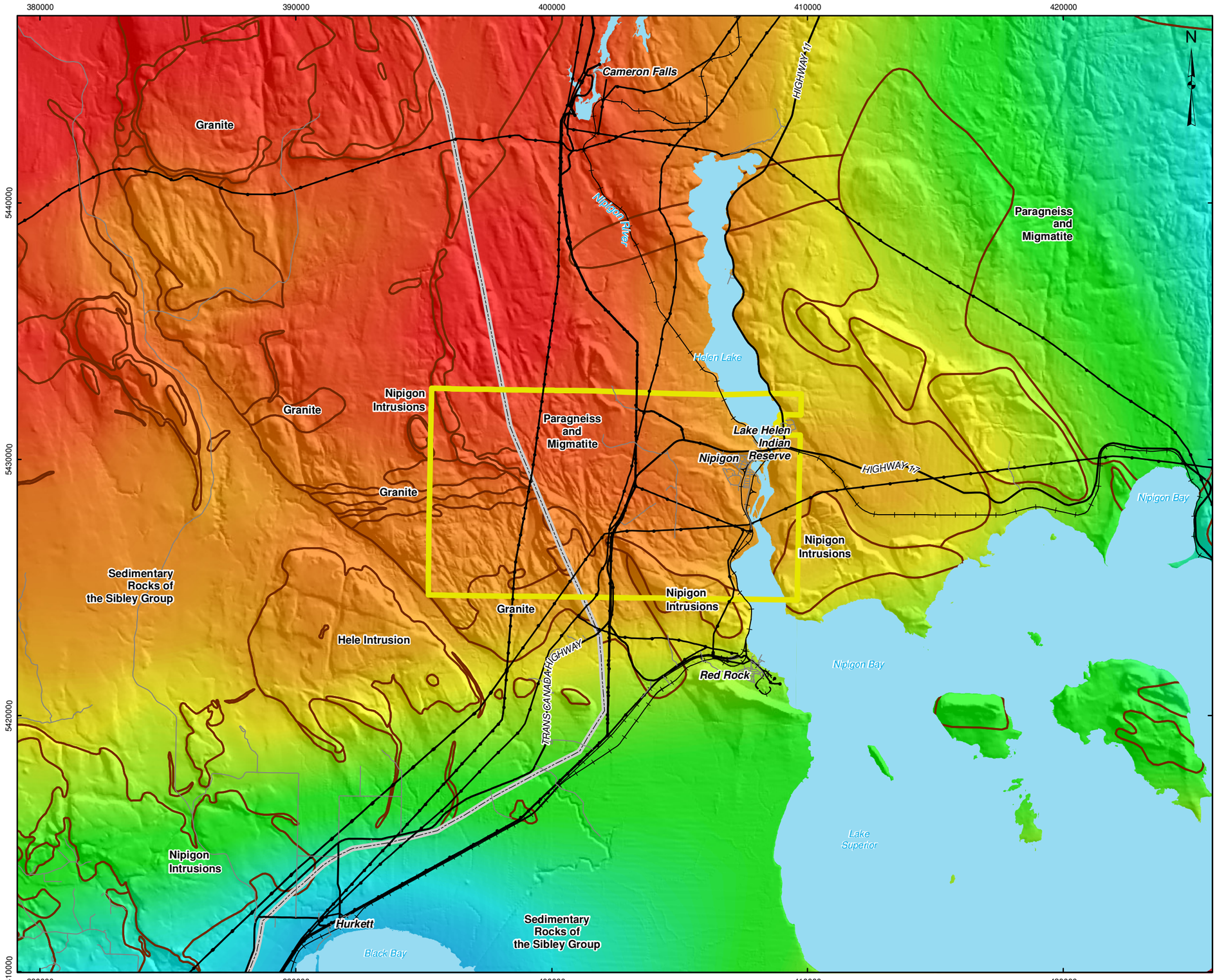
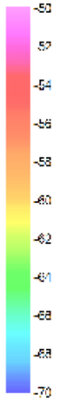


LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Eastern Limit of Mapping by Hart (2005)
- Water Area, Permanent
- Geological Contact

Gravity Anomaly (mGal)



REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4; DEM - MRN LIO DEM Version 1.1.0 - 2005
Geophysics: Ontario Prospectors Association, 2004. Ground Gravity Survey Lake Nipigon Geoscience Initiative; Ont. Geological Survey, GDS1052 - Survey Data Spacing - variable between 0.25 and 1.0 km
Geology: Modified 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 - incorporating detailed mapping published by Hart (2005)
Produced by Golder Associates Ltd under licence from Ontario MNR, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

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SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Gravity Map of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	JF	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.4

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380000 390000 400000 410000 420000

5440000 5430000 5420000 5410000

Granite
Granite
Granite
Granite
Cameron Falls
HIGHWAY 11
Nipigon River
Paragneiss and Migmatite
Helen Lake
Nipigon Intrusions
Paragneiss and Migmatite
Lake Helen Indian Reserve
Nipigon
HIGHWAY 17
Nipigon Bay
Nipigon Intrusions
Nipigon Intrusions
Sedimentary Rocks of the Sibley Group
Hele Intrusion
TRANS-CANADA HIGHWAY
Red Rock
Nipigon Bay
Lake Superior
Nipigon Intrusions
Hurkett
Black Bay
Sedimentary Rocks of the Sibley Group

N

LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Eastern Limit of Mapping by Hart (2005)
- Limit of High Resolution Geophyics Data
- Water Area, Permanent
- Geological Contact

Residual Total Magnetic Field (nT)

490
420
350
280
210
140
70
0
-70
-140
-210
-280
-350

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4; DEM - MRN LIO DEM Version 1.1.0 - 2005
Geophysics: Ontario Geological Survey 2004 - Survey Data Spacing: 800 m. Ontario airborne geophysical surveys, magnetic and gamma-ray spectrometer data, Lake Nipigon Embayment Area;
Geophysical Data Set1047 - Survey Data Spacing: 150 m
Geology: Modified 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 - incorporating detailed mapping published by Hart (2005)
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

2.5 1.25 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Residual Total Magnetic Field of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
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REVIEW	GS	1 Feb. 2012		

FIGURE: 3.5

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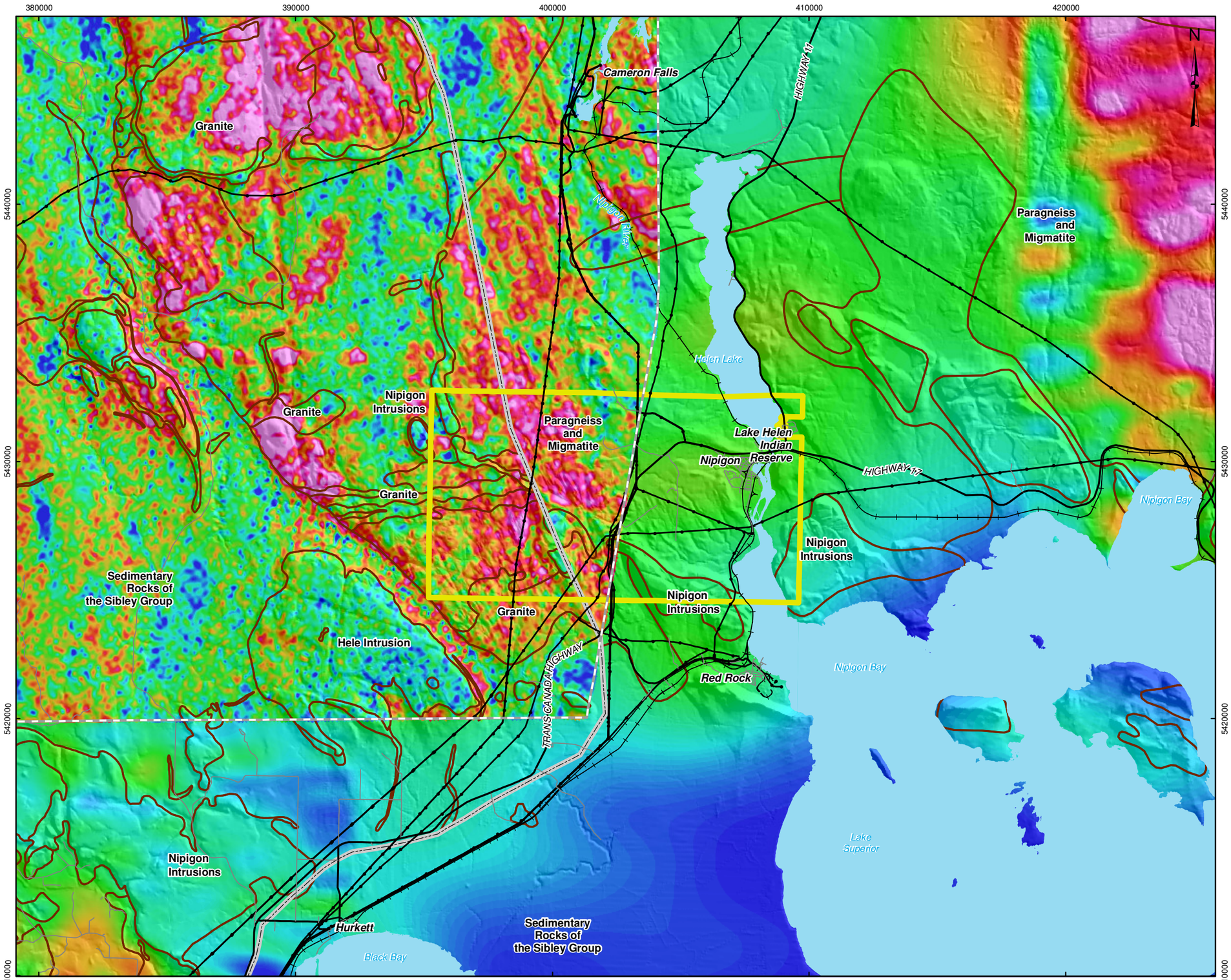
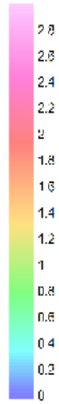


LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- Eastern Limit of Mapping by Hart (2005)
- Limit of High Resolution Geophyics Data
- Water Area, Permanent
- Geological Contact

Equivalent Uranium (ppm)



REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4; DEM - MRN LIO DEM Version 1.1.0 - 2005
Geophysics: Ontario Geological Survey 2004 - Survey Data Spacing: 800 m. Ontario airborne geophysical surveys, magnetic and gamma-ray spectrometer data, Lake Nipigon Embayment Area;
Geophysical Data Set1047 - Survey Data Spacing: 150 m
Geology: Modified 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 - incorporating detailed mapping published by Hart (2005)
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

2.5 1.25 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Equivalent Uranium of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
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REVIEW	GS	1 Feb. 2012		

FIGURE: 3.6

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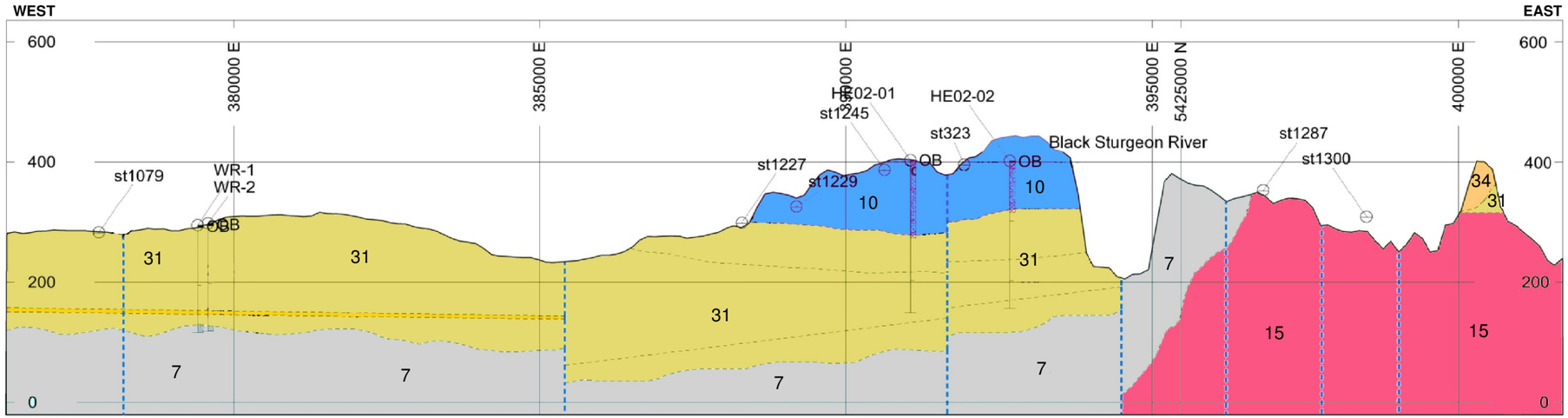
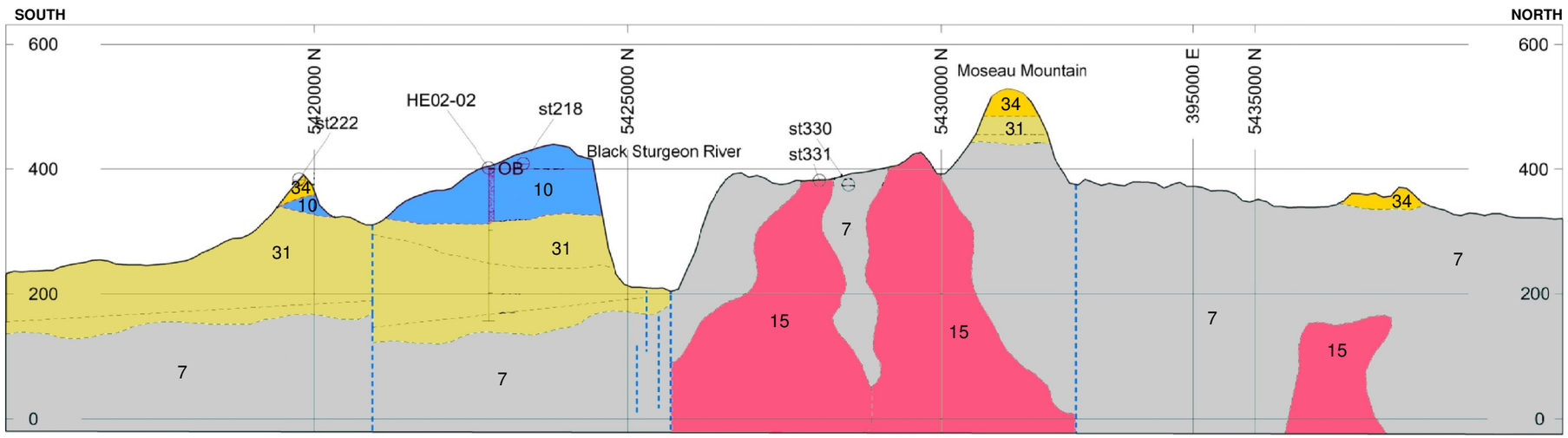
SECTION B-I

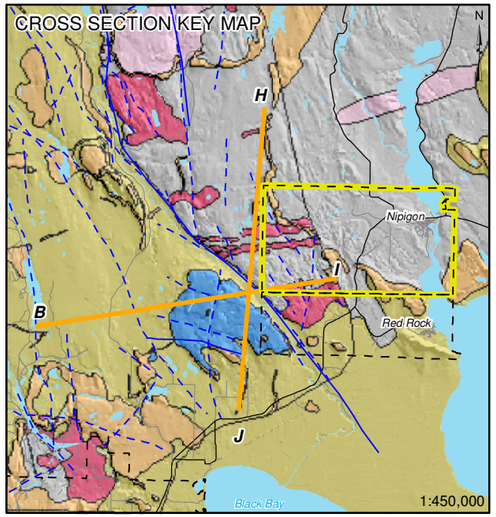


SECTION J-H



LEGEND

- Fault; Unknown Vertical Component (trend only, interpreted)
- 34 - Mafic Intrusive Rocks (Nipigon Sills)
- 31 - Sibley Group Sedimentary Rocks
- 15 - Biotite Granite Suite
- 10 - Mafic to Ultramafic Intrusive Rocks
- 7 - Gneissic to Migmatitic Suite



REFERENCE

Hart, 2005, Precambrian Geology of the Southern Black Sturgeon River and Seagull Lake Area

PROJECT

NWMO Desktop Level Initial Screening

TITLE

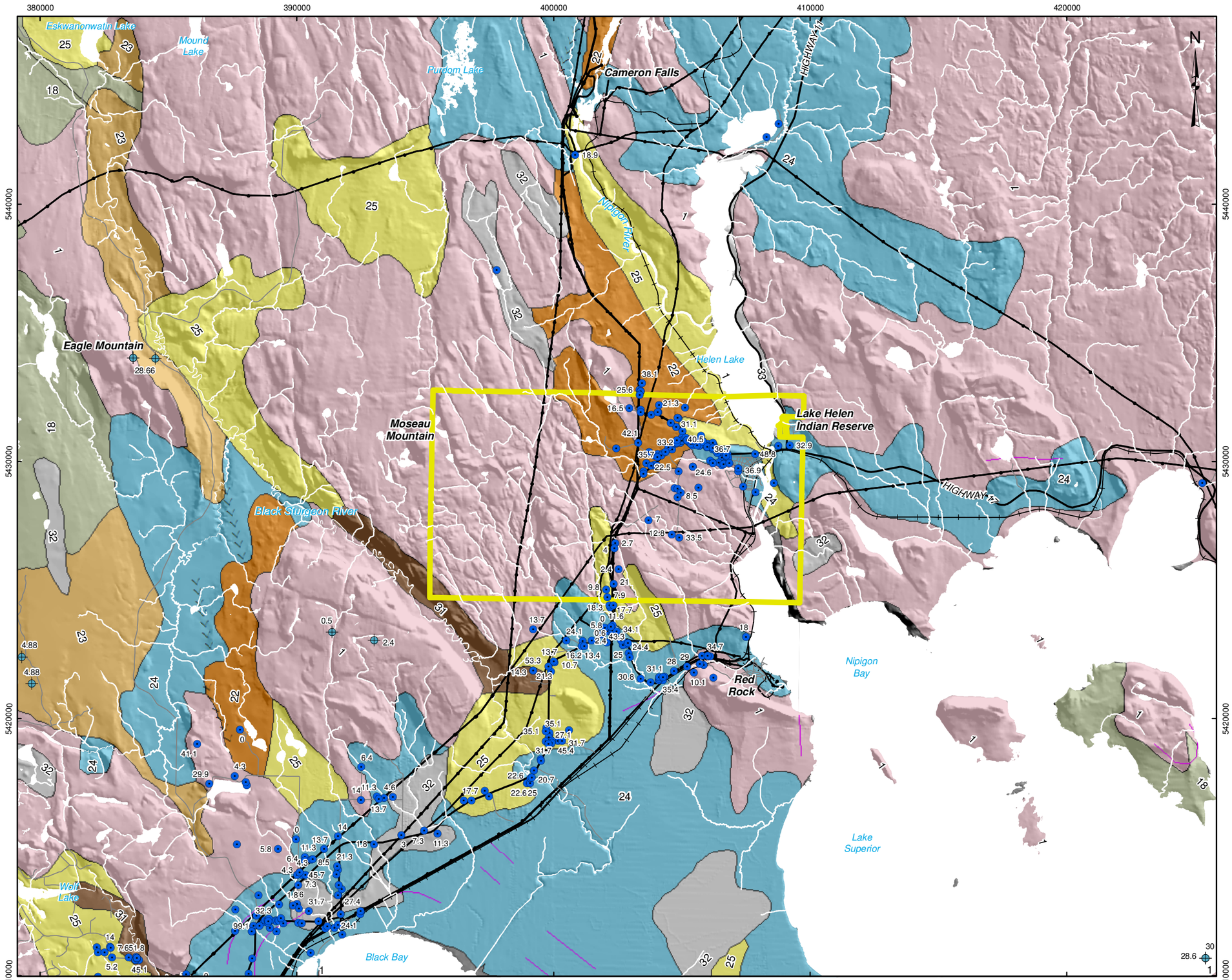
Conceptual Geological Cross Sections Near Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.7

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase9000\ConceptualGeologicalCrossSection.mxd



LEGEND

- Township of Nipigon
- Main Road
- Local Road
- Railway
- Utility Line
- MOE Well Location (Overburden Thickness - m)
- Diamond Drill Hole (Overburden Thickness - m)
- Esker or Area of Eskers
- Drumlin or Area of Drumlins
- Terrace Escarpment (Abandoned Shore Bluff)
- Terrace Escarpment; Fluvial
- Trend of End Moraine Crest
- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice - Contact Deposits
- 23: Glaciofluvial Outwash deposits
- 24: Glaciolacustrine Deposits – Fine Grained
- 25: Glaciolacustrine Deposits – Coarse Grained
- 28: Fluvial Deposits - Pleistocene
- 31: Fluvial Deposits - Recent
- 32: Organic deposits
- 33: Water Area

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
DEM - MNR LIO Digital Elevation Model Version 1.1.0 - 2005
Geology: Modified Quaternary geology, seamless coverage of the province of Ontario:
Ontario Geological Survey, Data Set 14
Ontario Drill Holes: Ontario Geological Survey, Data Set 13-Revision 1. December 2005 Release
Wells: Ontario Ministry of the Environment, Water Well Database, 2010
Produced by Golder Associates Ltd under licence from Ontario MNR, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

2.5 1.25 0 2.5 5 7.5
KILOMETRES
SCALE 1:150,000

PROJECT
NWMO Desktop Level Initial Screening

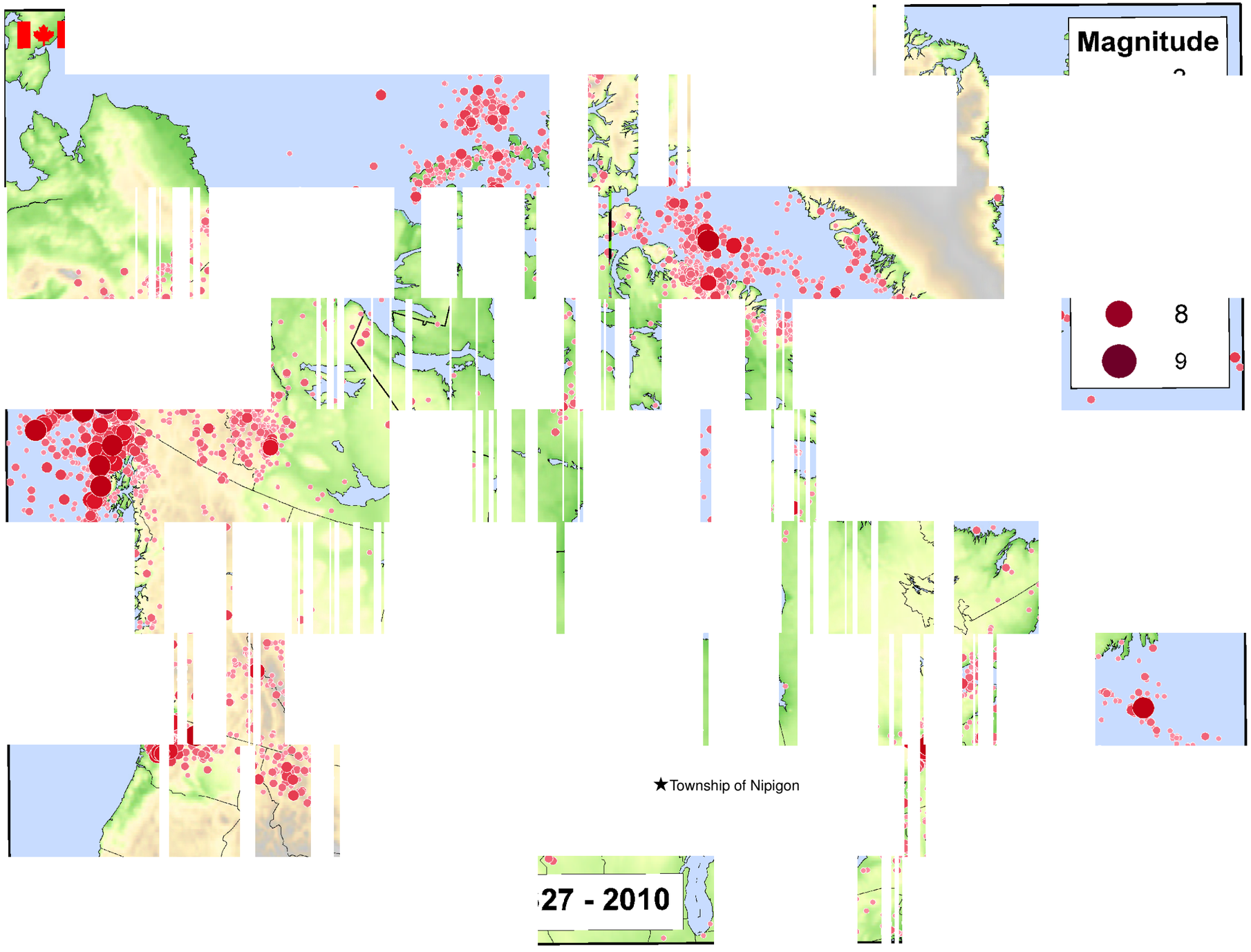
TITLE
Quaternary Geology of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	27 Jan. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.8

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase9000\QuaternaryGeologyNipigon.mxd



LEGEND

★ Township of Nipigon

REFERENCE

Base Data - ESRI Digital Chart of the World,2010
Seismic: Resources Canada (NRC). Earthquakes Canada
Website. http://earthquakescanada.nrcan.gc.ca

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Earthquakes Map of Canada 1627-2010

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PB	30 Aug. 2010		
GIS	PRM	1 Feb. 2012		
CHECK	JF	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 3.9

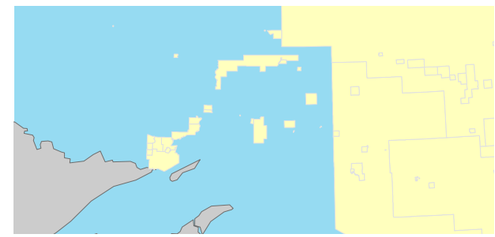
G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase9000\EarthquakesMapofCanada1627to2010.mxd

380000 390000 400000 410000 420000

5440000 5430000 5420000 5410000

Eskwanonwatin Lake
Mound Lake
Purdom Lake
Cameron Falls
HIGHWAY 11
Nipigon River
HIGHWAY 585
Helen Lake
Lake Helen Indian Reserve
Black Sturgeon River
HIGHWAY 17
Wolf Lake
HIGHWAY 582
Hurkett
Black Bay
HIGHWAY 628
Red Rock
Nipigon Bay
Lake Superior
N

LEGEND



Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
DEM - MRN LIO Digital Elevation Model Version 1.1.0 - 2005
Geology: Modified Quaternary geology, seamless coverage of the province of Ontario: Ontario Geological Survey, Data Set 14
Wells: Ontario Ministry of the Environment, Water Well Database, 2010
Produced by Golder Associates Ltd under licence from Ontario MNR, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

PROJECT
NWMO Desktop Level Initial Screening

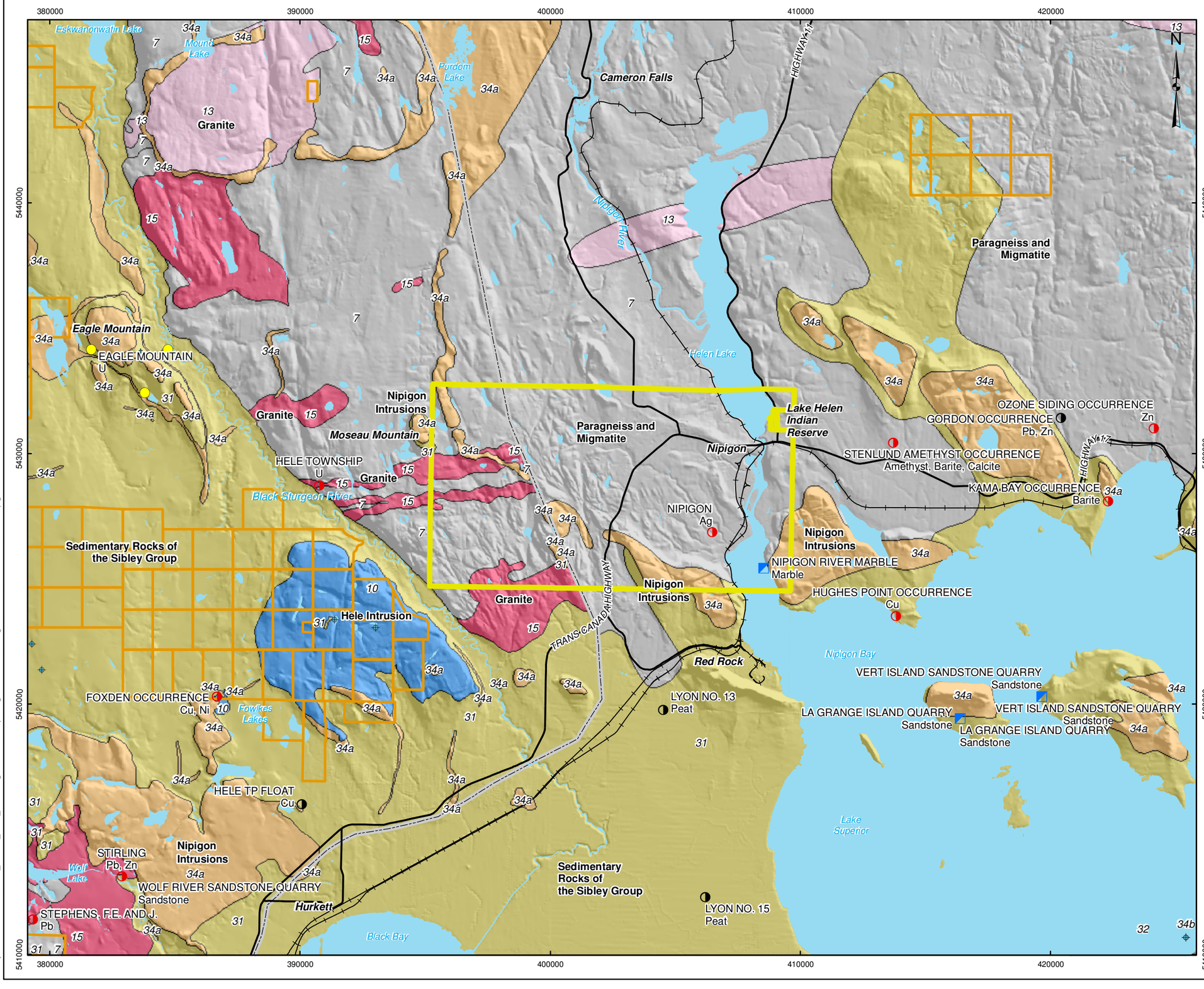
TITLE
Water Well Records of the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011		
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

FIGURE: 4.1

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\ReportingPhase9000\WaterWellRecordsoftheNipigonArea.mxd



LEGEND

- Township of Nipigon
- Main Road
- Railway
- Water Area, Permanent
- Discretionary Occurence (Golder)
- Discretionary Occurence (OGS)
- Occurence
- Past Producing Mine with Reserves
- Diamond Drill Hole
- Eastern Limit of Mapping by Hart (2005)
- Active Mining Claims

Southern Province

- 34 Mafic and related intrusive rocks (Keweenawan age)
- 34a Logan and Nipigon sills (1109 Ma): diabase sills
- 31 Sibley Gp.

Superior Province (Quetico Subprovince)

- 15 Massive granodiorite to granite
- 15a Potassium feldspar megacrystic units
- 13 Muscovite-bearing granitic rock
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 10a Gabbro
- 10b Anorthosite
- 7 Metasedimentary rocks (Paragneisses and Migmatites)

REFERENCE

Base Data - MNR NRVIS, obtained 2009, CANMAP v2006.4
DEM - MRN LIO Digital Elevation Model Version 1.1.0 - 2005
Claims - Ministry of Northern Development and Mines January 2012
Mineral Inventory - Mineral Deposit Inventory of Ontario v2, 2004
Ontario Drill Hole Database: Dec. 2005 Release, Ontario Geological Survey, Data Set 13-Revision 1.
Geology: Modified 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126 - incorporating detailed mapping published by Hart (2005)
Produced by Golder Associates Ltd under licence from Ontario MNR, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

2.5 1.25 0 2.5 5 7.5
SCALE 1:150,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Mining Claims and Mineral Potential in the Nipigon Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	22 Nov. 2011	FIGURE: 5.1	
GIS	PRM	1 Feb. 2012		
CHECK	CM	1 Feb. 2012		
REVIEW	GS	1 Feb. 2012		

G:\Projects\201010-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase9000\MiningClaimsandMineralPotentialintheNi

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