nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

October 17, 2012

The Township of White River
P.O. Box 307, 102 Durham Street
White River, ON P0M 3G0

Attn: Ms. Marilyn Parent-Lethbridge, Clerk/Administrator

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

Dear Ms. Parent-Lethbridge,

Further to the Township of White River'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 White River 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 White River from further consideration in the NWMO site selection process. The initial screening suggests that the White River area comprises geological formations 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 White River 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, White River 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

Cc: Mayor Angelo Bazzoni

October 2012

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

Township of White River, Ontario

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

REPORT

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EXECUTIVE SUMMARY

On April 11, 2012 the Township of White River expressed interest in learning more about the Nuclear Waste Management Organization (NWMO) site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel (NWMO, 2010). This report summarizes the findings of an initial screening, conducted by Golder Associates Ltd., to evaluate the potential suitability of the White River 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 White River from further consideration in the site selection process. The initial screening focused on the Township of White River and its periphery, which are referred to as the "White River area" in this report.

The five initial screening criteria are defined in the site selection process document (NWMO, 2010) and relate to: having sufficient space to accommodate surface and underground facilities, being outside protected areas and heritage features, the absence of known groundwater resources at repository depth, absence of known natural resources, and avoiding areas having known hydrogeologic and geologic conditions that would make it unsafe 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 White River from further consideration in the NWMO site selection process. The initial screening indicates that the White River area contains large portions of land with geological formations that are potentially suitable for hosting a deep geological repository. Examples of these formations include the Pukaskwa and Black Pic Batholiths, the Danny Lake Stock, and the Anahereo Lake Pluton.

It is important to note that the intent of this initial screening is not to confirm the suitability of the White River 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 White River remain interested in continuing with the site selection process, more detailed studies would be required to confirm and demonstrate whether the White River 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.

A brief summary of the assessment results for each of the initial screening criteria is provided below.

Availability of Land

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

Protected Areas, Heritage Sites, Provincial Parks and National Parks

The White River area contains sufficient land outside of protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities. There are no protected areas in the Township of White River. At the periphery of the Township there is one provincial park and three conservation reserves, as well as three candidate ANSIs, which occupy a small portion of the available land. There is one documented archaeological site in the area, one National Historic Site and one Provincial Historic Site. These sites are

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

Absence of Known Groundwater Resources at the Repository Depth

The review of available information did not identify any known groundwater resources at repository depth (approximately 500 m) for the White River area. The Ontario Ministry of Environment (MOE) Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the White River area or anywhere else in Northern Ontario. Water wells in the White River area obtain water from overburden or shallow bedrock aquifers at depths ranging from 5 to 99 m, with most water wells between 15 and 30 m deep. Based on experience in similar crystalline rock settings in the Canadian Shield, the likelihood of the existence of exploitable aquifers at typical repository depth in the White River area is considered low. 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 White River area contains sufficient land, free of known economically exploitable natural resources, to accommodate the required repository facilities. The potential for mineral resources in the White River area is largely limited to the rocks of the Dayohessarah Greenstone Belt. The granitic rocks in the White River area are considered to have a generally low potential to host economic mineralization. Potential for non-metallic mineral extraction exists in the White River area, but the risk that these resources would pose for future human intrusion is negligible, as quarrying operations would be limited to shallow depths.

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

Based on the review of readily available geoscientific information, the White River area comprises portions of land that do not contain known unsafe geological and hydrogeological conditions. There are a number of geological units with geoscientific characteristics that are potentially suitable for hosting a deep geological repository within the White River area. Examples of these units include the Pukaskwa and Black-Pic Batholiths, the Anahereo Lake Pluton, and the Danny Lake Stock.

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1.0 INTRODUCTION

On April 11, 2012 the Township of White River 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 (Step 2 in the site selection process), conducted by Golder Associates Ltd., to evaluate the potential suitability of the White River area against five screening criteria using readily available information. The initial screening focused on the Township of White River and its periphery, which are referred to as the “White River area” in this report.

1.1 Background

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

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

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

1.2 Objectives and Approach for Conducting Initial Screenings

The 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 regard to potential suitability.

2.0 PHYSICAL GEOGRAPHY

2.1 Location

The Township of White River is located in Northern Ontario, about 300 km east of Thunder Bay and 80 km east of Marathon, near the northeastern end of Lake Superior (index map in Figure 2.1). The Township is approximately 110 km^2 in size. Satellite imagery for the White River area (SPOT 5 panchromatic, taken in 2006 to 2007) is presented on Figure 2.2.

2.2 Topography

The Township of White River is located in the Canadian Shield physiographic region, a low-relief, dome-like, gently undulating land surface. Figure 2.3 shows the general physiographic regions of Ontario (Thurston, 1991), including the subdivision of the Canadian Shield physiographic region into the Severn Upland, the Nipigon Plain, the Abitibi Upland and the Laurentian Highlands.

The Township of White River lies in the Abitibi Highlands, a broadly rolling surface of Canadian Shield bedrock that occupies most of north-central Ontario (Natural Resources Canada (NRC), 2011a). Within the Abitibi Highlands, bedrock is typically either exposed at surface or covered with a relatively thin blanket of Quaternary glacial deposits or post-glacial organic soils (Thurston, 1991).

The topography of the White River area is presented on Figure 2.4. The land surface is generally rugged with elevation exceeding 500 masl to the north, east and southwest of the Township of White River. Lands further to the west and northwest are less rugged and lower in elevation (from 300 to 375 masl).

Topography for most of the Township of White River is relatively flat, mainly in the central area. The land surface becomes more rugged towards the northwest corner of the Township in the Tukanee Lake area, where the highest elevations are found. Here, elevations reach 550 masl and form part of a west-east trending ridge that runs to the north of the Township of White River with elevations from 450 to 550 masl. Elevations exceeding 450 masl also occur north of Whitefish Lake in the southwestern area of the Township. The lowest elevations within the Township occur along the Trans-Canada highway (Highway 17) and the banks of the White River, where they are approximately 300 masl (Figure 2.4). Topographic highs generally correspond to exposed bedrock while topographic lows are typically areas of thicker overburden.

2.3 Drainage

Surface water drainage for the White River area is shown on Figure 2.5. The eastern part of the White River area straddles a drainage divide, which separates the Atlantic Watershed (via Lake Superior and the St. Lawrence River) from the Arctic Watershed (via Hudsons Bay). The Township of White River is located within the Atlantic Watershed.

In much of the southern part of the White River area, drainage is into the White River which flows in a north-westward direction into White Lake (Figure 2.5). In the northern part of the White River area drainage is towards the north ultimately entering White Lake to the north of the White River area. The area draining north includes Kwinkwaga Lake and Dayohessarah Lake. From White Lake water flows towards the southwest into Lake Superior.

2.4 Protected Areas

Parks and Reserves

Figure 2.1 shows the location of protected areas in the White River area, including parks, reserves and Areas of Natural & Scientific Interest (ANSIs). There are no protected areas within the Township of White River. At the periphery of the Township there is one provincial park, three conservation reserves and three candidate ANSIs.

The 18 km^2 Pokei Lake/White River Wetlands Provincial Park is located to the north of Pokei Lake, approximately 2 km south of the Township (Figure 2.1). The Kwinkwaga Ground Moraine Uplands Conservation Reserve covers an area of about 126 km^2 in the northwestern part of the White River area, about 12 km northeast of the Township. It contains two smaller areas of Forest Reserve. To the southeast of the Township is the 5 km^2 Kakakiwibik Esker Conservation Reserve, covering an area of about 9 km^2. Straddling the eastern boundary of the White River area to the northeast is the Strickland River Mixed Forest Wetland Conservation Reserve, covering an area of about 16 km^2.

There are three candidate ANSI areas within the White River area, two of which extend over part of the Pokei Lake/White River Wetlands Provincial Park and the Kakakiwibik Esker Conservation Reserve (Figure 2.1). An additional 23 km^2 candidate ANSI, the Bremner River Wetland, is located to the southwest of the Township.

Heritage Sites

The cultural heritage screening examined known archaeological and historic sites in the White River area, using the Ontario Heritage Trust Database, the Ontario Heritage Properties Database, and the National Historic Sites Database.

There is only one known archaeological site in the White River area. There is also one National Historic Site, the Canadian Pacific Railway Station; and one Provincial Historic site, the Canadian Pacific Railway Superintendent's House (Ontario Heritage Properties Database, 2012; Parks Canada, 2010). Locations of known archaeological, National and Provincial Historic sites are not shown in maps within this report to comply with Ministry of Tourism and Culture publication guidelines.

The Caribou Lodge archaeological site in the White River area lies east of the Township in the Depew River area and was recorded in 1974 by W.A. Fox (von Bitter, 2012). It is uncertain whether the site is pre-contact or historic Aboriginal or Euro-Canadian. Artifacts are scarce but fire cracked rock found at the site suggests a campsite.

The Canadian Pacific Railway Station is a brick-clad railway station comprised of two adjoined parts: a two-storey Telegraph Building built in 1926-27 and expanded in 1930; and a one-storey International-style passenger facility built in 1957 (Parks Canada, 2010). The station is located on Winnipeg Street, between Elgin and Durham Streets in the settlement area of White River. The formal recognition is confined to the railway station building itself. The Railway Superintendent's House, located at 80 Railway Street, served as the home for White River's first C.P.R. Superintendent in the early 1900s. In 1920 it became the residence and office of the town doctor, and remained as such until 1976 when the Medical Clinic was built; however, it was still the residence of the doctor up until 1984 (Ontario Heritage Properties Database, 2012).

Archaeological potential is established by determining 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 primary water courses, including lakeshores, rivers and large creeks, as well as secondary water sources, including swamps and small creeks (Government of Ontario, 2011).

The absence of local protected areas and heritage sites would need to be confirmed in discussion with the community and Aboriginal peoples in the area if the community remains interested in continuing with the site selection process.

3.0 GEOLOGY AND SEISMICITY

3.1 Regional Bedrock Geology

The geology of the White River area consists of a thin layer of unconsolidated Quaternary deposits overlying 3 to 2.4 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 a billion years.

The Township of White River is situated in the Superior Province of the Canadian Shield (Figure 3.1), which covers an area of approximately 1,500,000 km^2 stretching from the Ungava region of Northern Québec through the northern part of Ontario and the eastern portion of Manitoba, and extending south through to Minnesota and the northeastern part of South Dakota. The Superior Province has been divided into various regionally extensive subprovinces, as shown on Figure 3.1, based on lithology, age, genesis and metamorphism. The Township of White River is situated in the Wawa Subprovince. The Wawa Subprovince is approximately 900 km long by 150 km wide and runs parallel to and immediately south of the Quetico Subprovince, extending from central Minnesota to the Kapuskasing Structural Zone in Northeastern Ontario. It is bounded by the metasedimentary rocks of the Quetico Subprovince to the north, and Proterozoic-aged (2.4 to 1.1 billion year old) rocks of the Southern Province to the southwest. To the east, the Wawa Subprovince is truncated by the Kapuskasing Structural Zone which separates the Wawa Subprovince from the Abitibi Subprovince. Some authors, including Percival et al. (2006) and Percival and Easton (2007), consider the Wawa Subprovince to be the extension of the Abitibi Subprovince across the Kapuskasing Structural Zone.

Regional bedrock geology of the White River area is shown on Figure 3.2. The regional bedrock geology is composed predominantly of large granitic masses and greenstone belts, mostly formed during the period from 2.77 to 2.69 billion years ago (Carter 1988; Williams et al., 1991; Corfu and Stott, 1998; Zaleski et al., 1999; Polat and Kerrich, 2001). The granitic rocks cover approximately 70 to 80% of the region, while metavolcanic rocks of the greenstone belts occur in sinuous belts or slivers amidst large batholiths. The greenstone belts occur in two main linear concentrations: one along the Wawa – Quetico Subprovince boundary in the north (Dayohessarah-Kabinakagami, Manitouwadge-Hornepayne, and Schreiber-Hemlo Greenstone Belts), and one to the south (Michipicoten Greenstone Belt) (Figure 3.2).

The deposition of the metavolcanics and original sediments of the greenstone belts is associated with a period of volcanism that occurred in the White River area from approximately 2.77 to 2.69 billion years ago (Stott, 1999; Beakhouse, 2001; Muir, 2003). The rocks of the greenstone belts were deformed in multiple episodes, from around 2.70 to 2.65 billion years ago with the resulting emplacement of a number of discrete granitic bodies.

The greenstone belts and granitic intrusions of the region of White River are cut by a series of diabase dikes (Figure 3.2). Diabase dikes of the regional Matachewan-Hearst Dike Swarm strike north-northwest and some are traceable based on their distinct magnetic signature. Estimated dates for the intrusion of the Matachewan-Hearst mafic dikes range from 2.473 to 2.446 billion years ago (Heaman, 1997). A younger and less numerous suite of northeast-striking dikes is known as the Biscotasing Dike Swarm. The Biscotasing Dike Swarm intruded approximately 2.17 billion years ago (Halls and Davis, 2004). Some of the northeast-trending dikes are of indeterminate age and may be part of the younger Abitibi Dike Swarm (Stott and Josey, 2009).

3.2 Local Bedrock Geology

3.2.1 Lithologies

The bedrock geology of the White River area is shown on Figure 3.3. The Township of White River is primarily (about 85%) underlain by granitic rocks of the Pukaskwa and Black Pic Batholiths, which extend beyond the Township boundaries mostly to the south and north, respectively. An east-west trending narrow band of metasedimentary rocks (paragneiss, migmatite or a partially melted rock), approximately 2 to 3 km wide, extends from north of the settlement area of White River across the northeastern edge of the Township, and extends beyond the Township boundaries to the east. As shown in Figure 3.3, both the granitic and metasedimentary rocks within the Township of White River are intruded by a number of northwest-trending dikes. The characteristics of these dikes are discussed in section 3.2.1.3.

In the area surrounding the Township of White River the bedrock geology is also dominated by granitic intrusive complexes of generally batholithic dimensions. These include: the Pukaskwa and Black-Pic Batholiths, which cover most of the southern and northern sectors of the White River area respectively; the Anahereo Lake and Strickland Plutons, about 2.5 km southeast and 18 km northeast of the Township respectively; and the Danny Lake Stock, approximately 4 km north of the Township of White River (Figure 3.3). In the northeastern portion of the White River area the Dayohessarah Greenstone Belt runs north-south amidst the granitic intrusions, about 18 km northeast of the Township. Metavolcanic and metasedimentary rocks of this greenstone belt are also found within the Black-Pic Batholith as narrow, north-south trending bands in the northern sector of the White River area, of which the largest is about 4 km long. These rocks form part of a discontinuous series of west to east greenstone belts from the Hemlo Greenstone Belt west of the White River area to the Dayohessorah belt in the east (Stott, 1999).

The granitic intrusive complexes in the White River area are typically multi-phased and poorly understood compared to the metavolcanic-metasedimentary greenstone belts, which have been the subject of intensive mineral exploration and research over the years.

Figures 3.4 to 3.6 show the regional geophysical data available for the White River area, including airborne magnetic, gravity and airborne radiometric surveys. The variations in aeromagnetic and radiometric responses (Figures 3.4 and 3.6) are largely due to variations in mineral composition in the rocks, while the variation in gravity response (Figure 3.5) is in part a result of the density differences between exposed rock types, but may also be related to variations in deeper structures, including crustal roots.

Aeromagnetic data presented on Figure 3.4 shows a moderately elevated band striking across the north and west portions of the White River area, generally corresponding to the Hemlo and Dayohessarah Greenstone Belts, the Strickland Pluton, the Danny Lake Stock and the greenstone slivers in the intra belt region north of the stock. It is likely that the elevated aeromagnetic response is caused by an increased magnetite content typically found within the mafic-dominated rocks of the greenstone belts compared to felsic intrusive rocks. Also visible on Figure 3.4 are a series of northwest- and northeast-striking magnetic lineaments, which most likely correspond to the Matachewan-Hearst and Biscotasing Dike Swarms, respectively, as mentioned in Section 3.1.

Gravity data for the area (Figure 3.5) shows density contrast within a larger regional gravity low that extends well beyond the White River area and corresponds to the large granitic batholiths (i.e. the Black-Pic and Pukaskwa Batholiths and the large granitic complexes further to the east). Within the White River area, a positive gravity response is associated with the Dayohessarah Greenstone Belt, while a pronounced negative gravity signature occurs in the "Anahereo Lake Pluton" in the Duffy Lake area. Gravity variations are due to the relative density of rock types, with felsic rocks (e.g., granites) having a lower density and thus a negative gravity response, and mafic rocks (e.g., gabbro) having a higher density and thus a positive gravity response. It is noted that gravity responses in themselves do not uniquely define geology, and could be derived from multiple geological configurations.

Airborne radiometric data for the White River area (equivalent uranium) is provided on Figure 3.6. The gamma-ray spectrometry parameters (potassium, uranium and thorium) reflect variations in lithology, noting that radiometric response is a measurement of the rock or soil response at surface, so the rock response will be suppressed where overburden cover is present. Where the rocks are exposed at surface, the responses are typically elevated in granitic rocks compared to volcanic rocks and this relationship is seen in the White River area. Radiometrically elevated responses appear to show an inverse correlation to the aeromagnetic data with a generally low response along the north portion of the White River area and localized positive radiometric anomalies centred over the Tukanee Lake area and over the area to the southeast of Round Lake. More subdued radiometric highs are present in the Duffy Lake area and over portions of the Pukaskwa Batholith to the southeast of the Township of White River (Figure 3.6).

The main geological units occurring in the White River area are further described below.

3.2.1.1 Felsic Plutonic Units

As described in Section 3.2.1, the White River area is dominated by a number of large areally extensive felsic intrusive rocks including the Black-Pic and Pukaskwa Batholiths as well as smaller units including the Strickland Pluton, the Danny Lake Stock and a large unnamed granitic body referred to in this report as the "Anahereo Lake Pluton" (Figure 3.3). Each of these major felsic intrusive rock units are briefly described below.

Black-Pic Batholith

The Black-Pic Batholith lies mostly north and northwest of the Township of White River (Figure 3.3). It is a large, regionally-extensive intrusion that encompasses a roughly 3,000 km^2 area within the Wawa Subprovince (Figure 3.2). No readily available information regarding the thickness of the batholith was found, though it is part of a broad regional gravity anomaly which implies a probable thickness of several kilometres. The Black-Pic Batholith is a multi-phase intrusive unit that includes hornblende-biotite, monzodiorite, tonalite and pegmatitic granite (Williams and Breaks, 1989). The predominant rock type of the Black-Pic Batholith was originally described by Milne (1968) as foliated biotite-granodiorite gneiss in his mapping of the Black River Region, approximately 50 km to the east of the Township of White River. Within the White River area, the batholith is mapped as a gneissic tonalite; however, in areas adjacent to the Dayohessarah Greenstone Belt these intrusive rocks have been locally described as biotite granitic gneiss and biotite granite (Fenwick, 1967).

The Black-Pic Batholith is interpreted to be a domal structure, with slightly dipping foliations radiating outwards from the center. Within the batholith, Williams and Breaks (1989) found that deeper levels of the tonalite suite are strongly foliated with a sub-horizontal planar fabric. Upper levels of the tonalite are frequently cut with granitic sheets of pegmatite and aplite and are generally more massive (Williams and Breaks, 1989).

Also within the Wawa Subprovince north of the White River area are zones of migmatized volcanic rocks, and zones of massive granodiorite to granite (Figure 3.2) embodied in the Black-Pic Batholith. The contact between these rocks and the tonalitic rocks of the Black-Pic Batholith is relatively gradational with extensive sheeting of the tonalitic unit (Williams and Breaks, 1989; Williams et al., 1991).

The age of emplacement of the Black-Pic Batholith is poorly constrained. Its gneissic biotite tonalite phase, the oldest phase of this batholith, has been dated as 2.720 billion years old (Jackson et al., 1998) northwest of the White River area near the settlement area of Agonzon (Figure 3.2). A younger monzodioritic phase has been dated as 2.689 billion years old (Zaleski et al., 1999) about 70 km northwest of the White River area, in the Manitouwadge area (Figure 3.2).

Pukaskwa Batholith

The Pukaskwa Batholith extends over most of the southern half of the White River area (Figure 3.3). The Pukaskwa Batholith is bounded to the north by the Hemlo and Dayohessorah-Kabinakagami Lake Greenstone Belts and by the Black-Pic Batholith; to the south it is bounded by the Michipicoten Greenstone Belt (Figure 3.2). It is a large, regionally-extensive intrusion covering an area of at least 5,000 km^2 (the eastern limit of the batholith is poorly defined). No readily available information regarding the thickness of the batholith was found; however the Pukaskwa Batholith, together with the Black-Pic Batholith and the Anahereo Lake Pluton, forms part of a broad negative gravity anomaly. This gravity anomaly suggests that the Pukaskwa Batholith extends to a depth of at least several kilometres.

The Pukaskwa Batholith, including the foliated tonalite and gneissic tonalite suites in the southern half of the White River area (Figure 3.3), is a multi-phase body emplaced over a period of some 50 million years (Stott, 1999; Beakhouse and Lin, 2006; Beakhouse et al., 2011). Early phases are typically of tonalite–trondhjemite–granodioritic composition which Stott (1999) considers to reflect partial melting of deep basaltic crust. Tonalitic rock formations in the southern half of the White River area are part of this early phase. Synvolcanic phases slightly post-date the volcanism and have a more mafic character ranging from granodiorite to quartz monzodiorite suggesting interaction with an ultramafic source (Beakhouse et al., 2011). West of the White River area, adjacent to Lake Superior, a tonalitic phase of the Pukaskwa Batholith has been dated as 2.718 billion years old (Jackson et al., 1998); this date is comparable to the 2.719 billion years old date obtained by Corfu and Muir (1989). Post-volcanic uplift of the batholith is associated with the emplacement of late granitic to dioritic phases dating to approximately 2.667 billion years ago (Beakhouse et al., 2011). Considering all identified phases, the batholith was emplaced during a time span of approximately 50 million years between 2.718 to 2.667 billion years ago.

Strickland Pluton

The Strickland Pluton occurs in the northeast corner of the White River area bordering the Dayohessarah Lake Greenstone Belt to the east. The pluton is of batholithic proportions covering some 600 km^2, of which only about 100 km^2 falls within the White River area. Stott (1999) describes the Strickland Pluton as a relatively homogeneous quartz porphyritic granodiorite with tonalitic to dioritic phases and foliation that increase toward the margins of the pluton. No readily available information regarding the thickness of the pluton was found and the rock lacks any distinctive gravity signature. Stott (1999) notes that the pluton is petrographically similar to the 2.697 billion years old Dotted Lake Pluton on the northern margin of the Hemlo Greenstone Belt (Figure 3.2).

Danny Lake Stock

The Danny Lake Stock is an east-west elongated intrusion (5 km wide by 22 km long) located approximately 4 km north of the Township of White River. While no dating is available for the stock, it is described (Stott, 1999) as a relatively young, late tectonic body comprised of quartz monzonite to quartz monzodiorite with local hornblende porphyritic zones. The stock lacks a distinct gravity or aeromagnetic signature and no information regarding its thickness was available in the reviewed literature.

Anahereo Lake Pluton

The (informally named) Anahereo Lake Pluton is a large felsic intrusion approximately 500 km^2 in size, of which 142 km^2 is located within the White River area (Figure 3.2). A pronounced negative gravity anomaly associated with this large body of granodiorite-monzonite-trondhjemite suggests that it is distinct from the Pukaskwa Lake Batholith, however little information regarding its mineralogy and structural setting exists in the reviewed literature. The eastern extent of the pluton, beyond the White River area, was mapped by Siragusa (1977) who described it as a coarse-textured quartz monazite with granodioritic to trondhjemitic phases and occasional pegmatitic and muscovite-bearing zones. Siragusa (1978) described the unit in the Esnagi Lake area as the youngest granitic phase on the basis of cross-cutting relationships and the presence of metavolcanic and dioritic xenoliths. No foliation is described for most mapped outcrops west of Anahereo Lake, where the intrusion is frequently described as “massive” – consistent with a late emplacement post-dating the major period of tectonism in the area. No information regarding the thickness of the pluton was found in the reviewed literature but the presence of a gravity anomaly (Figure 3.5) suggests a probable thickness exceeding 1 km.

3.2.1.2 Greenstone Belts

Greenstone belts in the White River area occur in sinuous belts or slivers amidst the large batholiths and smaller plutons of granitoid rocks that dominate the area. The main greenstone unit is the Dayohessarah Greenstone Belt, which occurs in the northeastern portion of the White River area.

Dayohessarah Greenstone Belt

The Dayohessarah Greenstone Belt is centred around Dayohessarah Lake in the northeastern part of the White River area, covering an area of approximately 4 km wide and 35 km long (Figure 3.3). No information regarding the thickness of the Dayohessarah Greenstone Belt has been found in the reviewed literature, however diamond drilling in the greenstone belt (borehole CH-45;SDA, 1998 – AFRI 42C15SW2003) indicates that the thickness of the greenstone belt exceeds 360 m at that location. The greenstone belt has been described and mapped by Fenwick (1967), Stott et al. (1995) and Stott (1999). It trends north-south, is concave to the east, and is enclosed by granitoid intrusions. The base of the Dayohessarah Belt consists of massive to pillowed basaltic flows that are overlain by tuff interlayered with clastic metasedimentary rocks (the Dayohessarah assemblage) that are predominant in the southern part of the belt and occur in the central portion of an axial central syncline. Fenwick (1967) noted intense migmatization in the rocks of the greenstone belt with pronounced schistosity in the metavolcanic and metasedimentary rocks. To the east, the greenstone belt is bounded by the Strickland Pluton. A chain of greenstone inclusions within the granitic rocks extends southwestward towards the Township of White River. According to Stott (1999), a belt of amphibolite discontinuously links the Dayohessarah Greenstone Belt to the Hemlo Greenstone Belt west of the White River area (Figures 3.2 and 3.3). Stott (1999) noted the lithostratigraphic correlation between northeastern Hemlo belt and strata around Dayohessarah Lake suggesting that the Dayohessarah Greenstone belt might be of similar age (2700--2680 Ma).

Other Units

A number of small greenstone “slivers” of uncertain affinity occur within the Black-Pic Batholith north of the Township of White River and west of the Dayohessarah Greenstone Belt (Figure 3.3). These slivers are generally mapped as amphibolite, or locally garnetiferous mafic schist or gneiss. Similar rocks are mapped along the northern boundary of the Hemlo Greenstone Belt and it is possible that these rocks represent a fragmented and highly metamorphosed remnant of a once more extensive greenstone package linking the Hemlo and Dayohessarah Greenstone Belts.

A 28 km long, 2.5 km wide belt of migmatite/biotite-quartz-feldspar paragneiss extends from the settlement area of White River through the northeastern corner of the Township of White River and eastward through the White River area. This gneissic strip appears to continue the strike of the main Hemlo Greenstone Belt except for its eastern extremity which curves northward to match the orientation of the Dayohessarah Greenstone Belt some 6 km to the northeast.

3.2.1.3 Late Mafic Intrusives (dikes)

Approximately 2.473 to 2.446 billion years ago, the White River area was intruded by a series of north-northwest striking diabase dikes of the Matachewan-Hearst Dike Swarm (Heaman, 1997). A second set of diabase dikes, the northeast-striking Biscotasing Dike Swarm intruded the area approximately 2.17 billion years ago (Halls and Davis, 2004). Both sets of diabase dikes are compositionally similar, and they cross-cut all other rock types in the White River area, including the metasedimentary rocks, greenstone belts, and granitoid plutons (Figure 3.3). Some also appear to be traceable on the aeromagnetic data (Figure 3.5).

The Matachewan-Hearst Dike Swarm consists of planar intrusions, with vertical to sub-vertical dips (Condie et al., 1987). They are typically unmetamorphosed and undeformed and commonly contain faulted contacts. The diabase dikes of the Matachewan-Hearst swarm are typically composed of coarse-grained, saussuritized, light green plagioclase phenocrysts in a fine to medium grained ophitic diabase matrix principally composed of clinopyroxene and plagioclase (Stott, 1999). The dikes are reportedly up to 100 m in width (Williams and Breaks 1996) with a typical width of approximately 10 m (Condie et al., 1987) with some reaching over 30 km in length (Figure 3.3).

The northeast-trending dikes in the White River area are generally mapped as part of the previously mentioned Biscotasing Dike Swarm, although some of the northeast-trending dikes are of indeterminate age and may be part of the younger (1.1 billion year old) Abitibi Dike Swarm (Stott and Josey, 2009) or even the Marathon Dike Swarm (2.126 to 2.101 billion years ago) (Halls et al., 2005). The northeast-striking dikes may also be related to the Kapuskasing Structural Zone (Halls and Davis, 2004).

3.2.2 Deformation and Metamorphism

No major regional faults have been mapped within the White River area. Smaller-scale ductile and brittle shearing, however, is widespread throughout the greenstone belts and a series of arcuate faults have been mapped within the gneissic tonalite of the Black-Pic Batholith approximately 10 km north of the Township of White River (Figure 3.3).

The structural history of the White River area is summarized by Fenwick (1967), Williams et al. (1991), Polat (1998), Polat et al. (1998), Stott (1999), Muir (2003), Halls and Davis (2004), Percival and Easton (2007) and Beakhouse et al. (2011). At least six phases of deformation are known to have occurred in the White River area (Muir, 2003) – mostly recognizable in the greenstone belts. The earliest recognizable event (D_1) is associated with stratigraphically bounded, subconcordant ductile faulting within the Dayohessarah Greenstone Belt and possibly contact-strain-induced fabric in the margin of the Pukaskwa Batholith and other older intrusive bodies. Muir (2003) dated D_1 to approximately 2.7 billion years ago.

D_2 structural elements include folding within the greenstone belts and the development of mineral lineations having varying orientations. D_3 deformation includes mineral foliations and crenulations overprinting the D_2 structures. The fourth phase of deformation (D_4) is recognizable in small-scale kink folds, fractures and small-scale faults overprinting the D_3 structures (Muir, 2003). D_2 to D_4 are dated between 2.695 and 2.670 billion years ago and therefore may potentially have affected the granitic plutonic rocks in the White River area.

Younger brittle structures are known throughout the area including at least two recognizable events (D_5 and D_6) dating to approximately 2.2 and 1.2 billion years ago contemporaneous with the emplacement of the Biscotasing and Abitibi Dike Swarms.

All Precambrian rocks within the White River area show evidence of metamorphism. Generally, the area is characterized by amphibolite facies conditions, with upper greenschist metamorphism occurring in portions of the greenstone belts. Synkinematic garnet is locally observed within some banded amphibolitic units, especially close to Strickland Pluton, while sillimanite is reported within metasediments in the southern portion of the Dayohessarah Lake Greenstone Belt (Stott, 1999). Locally, higher metamorphic grades may be found in the contact aureoles surrounding late granitic intrusions and in the metasedimentary rocks located in the northeastern corner of the Township of White River (Fenwick, 1967).

3.2.3 Summary

In summary, the bedrock geology of the White River area comprises mostly granitic rocks with interspersed subordinate metavolcanic rocks and lesser amounts of migmatitic rocks, all of which have been cross-cut by dikes.

The Township of White River is dominated by granitic to tonalitic, and foliated to gneissic rocks of the Archean-age Black-Pic and Pukaskwa Batholiths. These are multi-phase intrusions that extend over large areas to the west, south, north and east beyond the Township boundaries (Figure 3.2). Although no information on the thickness for any of these batholiths was found in the ready available literature, geophysical data in the area suggests thicknesses of several kilometres. In the northeastern quadrant of the Township, a sliver of migmatitic rocks approximately 28 km long and 2.5 km wide extends in an east-west direction and expands beyond the Township boundaries to the east. Little information exists on these rocks.

Other large intrusive bodies in the White River area include the Anahereo Lake and Strickland Plutons, and the Danny Lake Stock (Figure 3.3), which may be considered as relatively homogeneous bodies. No information was found regarding the thickness of these intrusions. The Dayohessarah Greenstone Belt, northeast of the Township of White River, comprises a series of heterogeneous metavolcanic and subordinated metasedimentary rocks that have undergone several phases of deformation involving folding, shearing and faulting. Diamond drilling in this greenstone belt indicates a thickness of the volcano-stratigraphic package of at least 360 m. All the bedrock units present in the White River area are cross-cut by northwest and northeast trending diabase dikes (Figure 3.3).

The White River area is largely devoid of known major faults and regional-scale structures (Figure 3.3). Only a discrete set of arcuate faults and a few discrete faults have been mapped in the granitic bodies north and northeast of the Township (Figure 3.3). Smaller-scale brittle and ductile structures are widespread within the Dayohessarah Greenstone Belt (Stott, 1999).

3.3 Quaternary Geology

Figure 3.7 illustrates the extent and type of Quaternary deposits present in the White River area, and the location of the water wells and diamond drill holes from which information on overburden thickness was obtained. Approximately 70% of the Township is covered by Quaternary deposits, with the other 30% being bedrock that is either directly exposed or covered by a thin layer of ground moraine (Gartner and McQuay, 1980). A generally similar ratio of Quaternary cover versus exposed bedrock is found in the White River area outside of the Township boundaries. Considering limited information from both water well records and diamond drill holes, overburden thickness within the White River area typically ranges from 0 to 12 m, but may exceed 30 m in some areas.

The Quaternary cover mostly comprises different types of glacial deposits that accumulated with the progressive retreat of the ice sheet during the end of the Wisconsinan glaciation. This period of glaciation began approximately 115,000 years ago and peaked about 21,000 years before present, at which time the glacial ice front extended south of Ontario into what is now Ohio and Indiana (Barnett, 1992).

The earliest known Quaternary deposits in the White River area are thin basal till deposits laid down during the late Wisconsinan glaciations. While earlier glacial and interstadial deposits are encountered in a few Northern Ontario locations (e.g. the interstadial or interglacial Missinaibi Beds of the Moose River drainage or the interstadial Owl Creek Beds of the Timmins area), none are known in the White River area and it is likely that any earlier deposits in the White River area have been largely or entirely removed by glacial erosion which stripped away the pre-existing overburden and eroded the crystalline bedrock. The glacial retreat from the White River area is estimated at approximately 9,000 years ago when the ice receded to the northeast (Barnett, 1992; Gartner and McQuay, 1980).

Overburden within the White River area consists predominately of till, glaciofluvial outwash deposits and some glaciolacustrine deposits locally. The tills, which extend from the southwest to the northeast of the White River area, are generally silty to sandy with stones, cobbles and boulders. Glaciofluvial sediments, deposited by glacial meltwater, exist in the low relief portions of the area, particularly along bedrock valleys. A number of eskers occur as ridges of sand and gravel throughout the White River area. They are generally less than 15 to 20 m in height. There are some areas of fine-grained glaciolacustrine deposits, notably to the east of White Lake and to the northeast of Dayohessarah Lake, which would have been deposited in glacial lakes (Gartner and McQuay, 1980; Geddes and Kristjansson, 2009). The youngest Quaternary deposits in the White River area are recent organic soils, lake sediments and alluvium accumulated along stream channels and in low-lying areas. Extensive peatlands (i.e. muskeg) are not present within the White River area, however, organic soils are locally important, particularly along some lake and stream margins.

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 White River area is typical of many areas of the Canadian Shield, which have been subjected to numerous glacial cycles during the last million years (Shackleton et al., 1990; Peltier, 2002). During the maximum extent of the Wisconsinan glaciation, approximately 20,000 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 White River area would likely be slightly greater due to its closer proximity to the main center of glaciation.

Post-glacial isostatic rebound began with the waning of the continental ice sheets and is still occurring across most of Ontario. The greatest rates of crustal rebound (approximately 12 mm/a) are recorded in the Hudson Bay region, where the thickest glacial ice occurred (Sella et al., 2007). As a result of glacial unloading, horizontal stresses are created locally and culminate in natural stress release features that include elongated compressional ridges or pop-ups such as those described in Karrow and White (2002) and McFall (1993).

No detailed identification and interpretation of neotectonic structures is available in the readily available literature for the White River 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 on a number of plutons in the Canadian Shield and in the crystalline basement rocks of Western Ontario. These various studies showed that fractures below a depth of several hundred metres in plutonic rock were ancient features. Early-formed fractures have tended to act as stress domain boundaries. Subsequent stresses, such as those caused by plate movement or by continental glaciations, generally have been relieved by reactivation along the existing zones of weakness rather than by the formation of large, new fracture zones.

3.5 Seismicity

The Township of White River lies in the Superior Province of the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). Hayek et al. (2009) indicate that the general Western Superior Province has experienced a number of low magnitude, shallow seismic events. Figure 3.8 presents the location of earthquakes with magnitude 3 or greater that are known to have occurred in Canada from 1627 until 2010. Figure 3.9 shows the location and magnitude of seismic events recorded in the National Earthquake Database for the period between 1985 and 2011 in the White River area (Natural Resources Canada (NRC), 2011b).

A single low magnitude seismic event (less than magnitude 3) is recorded during the last 25 years in the White River area (Figure 3.9). No other seismic events are recorded for the White River area and no large events (i.e., approaching magnitude 6) are located closer than the Temiskaming region of Québec some 460 km to the east.

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

4.0 HYDROGEOLOGY

The Township of White River obtains its potable water from a surface water intake on Tukanee Lake some 5 km to the north of the settlement area with augmentation from a number of groundwater wells. Treatment involves ozonation, primary filtration and slow sand filtration followed by chlorination.

Information concerning groundwater in the White River area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database (Ontario Ministry of the Environment (MOE), 2010). The locations of known water wells in the White River area are shown on Figure 4.1. The availability of municipal services is reflected in the low number of private wells located within the White River area. A total of 18 water well records are listed in the MOE's database, most of which are located within the Township. A summary of these wells is provided in Table 4.1.

Table 4.1 - Water Well Record Details – White River Area

Water Well Type	Number of Wells	Total Well Depth (m)	Static Water Level (m below surface)	Tested Well Yield (L/min)	Depth to Top of Bedrock (m)
Overburden	5	5 to 39	N/A	35 to 180	N/A
Bedrock	13	15 to 99	2.4 to 8.5	5 to 430	13 to 27

4.1 Overburden Aquifers

A total of 5 overburden wells are recorded for the White River area, ranging from 5 to 39 m in depth. Well yields are variable with recorded values of 35 to 180 L/min. These values reflect the purpose of the wells (a mixture of municipal and private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from the aquifer. The limited number of well records and their concentration along the main roadways limits the available information regarding the extent and characteristics of the overburden aquifers in the White River area.

4.2 Bedrock Aquifers

No information was found on deep groundwater conditions in the White River area at a typical repository depth of approximately 500 m. In the White River area there are 13 well records that can be confidently assigned to the shallow bedrock aquifer. These wells range from 15 to 99 m in depth, with most wells from 16 to 31 m deep. Measured pumping rates in these wells are variable and range from 5 to 430 L/min, with yields typically between 5 and 55 L/min. As with the overburden wells, these values 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.

The MOE Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the White River area or anywhere else in Northern Ontario. Experience from other areas in the Canadian Shield has shown that active groundwater flow is generally confined to shallow fractured localized systems. In these regions, flow tends to be dependent on the secondary permeability created by fractures (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth (Everitt et. al., 1996). The low topographic relief of the Canadian Shield tends to result in low hydraulic gradients for groundwater movement in the shallow active region (McMurry et al., 2003). In deeper regions, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al., 1996; McMurry et al., 2003). Increased vertical and horizontal stresses at depth tend to close or prevent fractures, thereby reducing permeability and resulting in diffusion-dominated groundwater movement (Stevenson et al., 1996; McMurry et al., 2003).

4.3 Hydrogeochemistry

No information on groundwater hydrogeochemistry was found for the White River 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 that extends to a depth of about 150 to 300 m, and a deeper, saline water flow system (Singer and Cheng, 2002).

Gascoyne et al. (1987) investigated the saline brines within 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 occurring at above 300 m, with a shift to diffusion-controlled flow below that depth. It was noted that major fracture zones within the bedrock can, where present, extend the influence of advective processes to greater depths.

In the deeper regions, where groundwater transport in unfractured or sparsely fractured rock tends to have 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 (TDS) 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 White River area is located in a crystalline geological setting where the potential for petroleum resources is negligible. No hydrocarbon exploitation or exploration activities are known to occur in the White River area.

5.2 Metallic Mineral Resources

Figure 5.1 shows the areas of exploration interest in the White River area as evidenced by active mining claims, as well as known mineral occurrences identified in the Ontario Geological Survey's Mineral Deposit Inventory Version 2 (Ontario Geological Survey (OGS), 2004). There are no past or currently producing mines in the White River area. The closest producing mines, primarily exploiting gold with some secondary antimony, barite, molybdenum and silver, are approximately 25 km to the west of the White River area in the Hemlo Greenstone Belt. Abundant active mining claims and mineral occurrences are documented in the northeast part of the White River area, around Dayohessarah Lake in the Dayohessarah Greenstone Belt. The "Sugar Zone" in this area is a developed prospect within the greenstone belt, with gold reserves along the eastern shore of Dayohessarah Lake. Other minerals present in the Dayohessarah Greenstone Belt include copper, nickel and gold occurrences to the north, and molybdenum to the south of the Dayohessarah Lake. There are a number of active claims along the western margin of the Strickland Pluton. It is unknown if such claims are related to mineral exploration in the adjacent greenstone belt or within the intrusion itself. There are a few additional active mining claims in the Black-Pic and Pukaskwa Batholiths west and northwest of the Township of White River (Figure 5.1).

Base Metals

Base metals include copper, nickel, lead, zinc, tungsten, molybdenum and cobalt, which are often found in characteristic associations: volcanogenic massive sulphide formations dominated by Cu-Zn (with accessory gold) or by Cu-Zn-Pb (with accessory silver and minor gold); magmatic deposits dominated by Cu-Ni (often with accessory gold and PGE), and "porphyry" type deposits that may include one or more of Mo-Cu-Ag-W-Au in varying proportion.

A number of base metal occurrences are documented in the Mineral Deposit Inventory (OGS, 2004) within the White River area, in the Dayohessarah Greenstone Belt and in one of the greenstone "slivers" north of the Danny Lake Stock, as shown on Figure 5.1. The economic viability of these occurrences has not been proven to date. The presence of spinifex-textured komatiitc flows and differentiated mafic intrusion to the north of Dayohessarah Lake have potential for nickel and platinum group metals (Stott, 1999).

Precious Metals

Numerous small gold showings are known within the Dayohessarah Greenstone Belt, including the "Sugar Zone" in which gold-mineralized quartz veins occur in association with strongly foliated amphibolitized basaltic flow and injected by felsic sills related to the Strickland Pluton (Stott, 1999). Active exploration activity continues in this area.

Uranium

No economic deposits of uranium have been identified in the available literature for the White River area.

Rare Metals

Rare earth mineralization has not been identified in the White River area. However, in a regional lake sediment and water geochemical survey (Jackson, 2003) anomalously high values of Rare Earth Elements (REE), uranium and thorium were observed around the settlement area of White River. One cluster is located about 7 km northwest of the settlement area of White River and another east of the Township at the edge of the White River area. The bedrock geology of these areas is mapped as pegmatic granitic intrusive rocks (Fenwick, 1967; Stott, 1999). S-type granite pegmatites containing rare elements are potentially present throughout the many areas of the Wawa Subprovince (Breaks et al., 2003).

5.1 Non-Metallic Mineral Resources

Known non-metallic mineral resources within the White River area include stone, sand and gravel, and industrial minerals.

The tonalitic gneisses of the Black-Pic and Pukaskwa Batholiths represent a potential source of dimension stone where homogeneous exposures and few fractures can be found. Stott (1999) identified the Danny Lake Stock as having characteristics favourable for exploitation as dimension stone. He suggested that other massive homogeneous felsic plutons in this region could have dimension-stone potential.

Gartner and McQuay (1980) estimated a low potential for sand and gravel resources in the White River area. There are a number of small-scale sand and gravel pits along highways as shown on Figure 5.1. Portions of rock outcrop in the area may have the potential to be used as crushed stone resources, but no quarrying is known to have occurred in the White River area.

Industrial minerals include micas, clay minerals, talc, abrasives, mineral fillers, etc. No occurrences of industrial minerals are known within the White River area; however, potential exists within localized settings such as the highly metamorphosed contact aureoles of the late granitic intrusions, especially where these are in contact with metasediments and greenstones.

No diamond-bearing kimberlites or lamproites have been identified in the White River 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. The closest known diamond bearing rocks occur in the Michipicoten Greenstone Belt, approximately 20 km to the south of the White River area (Vaillancourt et al., 2005), and are not associated with either kimberlite or lamproite formations.

6.0 INITIAL SCREENING EVALUATION

This section provides an evaluation of each of the five initial screening criteria (NWMO, 2010) for the White River 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 White River from further consideration in the site evaluation process.

Initial screening criteria (NWMO, 2010) require that:

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

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

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

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

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

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

6.1 Screening Criterion 1: Land Availability

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

Surface facilities associated with the deep geological repository will require a surface land parcel of about 1 km by 1 km (100 ha) in size, although some additional space may be required to satisfy regulatory requirements. The projected 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 White River 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 were 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 White River contains limited constraints that would prevent the development of repository surface facilities (Figures 2.1 and 2.2). These include permanent water bodies such as Picnic and Tukanee Lakes, which account for less than 5% of the Township area. Also, residential and industrial infrastructure covers a very small portion of the Township of White River, with developments limited mainly to roadways and the settlement area itself (Figure 2.1). The areas at the periphery of the Township of White River are largely undeveloped, with few natural or physical constraints such as permanent water bodies or major infrastructure.

As discussed in Section 2, topography is variable in the White River area, but no obvious topographic features that would prevent construction and characterization activities have been identified for the majority of the area. Most of the White River area could be accessed from the main roads, Highways 17 and 631, via a network of secondary and logging roads (Figure 2.1).

As discussed in Section 6.5, readily available information suggests that the White River area has the potential to contain sufficient volumes of host rock to accommodate underground facilities associated with a deep geological repository.

Based on the review of readily available information, the White River 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 lands, heritage sites or parks, as defined by provincial or federal authorities.

The White River area was screened for federal, provincial and municipal parks, conservation areas, nature reserves, national wildlife areas and archaeological and historic sites using available data from the Ontario Ministry of Natural Resources (Land Information Ontario) and the Ontario Ministry of Tourism and Culture. With reference to Figure 2.1, there are one provincial park and three conservation reserves in the White River area: the Pokei Lake/White River Wetlands Provincial Park, approximately 2 km south of the Township and the Kwinkwaga Ground Moraine Uplands, Kakakiwibik Esker and Strickland River Mixed Forest Wetland conservation reserves at the periphery of the Township. There are also three candidate ANSIs in the White River area. These protected areas occupy only a small portion of the available land (approximately 9 %).

As discussed in Section 2.4, most of the land in the White River area is free of known heritage constraints. There is only one known archaeological site in the White River area, located at the periphery of the Township. In the settlement area of White River there are also one National and one Provincial Historic Sites. These sites are all localized and small in size.

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 White River area contains sufficient land outside of protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities.

6.3 Screening Criterion 3: Known Groundwater Resources at Repository Depth

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

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

The review of available information did not identify any known groundwater resources at repository depth for the White River area. As discussed in Section 4, the MOE Water Well Records (WWR) database shows that all water wells known in the White River area obtain water from overburden or shallow bedrock sources at depths ranging from 5 to 99 m, with most wells being between 15 to 31 m deep (MOE, 2010).

Experience from other similar 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). With increasing depth, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al. 1996; McMurry et al., 2003).

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

6.4 Screening Criterion 4: Known Natural Resources

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

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

The review indicates that there is no evidence of past or present exploration or development activities associated with hydrocarbon resources. Given the geological setting (i.e. crystalline rock), the potential for activities associated with these resources in the White River area is negligible.

There are no past or currently operating mines within the White River area. However, there is potential for active mining within the Dayohessarah Greenstone Belt in the northeast sector of the White River area, where gold occurrences have been identified and are currently being actively explored (Figure 5.1). The mineral potential of the granitic intrusions that underlie most of the White River area is considered low.

There is a potential in the White River area for industrial minerals, dimension stone, and aggregate extraction. However, the risk that these resources pose for future human intrusion is negligible, as development of these non-metallic resources is limited to shallow depths.

Based on the review of readily available information, the White River 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 White River 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 White River from further consideration in the site selection process at this stage. Specific factors are briefly discussed in the following subsections.

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 White River is almost entirely (about 85%) underlain by granitic to tonalitic rocks of the large Black-Pic and Pukaskwa Batholiths, which extend well beyond the Township boundaries mostly to the north and south, respectively, and dominate the bedrock geology in the White River area. In the northeastern quadrant of the Township, a sliver of migmatitic rocks approximately 28 km long and 2.5 km wide extends in an east-west direction and expands beyond the Township boundaries to the east. Little information exists on these rocks. Other large intrusive bodies in the White River area include the Anahereo Lake Pluton southeast of the Township and the Danny Lake Stock and Strickland Pluton north and northeast of the Township, respectively. In the northeastern sector of the White River area the Dayohessarah Greenstone Belt extends in a northwest direction just west of the Strickland Pluton.

The White River area is largely devoid of known major faults and regional-scale structures. Only a discrete set of arcuate faults and a few discrete faults have been mapped in the granitic bodies north and northeast of the Township (Figure 3.3). Smaller-scale brittle and ductile structures are widespread within the Dayohessarah Greenstone Belt. However, all the bedrock units in the White River area have been cross-cut by dikes (Figure 3.3).

The Dayohessarah Greenstone Belt, northeast of the Township of White River, comprises a series of heterogeneous metavolcanic and metasedimentary rocks that have undergone several phases of deformation involving folding, shearing and faulting. Although the greenstone belt may have sufficient thickness and lateral extent, it is unlikely to be suitable for hosting a deep geological repository due to structural complexity and lithological heterogeneity, as well as to its potential for natural resources (see Criterion 4). The narrow belt of metasedimentary gneiss in the northeast corner of the Township is also unlikely suitable due to its limited extent and heterogeneity.

The Black-Pic and Pukaskwa Batholiths are laterally extensive, multi-phase intrusions generally composed of older foliated to gneissic tonalitic to granodioritic phases and younger massive to foliated granodioritic to granitic phases. Although no information on the thickness of these batholiths was found in the ready available literature, geophysical data in the area suggests thicknesses of several kilometres. The granitic rocks of these batholiths appear to have favourable geological characteristics and sufficient rock volume (lateral extent and thickness) to potentially host a deep geological repository. The Anahereo Lake and Strickland Plutons, and the Danny Lake Stock have significant lateral extents and may be lithologically relatively homogeneous. Although no information was found regarding the thickness of these intrusions, they also warrant further consideration as potentially suitable host rocks. The extent to which the series of dikes that cross-cut these granitoid units extend to depth and their potential impact on the characteristics of the rock mass at depth would need to be evaluated during subsequent site evaluation stages, if the community remains interested in participating in the site selection process.

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 White River 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 similar 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).

In summary, the review indicates that the Township of White River and its periphery contains areas with no known obvious geological and hydrogeological conditions that would fail the containment and isolation requirements. The bedrock geology in these areas is dominated by the Black-Pick and Pukaskwa Batholiths and the smaller Danny Lake Stock, and Anahereo Lake and Strickland Plutons. 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 one 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 White River area. As discussed below, the review of readily available information did not reveal any such evidence.

The Township of White River 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 Section 3.5, no earthquakes of magnitude greater than 3 have been recorded in the White River area.

The geology of the White River 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 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 studies found that fractures below a depth of several hundred metres in the plutonic rock were ancient features. Subsequent geological processes such as plate movement and continental 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 White River area. 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 known to contain exploitable groundwater (aquifers) or economically exploitable mineral resources at repository depth.

This factor has been addressed in Sections 6.3 and 6.4, which conclude that the potential for deep groundwater resources at repository depths is low throughout the White River area, and that the potential for economically exploitable mineral resources in the White River area is mostly limited to the rocks of the Dayohessarah Greenstone Belt.

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. Besides 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 White River area. However, there is abundant information at other locations in the Canadian Shield that could provide insight into what should be expected for the White River 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 granitic intrusive rocks of the White River area have good potential to meet the constructability requirements.

The review of readily available information on the bedrock geology and Quaternary geology for the White River area (Sections 3.2 and 3.5) did not indicate any obvious conditions which could make the rock mass difficult to characterize, although such conditions may exist in localized areas. The degree to which these factors such as overburden thickness might affect the characterization and data interpretation activities would require further assessment during subsequent site evaluation stages of the site selection process, 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 White River 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 White River area against five initial screening criteria using readily-available information. The initial screening focused on the Township of White River and its periphery, which are referred to as the “White River area” in this report. 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 White River from further consideration in the NWMO site selection process. The initial screening indicates that the White River area contains large portions of land with geological formations that are potentially suitable for hosting a deep geological repository. Examples of these formations include the Pukaskwa and Black Pic Batholiths, the Danny Lake Stock, and the Anahereo Lake Pluton.

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 White River area, but rather to identify whether there are any obvious conditions that would exclude it from the site selection process. Should the Township of White River 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 White River 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.

8.0 REFERENCES

Arjang B. and G., Herget, 1997. In situ ground stresses in the Canadian hardrock mines: An update. International Journal of Rock Mechanics and Mining Science Vol 34. Issue 3-4. pp. 15.e1-15.e16.

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

Beakhouse, G.P., Lin, S. and S.L. Kamo, 2011. Magmatic and tectonic emplacement of the Pukaskwa batholiths, Superior Province, Ontario, Canada. Can. J. Earth Sci. **48**:187-204.

Beakhouse, G.P. and Lin, S. 2006. Tectonic Significance of the Pukaskwa Batholith and its Contact Relationships with the Hemlo and Mishibishu Greenstone Belts; *in* Summary of Field Work and Other Activities 2005, Ontario Geological Survey, Open File Report 6192, p.7-1 to 7-7.

Beakhouse, G.P., 2001. Nature, Timing and Significance of Intermediate to Felsic Intrusive Rocks Associated with the Hemlo Greenstone Belt and Implications for the Regional Geological Setting of the Hemlo Gold Deposit; Ontario Geological Survey, Open File Report 6020, 248 p.

Breaks, F., J.B. Selway and A.G. Tindle, 2003. Electron microprobe and bulk analyses of fertile peraluminous granites and related rare-element pegmatites: Superior Province, northwest and northeast Ontario: Operation Treasure Hunt; Ontario Geological Survey, Open File Report 6099, 179p.

Brevic, E. C. and J.R. Reid, 1999. Uplift-based limits to the thickness of ice in the Lake Agassiz basin of North Dakota during the Late Wisconsinan; Geomorphology, **32**:.161–16.

Chandler N., R. Guo and R. Read (Eds). 2004. Special issue: Rock Mechanics Results from the Underground Research Laboratory, Canada. International Journal of Rock Mechanics and Mining Science Vol 41. Issue 8. pp. 1221-1458.

Condie, K.C., D.J. Bobrow and K.D. Card, 1987. Geochemistry of Precambrian mafic dikes from the Southern Superior Province of the Canadian Shield; in Mafic Dike Swarms, Geological Association of Canada, Special Papers 34, pp. 95-108.

Corfu, F. and G.M. Stott. 1998. Shebandowan greenstone belt, western Superior Province: U-Pb ages, tectonic implications and correlations; Geological Society of America Bulletin, **110**: 1467–1484.

Corfu, F., and T. L. Muir, 1989. The Hemlo-Heron Bay greenstone belt and Hemlo Au-Mo deposit, Superior Province, Ontario, Canada: 1. Sequence of igneous activity determined by zircon U-Pb geochronology: Chemical Geology, v. 79, p.183-200

Earthquakes Canada, GSC, Earthquake Search (On-line Bulletin), http://seismo.nrcan.gc.ca/stnsdata/nedb/bull_e.php, Nat. Res. Can. Accessed June 2012Everitt, R.A. 1999. Experience gained from the geological characterization of the Lac du Bonnet Batholith, and comparison with other sparsely fractured granite batholiths in the Ontario portion of the Canadian Shield. OPG Report 06819-REP-01200-0069-R00. OPG. Toronto. Canada.

Everitt, R., McMurry, J., Brown, A., and Davison, C.C., 1996. Geology of the Lac du Bonnet Batholith, inside and out: AECL's Underground Research Laboratory, southeastern Manitoba. Field Excursion B-5:

Guidebook. Geological Association of Canada — Mineralogical Association of Canada, Joint Annual Meeting, 30 May 1996, Winnipeg, Man. 72p.

Fenwick, K.G., 1967. Geology of the Dayohessarah Lake Area, District of Algoma. Geological Report 49. Ontario Department of Mines, Toronto, Ontario.

Frape, S.K., P. Fritz and A.J. Blackmer, 1984. Saline groundwater discharges from crystalline rocks near Thunder Bay, Ontario, Canada; in Hydrochemical balances of freshwater systems, pp. 369-379, Publication 150, 428p. Proceedings of a symposium held at Uppsala, Sweden, September 1984

Gartner, J. F. and D.F. McQuay, 1980. White River Area (NTS 42C/NW), Districts of Algoma and Thunder Bay; Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 61, 18p. Accompanied by Maps 5094 and 5098, scale 1:100 000.

Gascoyne, M., 2004. Hydrogeochemistry, groundwater ages and sources of salts in a granitic batholith on the Canadian Shield, southeastern Manitoba. Applied Geochemistry **19**: 519-560.

Gascoyne, M., 2000. Hydrogeochemistry of the Whiteshell Research Area. Ontario Power Generation, Nuclear Waste Management Division Report, 06819-REP-01200-10033-R00. Toronto, Canada.

Gascoyne, M., C.C. Davison, J.D. Ross and R. Pearson, 1987. Saline groundwaters and brines in plutons in the Canadian Shield; In Saline water and gases in crystalline rocks, Editors: Fritz, P., and Frape, S.K.

Geddes, R.S. and Kristjansson, F.J. 2009. Quaternary geology of the White River area, northern Ontario; Ontario Geological Survey, Map 2682, scale 1:50 000.

Geological Survey of Canada, 2012. Canadian Aeromagnetic Data Base, Airborne Geophysics Section, GSC - Central Canada Division, Geological Survey of Canada; accessed June 2012.

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

Halls, H.C., G.M. Stott and D.W. Davis, 2005. Paleomagnetism, Geochronlogy and Geochemistry of Several Proterozoic Mafic Dike Swarms in Northwestern Ontario; Ontario Geological Survey, Open File Report 6171, 59 p.

Halls, H. C., and D. W. Davis, 2004. Paleomagnetism and U–Pb geochronology of the 2.17 Ga Biscotasing dyke swarm, Ontario, Canada: evidence for vertical-axis crustal rotation across the Kapuskasing Zone, Can. J. Earth Sci. **41**: 255–269.

Hayek, S., J.A. Drysdale, V. Peci, S. Halchuk, J. Adams and P. Street, 2009. Seismic Activity in the Northern Ontario Portion of the Canadian Shield: Progress Report for the Period of January 01 to December 31, 2008; NWMO TR-2009-05, 30 p.

Heaman, L.M., 1997. Global mafic magmatism at 2.45 Ga: Remnants of an ancient, large igneous province? Geology **25**: 299-302.

Jackson, S.L., 2003. Dayohessarah Lake area high density lake sediment and water geochemical survey, northeastern Ontario; Ontario Geological Survey, Open File Report 6103, 102p.

Jackson, S.L., Beakhouse, G.P. and D.W. Davis. 1998. Regional geological setting of the Hemlo gold deposit; an interim progress report. Ontario Geological Survey, Open File Report 5977.

Karrow, P.F. and O.L. White, 2002. A history of neotectonic studies in Ontario, Tectonophysics, **353**: 3-15.

McFall, G. H., 1993. "Structural Elements and Neotectonics of Prince Edward County, Southern Ontario"; Géographie physique et Quaternaire, vol. 47, n° 3, 1993, pp. 303-312.

McMurry, J., D.A. Dixon, J.D. Garroni, B.M. Ikeda, S. Stroes-Gascoyne, P. Baumgartner and T.W. Melnyk, 2003. Evolution of a Canadian deep geologic repository: Base scenario. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10092-R00. Toronto, Canada.

Milne, V.G., 1968. Geology of the Black River Area, District of Thunder Bay. Geological Report 72, Ontario Department of Mines, Toronto, Ontario.

Muir, T.L., 2003. Structural evolution of the Hemlo greenstone belt in the vicinity of the world-class Hemlo gold deposit. Can. J. Earth Sci. **40**:395-430.

Natural Resources Canada (NRC), 2011a. The Atlas of Canada, http://atlas.nrcan.gc.ca/site/english/maps/environment/land/arm_physio_shield, Accessed February 2011.

Natural Resources Canada (NRC), 2011b. Earthquakes Canada Website. http://earthquakescanada.nrcan.gc.ca

NWMO, 2005. Choosing a way forward. The future management of Canada's used nuclear fuel, Nuclear Waste Management Organization Final Study (454 pages). (Available at www.nwmo.ca)

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

Ontario Geological Survey (OGS), 2004 [shapefile]. Mineral Deposit Inventory Version 2 (MDI2), October 2004 Release; Ontario Geological Survey. ISBN 0-7794-7002-8

Ontario Geological Survey (OGS), 2012. Assessment file database (AFRI); accessed June 29, 2012.

Ontario Geological Survey (OGS), 2004. [shapefile]. Mineral Deposit Inventory Version 2 (MDI2), October 2004 Release; Ontario Geological Survey. ISBN 0-7794-7002-8; accessed June 29, 2012

Ontario Geological Survey (OGS), 2005. Ontario Drill Hole Database [shapefile]. December 2005 Release, Ontario Geological Survey, Data Set 13 - Revision 1; accessed June 29, 2012

Ontario Geological Survey (OGS), 2006. [shapefile]. 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release---Data 126-revised. ISBN 0-7794-5172-4; accessed June 29, 2012

Ontario Geological Survey (OGS), 1997. [shapefile]. 1:250 000 Quaternary geology, seamless coverage of the province of Ontario: Ontario Geological Survey, Data Set 14; accessed June 29, 2012

Ontario Heritage Trust. 2012. http://www.heritagetrust.on.ca/Home.aspx. Accessed June 29, 2012.

Ontario Heritage Properties Database. 2012. http://www.hpd.mcl.gov.on.ca/scripts/hpdsearch/english/default.asp accessed June 29, 2012.

Ontario Ministry of the Environment (MOE), 2010. Water Well Database, 2010.

Ontario Ministry of Natural Resources, 2005. LIO DEM Version 1.1.0 - 2005

Ontario Ministry of Northern Development and Mines 2012. Mining Lands Section: Ontario Mining Land Tenure Spatial Data, Accessed June 29, 2012

Parks Canada. 2010. National Historic Sites. http://www.pc.gc.ca/progs/lhn-nhs/index.aspx. Accessed November 2, 2010.

Peltier, W.R., 2002. On eustatic sea level history: Last Glacial Maximum to Holocene: Quaternary Science Reviews, **21**: 377–396.

Percival, J.A. and R.M. Easton, 2007. Geology of the Canadian Shield in Ontario: an update. Ontario Power Generation, Report No. 06819-REP-01200-10158-R00.

Polat, A. and Kerrich, R., 2001. Magnesian andesites, Nb-enriched basalt-andesites, and adakites from late Archean 2.7 Ga Wawa greenstone belts, Superior Province, Canada: Implications for late Archean subduction zone petrogenetic processes. Contrib. Mineral. Petrol, **141**: 36–52.

Polat, A., 1998. Geodynamics of the Late Archean Wawa Subprovince Greenstone Belts, Superior Province, Canada. Ph. D. Thesis, University of Saskatchewan, Department of Geological Sciences.

Polat, A, R. Derrich and D.A. Wyman, 1998. The late Archean Schreiber-Hemlo and White River-Dayohessarah greenstone belts, Superior Province: collages of oceanic plateaus, oceanic arcs, and subduction-accretion complexes. Tectonophysics, **289**: 295-326.

Sella, G.F., S. Stein, T.H. Dixon, M. Craymer, T.S. James, S. Mazzotti and R.K. Dokka, 2007. Observation of glacial isostatic adjustment in “stable” North America with GPS, Geophys. Res. Lett., 34, L02306, doi:10.1029/2006GL027081.

Shackleton, N.J., A. Berger and W.R. Peltier, 1990. An alternative astronomical calibration of the lower Pleistocene timescale based on ODP Site 677: Transactions of the Royal Society of Edinburgh: Earth Sciences, 81, pp. 251-261

Siragusa, G.M., 1978. Geology of the Esnagi Lake Area, District of Algoma; Ontario Geological Survey Report 176. 50 p. Accompanied by Map 2382, scale 1:63360 or 1 inch to 1 mile.

Siragusa, G.M., 1977. Geology of the Kabinakagami Lake Area District of Algoma; Ontario Division Mines. Geoscience Report 159, 39 p. Accompanied by Map 2355, scale 1:63,360 or 1 inch to 1 mile.

Singer, S.N. and C.K. Cheng, 2002. An Assessment of the Groundwater Resources of Northern Ontario, Ontario Ministry of the Environment.

Stevenson, D.R., E.T. Kozak, C.C. Davison, M. Gascoyne and R.A. Broadfoot, 1996. Hydrogeologic characterization of domains of sparsely fractured rock in the granitic Lac du Bonnet Batholith, Southeastern Manitoba, Canada. Atomic Energy of Canada Limited Report, AECL-11558, COG-96-117. Pinawa, Canada.

Stott, G.M. and Josey, S.D. 2009. Proterozoic mafic (diabase) dikes and other post-Archean intrusions of northwestern Ontario, north of latitude 49°30´; Ontario Geological Survey, Preliminary Map P.3606

Stott, G.M. 1999. Precambrian Geology of the Dayohessarah Lake Area, White River, Ontario. Ontario Geological Survey, Open File Report 5984, 54p.

Stott, G., Mahoney, K.L. and Zwiers, W.G., 1995. Precambrian Geology, Dayohessarah Lake Area (South); Ontario Geological Survey, Preliminary Map P.3311, scale 1:20,000.

Thurston, P.C. 1991. Geology of Ontario: Introduction; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, pp. 3-25.

Vaillancourt, C., J.A. Ayer and M.A. Hamilton, 2005. Synthesis of Archean Geology and Diamond-bearing Rocks in the Michipicoten Greenstone Belt: Results from Microdiamond Extraction and Geochronological Analyses; *in* Summary of Field Work and Other Activities 2005, Ontario Geological Survey, Open File Report 6172, p 8-1 to 8-13.

Von Bitter, R. 2012. Personal Communication on July 11, 2012 re: Archaeological Sites Database. Ministry of Tourism, Culture, and Sport.

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

Williams, H.R., G.M. Stott, K.B. Heather, T.L. Muir and R.P. Sage, 1991. Wawa Subprovince; In Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, pp. 485-539.

Williams, H.R. and F.R. Breaks, 1989. Project Unit 89-13. Geological studies in the Manitouwadge-Hornepayne region. In: Summary of Field Work and Other Activities 1989; Ontario Geological Survey, Miscellaneous Paper 146, pp. 79-91.

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

9.0 REPORT SIGNATURE PAGE

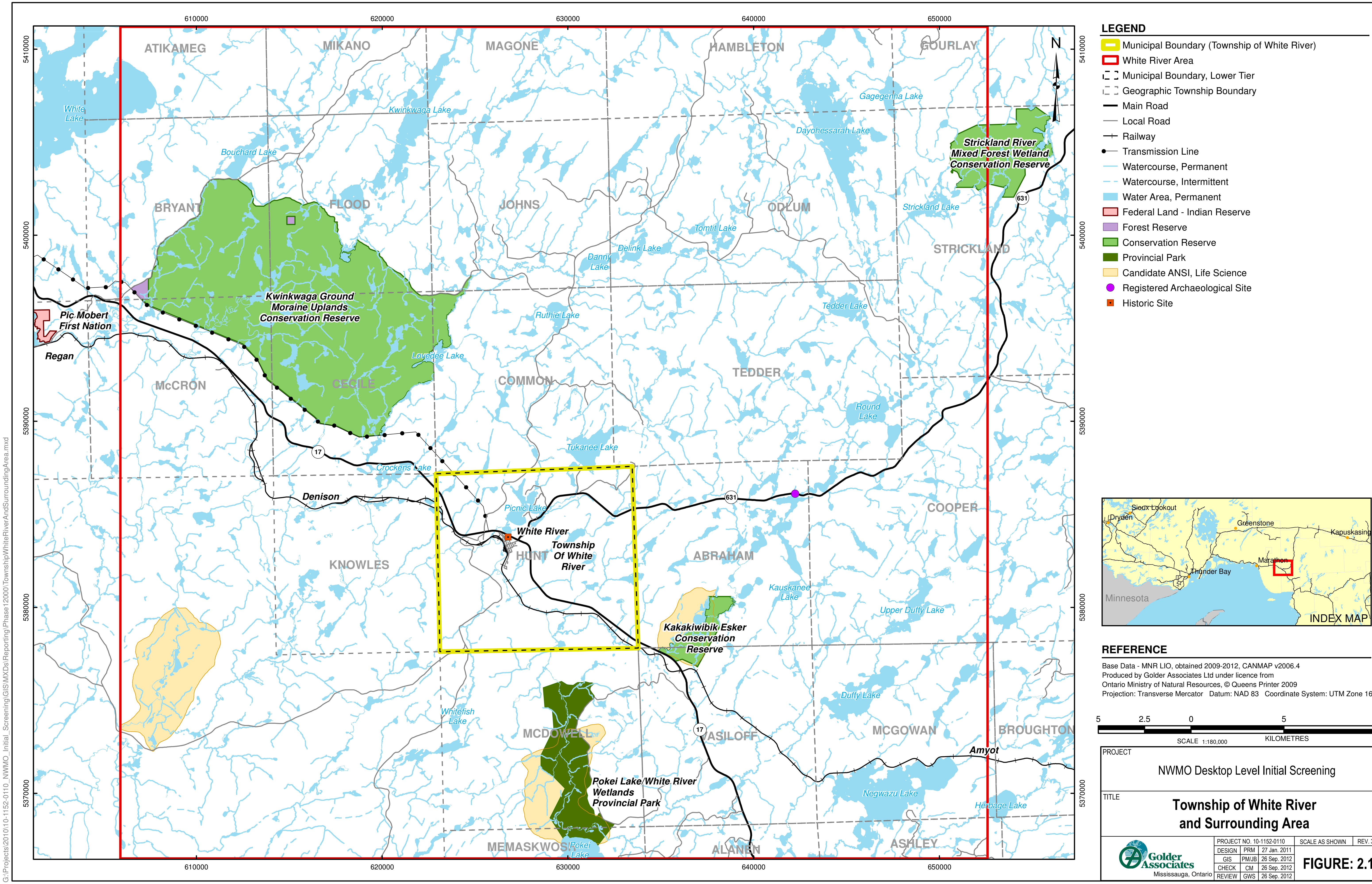
Charles Mitz, M.Eng., P.Geo.
Senior Geoscientist

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

JH/CM/GWS/wlm

c:\gws-work\1 - active\10-1152-0110 nwmo-initial screenings-on gws\12000 white river\07 finalized 12oct12\10-1152-0110 12000 white river_2012oct12_r4.docx

FIGURES



ATIKAMEG
MIKANO
MAGONE
HAMBLETON
GOURLAY
BRYANT
FLOOD
JOHNS
ODLUM
STRICKLAND
McCRON
CECILE
COMMON
TEDDER
COOPER
KNOWLES
HUNT
ABRAHAM
MCDOWELL
VASILOFF
MCGOWAN
BROUGHTON
MEMASKWOSH
ALANEN
ASHLEY
White Lake
Kwinkwaga Lake
Bouchard Lake
Gagegenha Lake
Dayohessarah Lake
Strickland Lake
Tomtit Lake
Delink Lake
Danny Lake
Ruthie Lake
Tedder Lake
Lovedee Lake
Round Lake
Tukanee Lake
Crockens Lake
Picnic Lake
Kauskanee Lake
Upper Duffy Lake
Duffy Lake
Whitefish Lake
Negwazu Lake
Herbage Lake
Pokei Lake
Strickland River Mixed Forest Wetland Conservation Reserve
Kwinkwaga Ground Moraine Uplands Conservation Reserve
Pic Mobert First Nation
Regan
Denison
White River
Township Of White River
Kakakiwibik Esker Conservation Reserve
Pokei Lake/White River Wetlands Provincial Park
Amyot
17
631
610000
620000
630000
640000
650000
5410000
5400000
5390000
5380000
5370000
N
LEGEND
Municipal Boundary (Township of White River)
White River Area
Municipal Boundary, Lower Tier
Geographic Township Boundary
Main Road
Local Road
Railway
Transmission Line
Watercourse, Permanent
Watercourse, Intermittent
Water Area, Permanent
Federal Land - Indian Reserve
Forest Reserve
Conservation Reserve
Provincial Park
Candidate ANSI, Life Science
Registered Archaeological Site
Historic Site
Sioux Lookout
Dryden
Greenstone
Kapuskasing
Marathon
Thunder Bay
Minnesota
INDEX MAP
REFERENCE
Base Data - MNR LIO, obtained 2009-2012, 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
5 2.5 0 5 10
SCALE 1:180,000
KILOMETRES
PROJECT
NWMO Desktop Level Initial Screening
TITLE
Township of White River and Surrounding Area
Golder Associates
Mississauga, Ontario
PROJECT NO. 10-1152-0110
SCALE AS SHOWN
REV. 3.0
DESIGN PRM 27 Jan. 2011
GIS PM/JB 26 Sep. 2012
CHECK CM 26 Sep. 2012
REVIEW GWS 26 Sep. 2012
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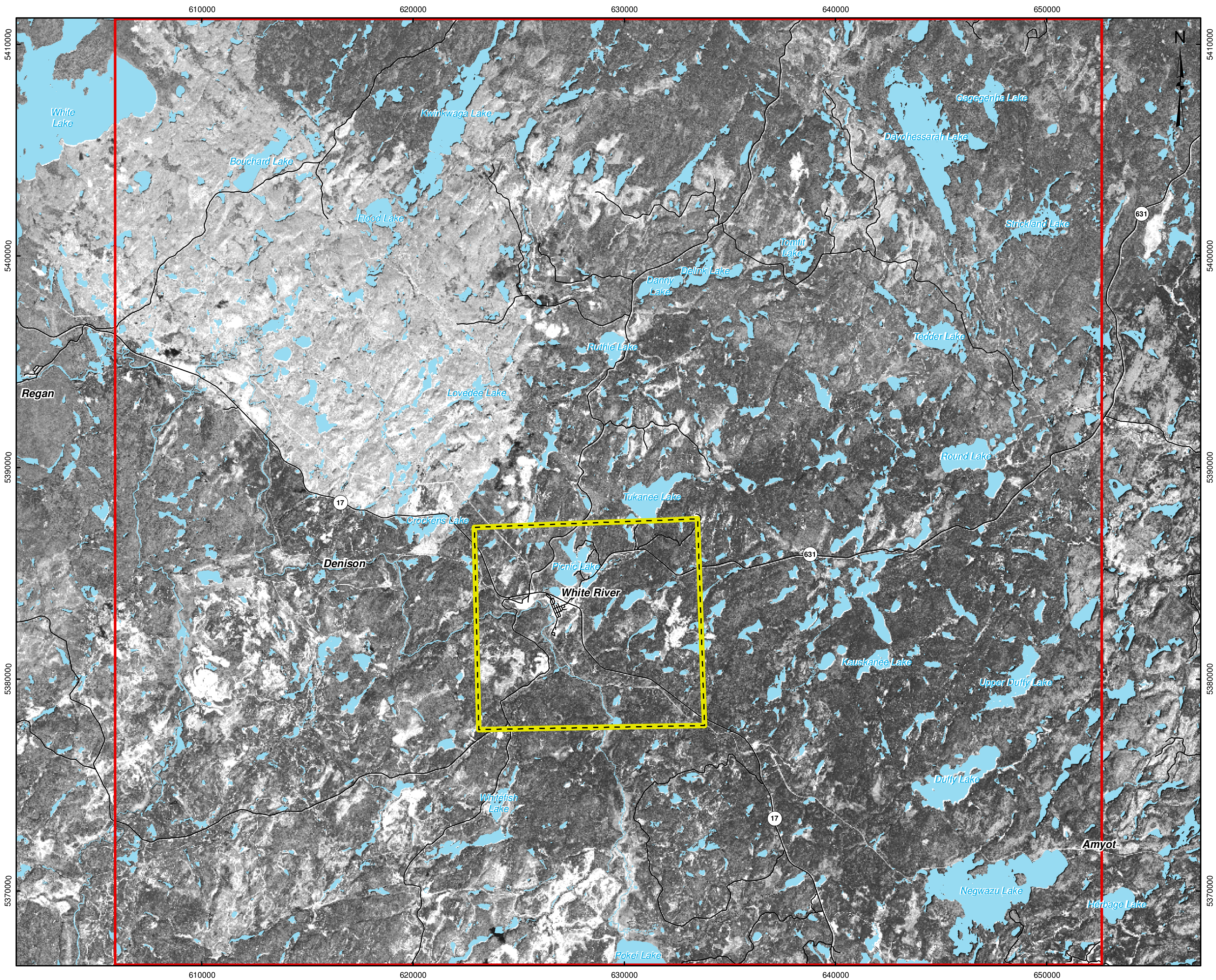
FIGURE: 2.1



LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Municipal Boundary, Lower Tier
- Road
- Water Area, Permanent

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Imagery: Spot 5 , Obtained from Geobase (2006 to 2007, 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

5 2.5 0 5 10

SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

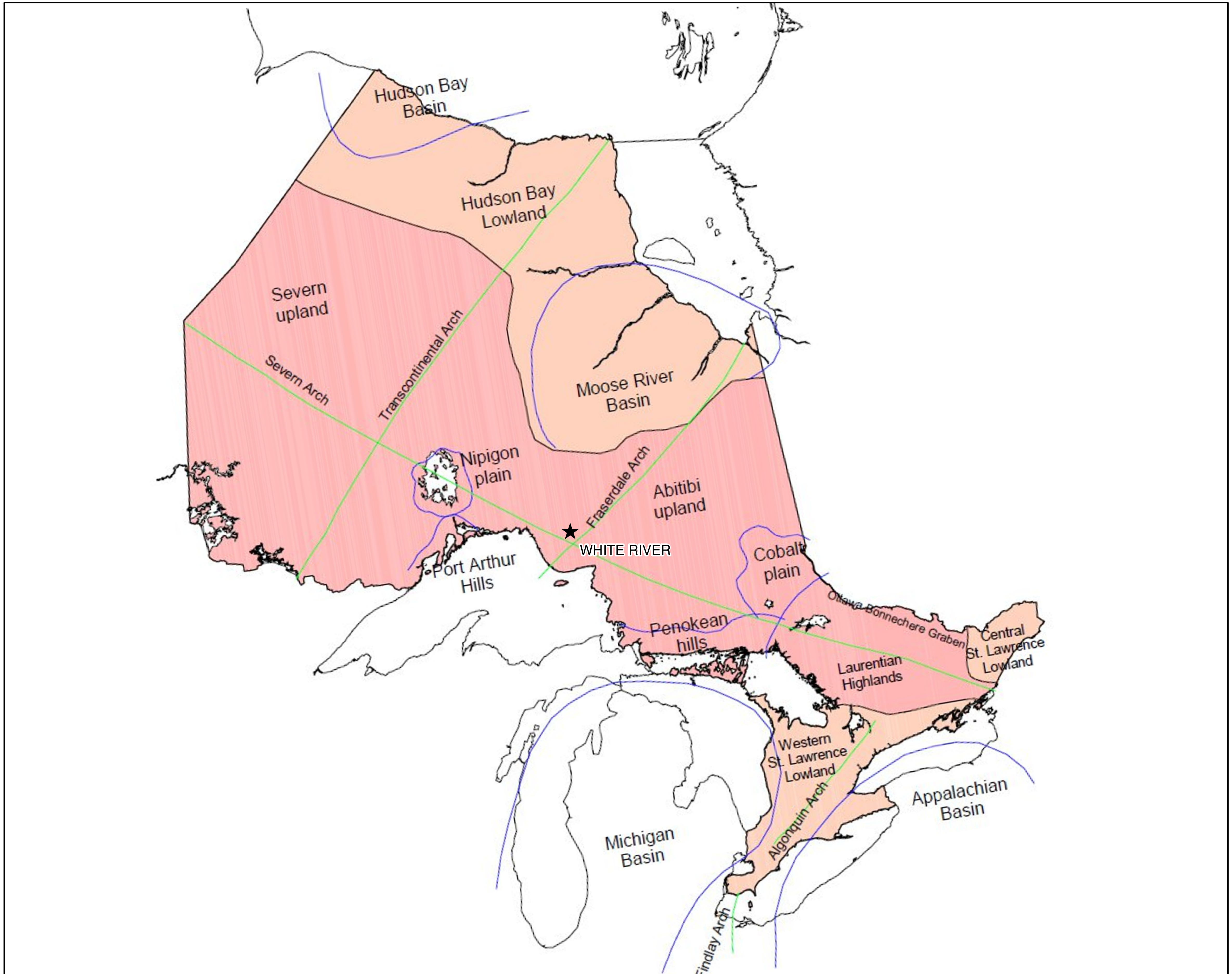
Satellite Imagery of the White River Area

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	27 Jan. 2011		
GIS	PM/JB	26 Sep. 2012		
CHECK	CM	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

Golder Associates
Mississauga, Ontario

FIGURE: 2.2

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase12000\SatelliteImageryoftheWhiteRiverArea.mxd



LEGEND

- ★ Township of White River
- 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	PRM	30 Aug. 2010		
GIS	PM/JB	26 Sep. 2012		
CHECK	JH	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

FIGURE: 2.3

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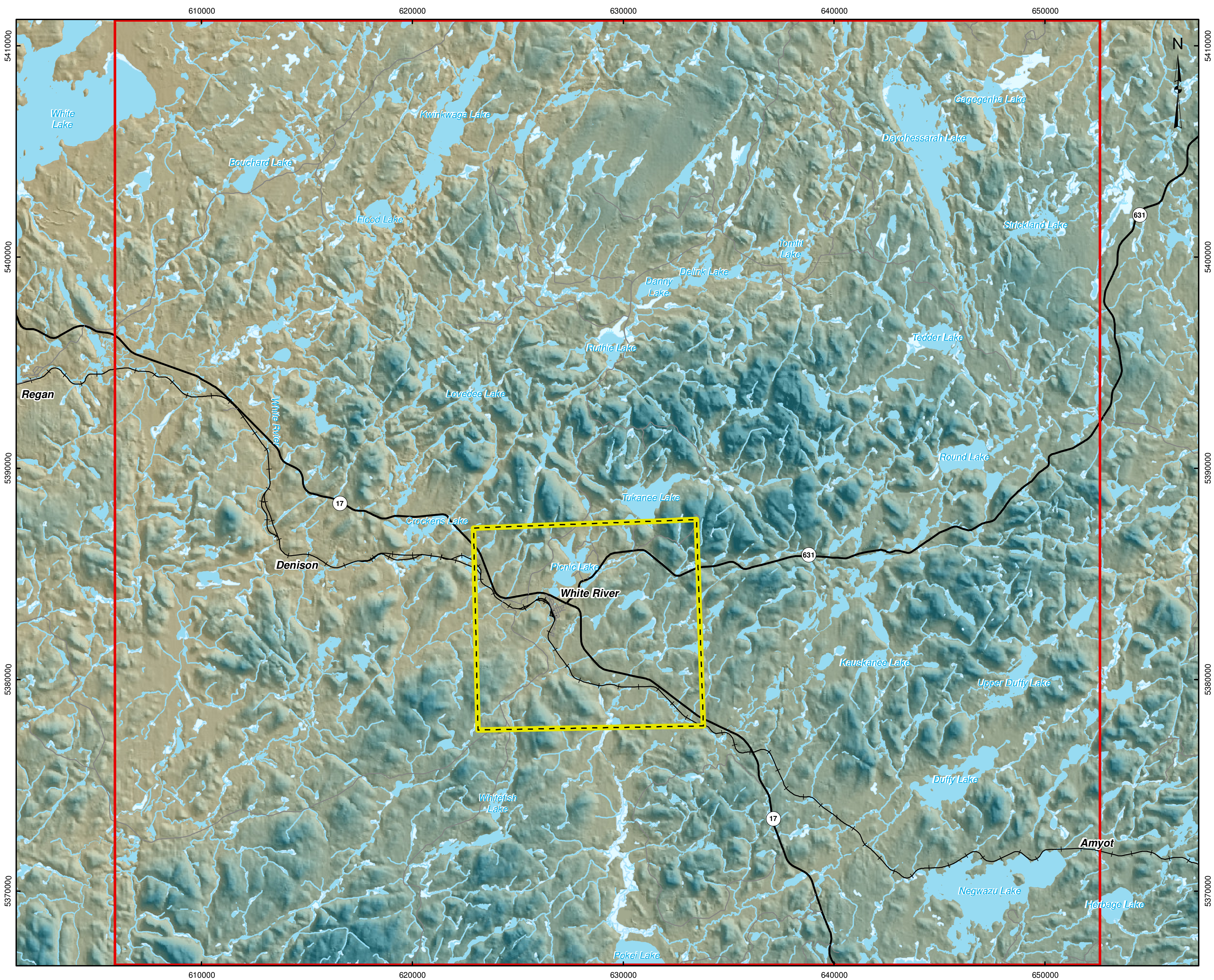

LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Watercourse, Permanent
- Watercourse, Intermittent
- Water Area, Permanent
- Wetland, Permanent

Elevation Model (masl)

525
475
450
425
400
375
350
325
300
275
215

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
DEM - MRN LIO DEM Version 1.1.0 - 2005
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

5 2.5 0 5 10
SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Digital Elevation Model (DEM) of the White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 3.0
DESIGN	PRM	27 Jan. 2011		
GIS	PRM	26 Sep. 2012		
CHECK	JH	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

FIGURE: 2.4

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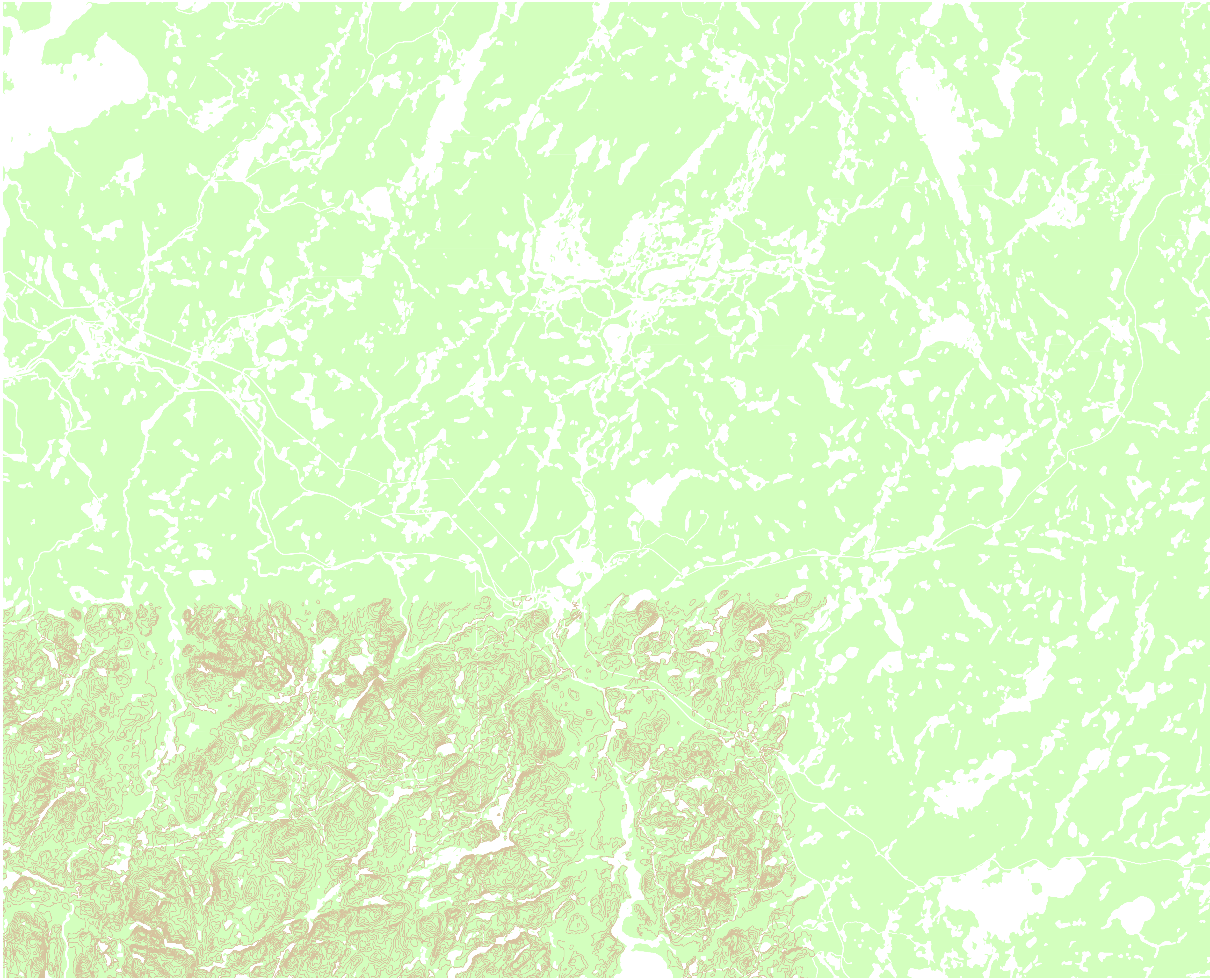
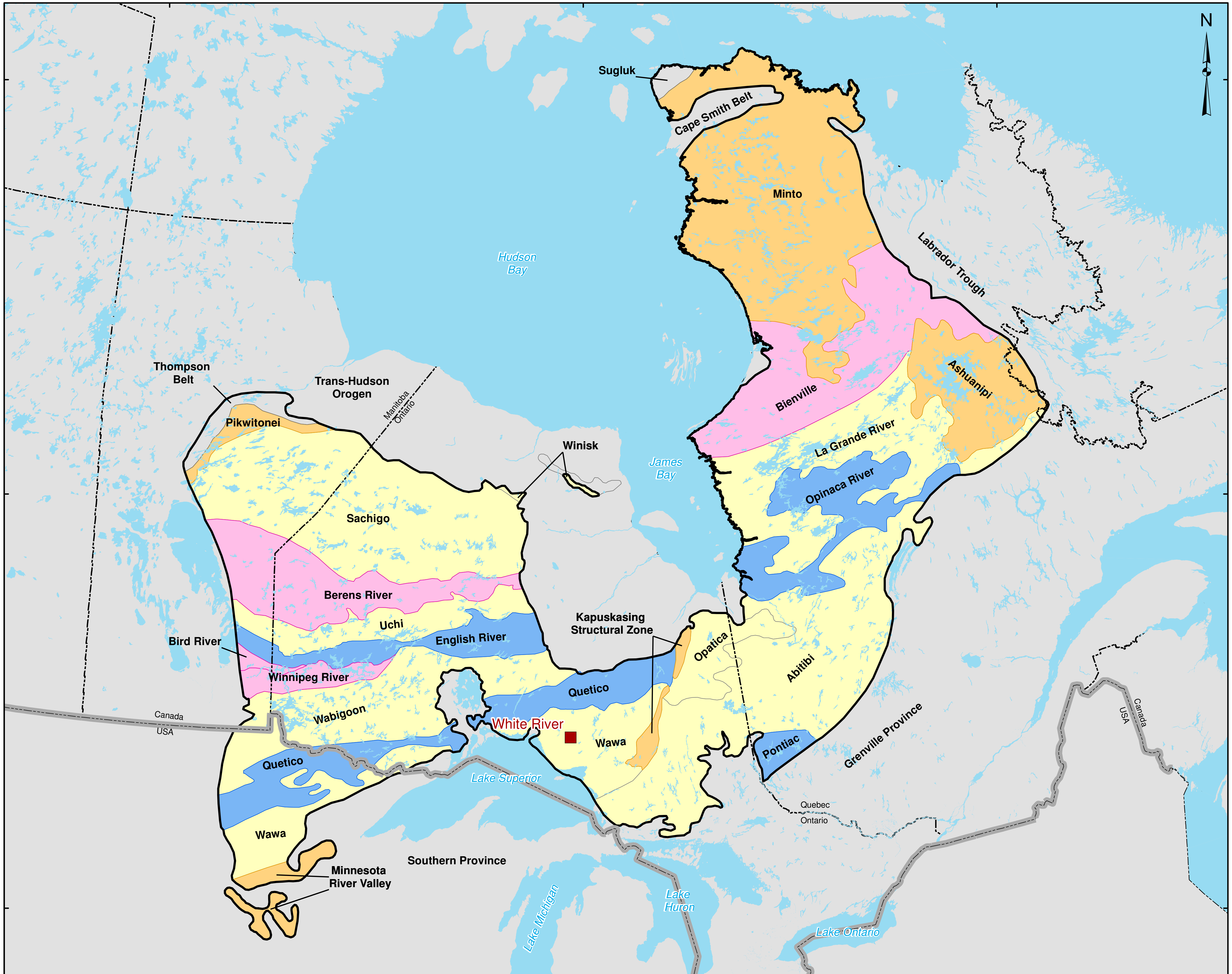


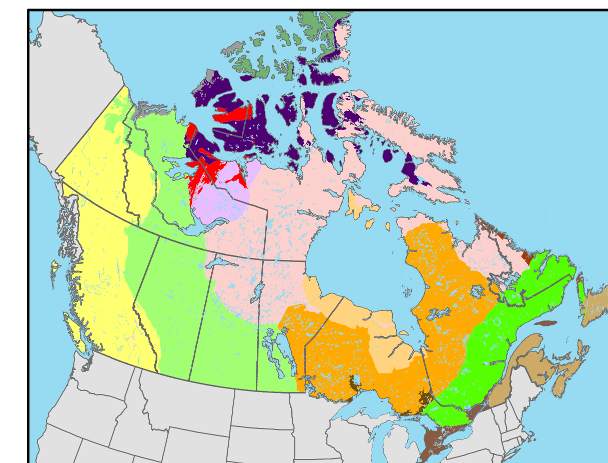


LEGEND

- Township of White River
- Provincial Boundary
- International Boundary
- Limit of Exposed Archean Rock

Superior Province (Archean)

- Sub-Province Gneiss - 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 LIO, obtained 2009-2012, CANMAP v2006.4
Subdivisions of Superior Province - Thurston, P. C. 1991 Geology of Ontario: Introduction in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, p.3-25
Geological Regions: Geological Map of Canada 1996, Map D1860A
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15

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

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Subdivision of the Superior Province of the Canadian Shield

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 2.0
DESIGN	PRM	30 Aug. 2010	**FIGURE: 3.1**	
GIS	PRM	26 Sep. 2012		
CHECK	CM	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

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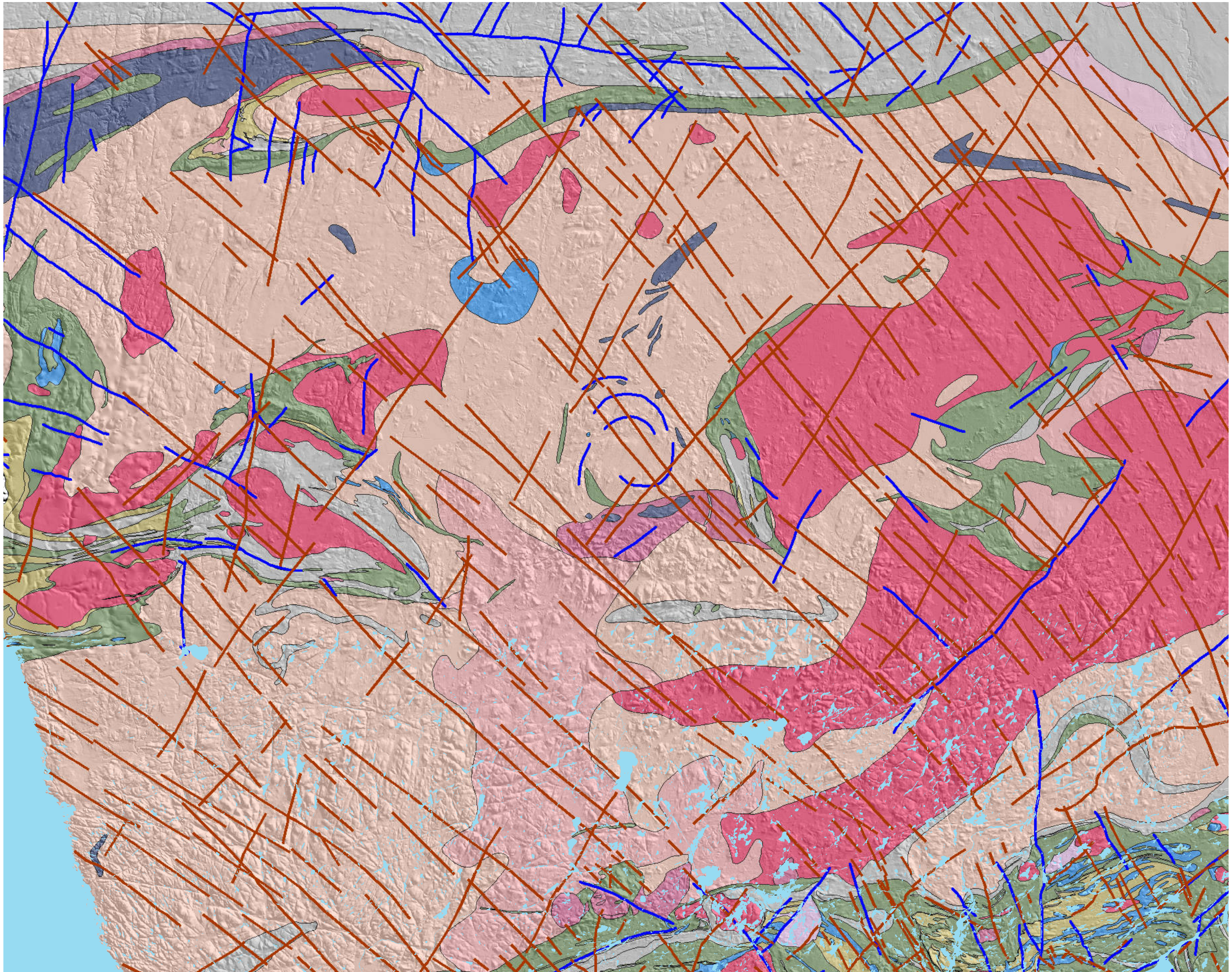
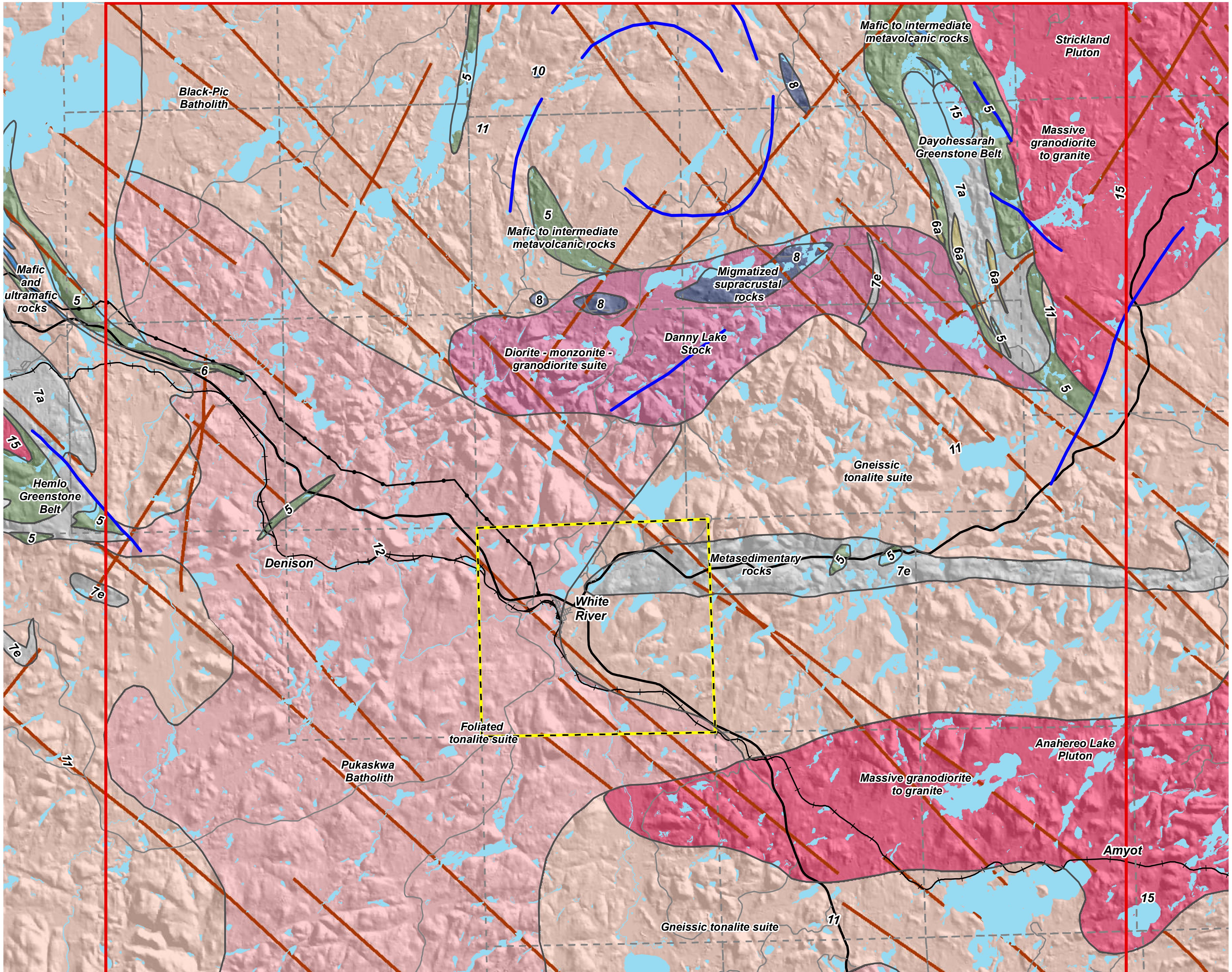
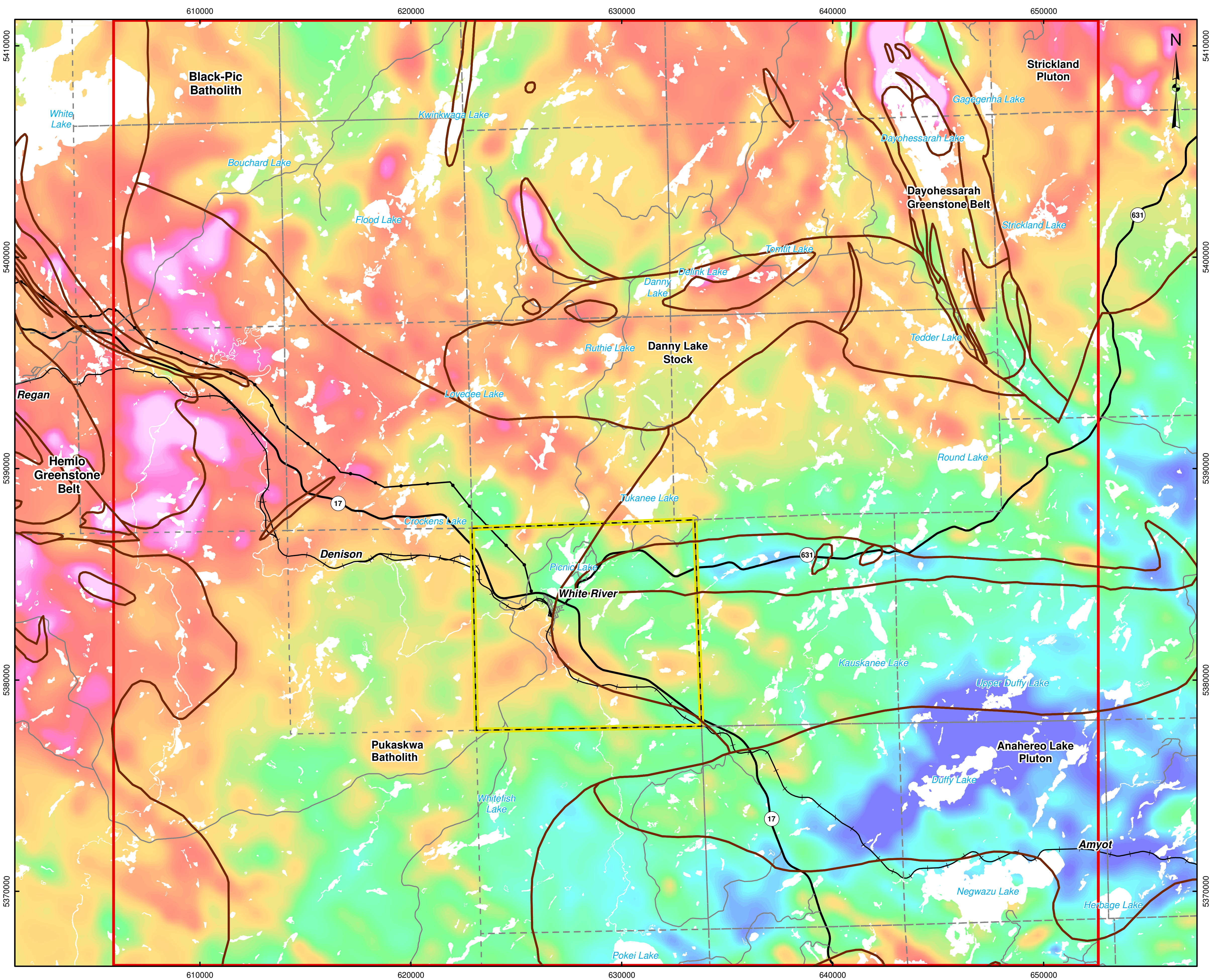



Black-Pic Batholith
Mafic to intermediate metavolcanic rocks
Strickland Pluton
Dayohessarah Greenstone Belt
Massive granodiorite to granite
Mafic and ultramafic rocks
Migmatized supracrustal rocks
Danny Lake Stock
Diorite - monzonite - granodiorite suite
Hemlo Greenstone Belt
Gneissic tonalite suite
Denison
Metasedimentary rocks
White River
Foliated tonalite suite
Anahereo Lake Pluton
Massive granodiorite to granite
Pukaskwa Batholith
Amyot
Gneissic tonalite suite



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LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Geographic Township Boundary
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Utility Line
- Water Area, Permanent
- Geological Contact

Residual Total Magnetic Field (nT)

250
200
150
100
50
0
-50
-100
-150
-200
-250

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geophysics: GSC Canada - 200m - Magnetic - Residual Total Field, 2008;
Canadian Aeromagnetic Data Base, Airborne Geophysics Section, GSC - Central Canada
Division, Geological Survey of Canada, Earth Sciences Sector, Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario (2007)
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10
SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

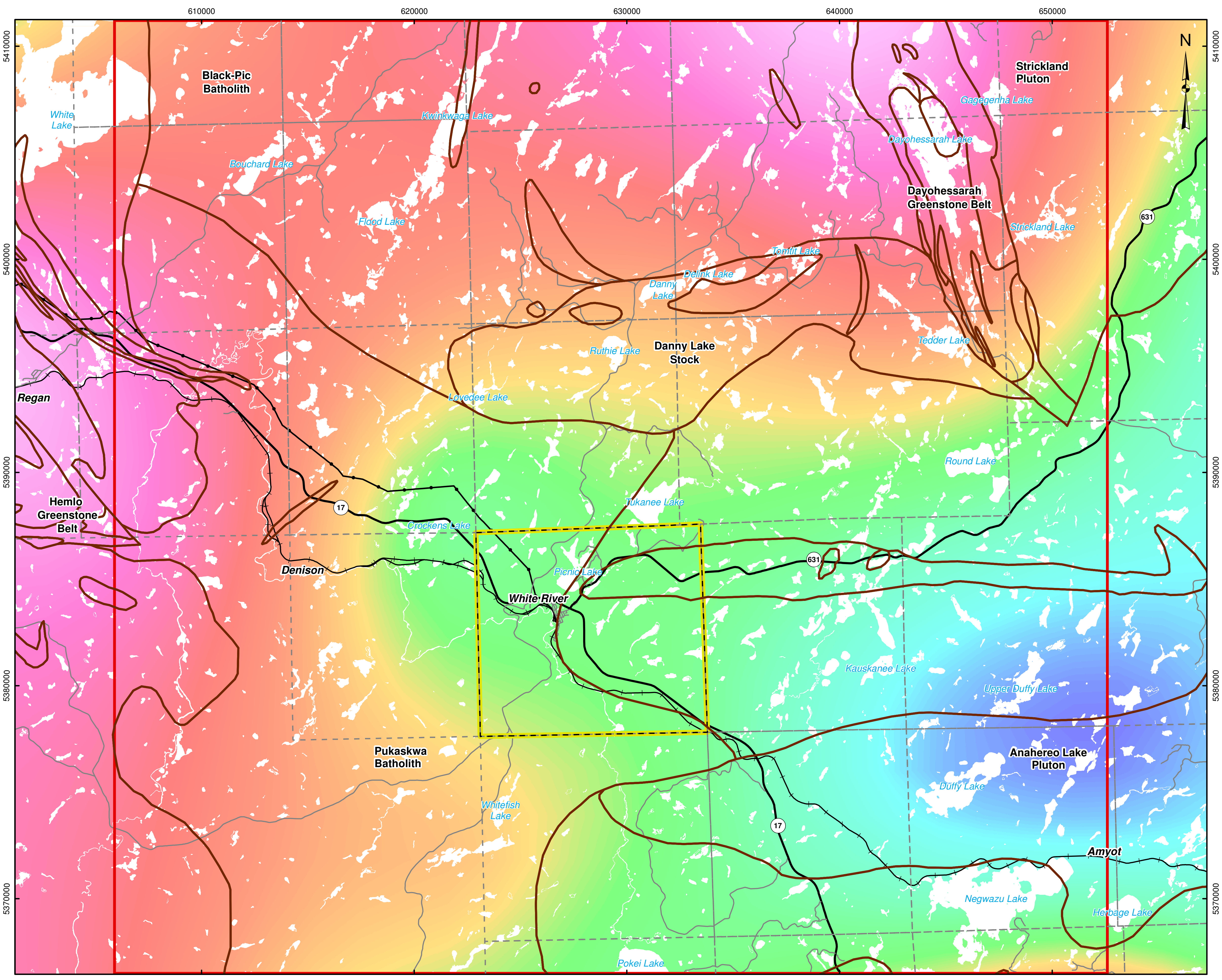
TITLE

Residual Total Magnetic Field of the White River Area

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 2.0
DESIGN	PRM	27 Jan. 2011		
GIS	PM/JB	26 Sep. 2012		
CHECK	JF	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

Golder Associates
Mississauga, Ontario

FIGURE: 3.4



LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Geographic Township Boundary
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Utility Line
- Water Area, Permanent
- Geological Contact

Gravity Anomaly (mGal)

60
62
64
66
68
70
72
74
76

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geophysics: GSC Canada - 2km resolution - Gravity Anomalies, 2010;
Canadian Aeromagnetic Data Base,Airborne Geophysics Section, GSC - Central Canada Division,Geological Survey of Canada,Earth Sciences Sector,Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario, 2007
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10
SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Gravity Map of the White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 3.0
DESIGN	PRM	27 Jan. 2011	**FIGURE: 3.5**	
GIS	PM/JB	26 Sep. 2012		
CHECK	JF	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

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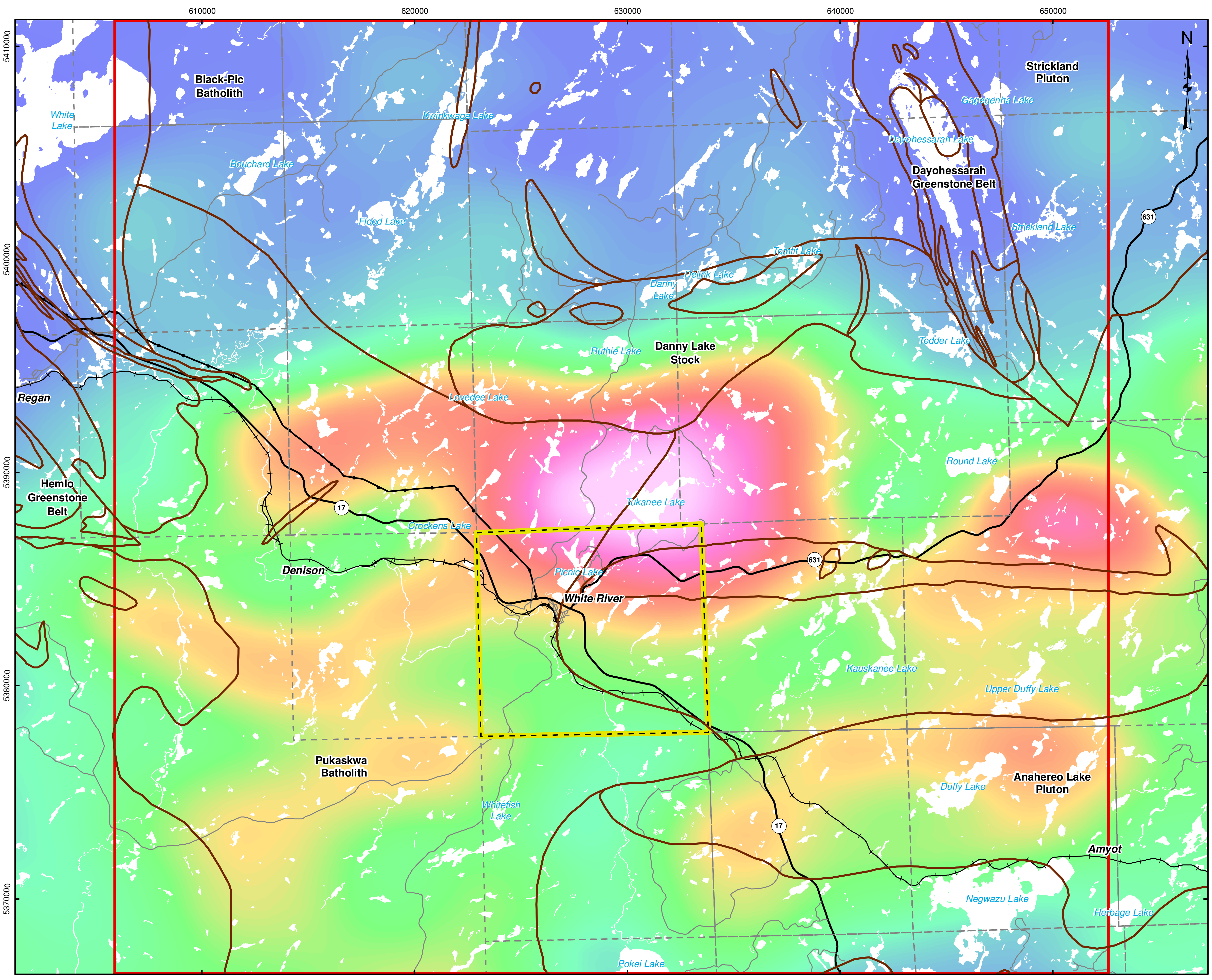

LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Geographic Township Boundary
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Utility Line
- Water Area, Permanent
- Geological Contact

Equivalent Uranium (ppm)

3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4;
Radiometrics: GSC Canada - 250m -Equivalent Uranium, 2010;
National Gamma-Ray Spectrometry Program Data Base, Airborne Geophysics Section,GSC -
Central Canada Division, Geological Survey of Canada, Earth Sciences Sector,Natural Resources Canada
Geology: MRD126-Bedrock Geology of Ontario, 2007
Produced by Golder Associates Ltd under licence from Ontario MNR, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10
SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Equivalent Uranium of the White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN / REV. 2.0
DESIGN	PRM	22 Nov. 2011	
GIS	PRM	26 Sep. 2012	
CHECK	JF	26 Sep. 2012	
REVIEW	GWS	26 Sep. 2012	

FIGURE: 3.6

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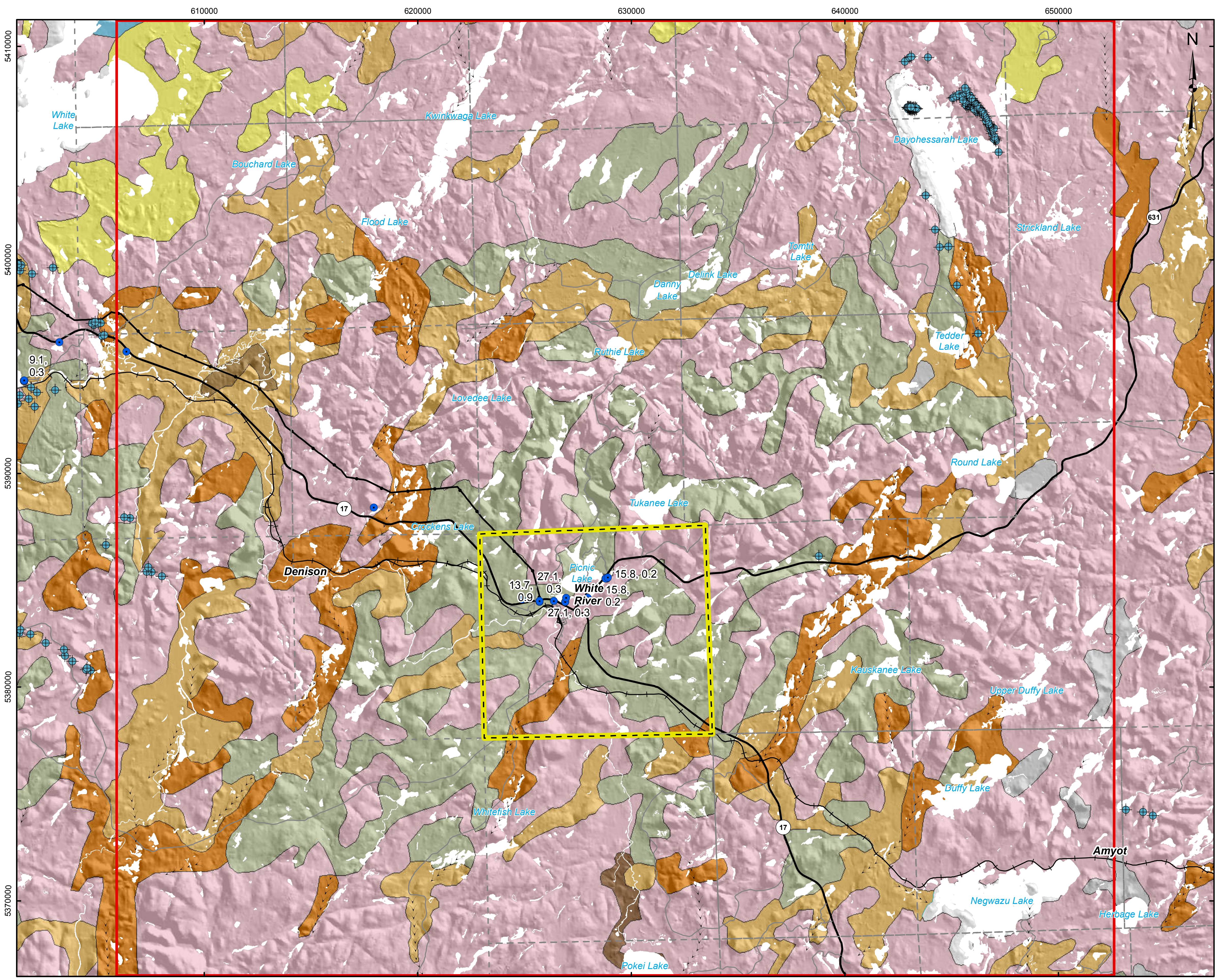

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LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Geographic Township Boundary
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Utility Line
- Diamond Drill Hole
- MOE Well (Depth to Bedrock in meters, Depth to Water - m)
- Esker or Area of Eskers; Direction of Flow Known or Assumed
- Beach, Bar or Spit
- Terrace escarpment; Fluvial

Quaternary Geology

- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice
- 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: Lakes

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2009
Geology: EDS014-Surficial Geology of Ontario 1:1,1000,000, 2000
Drillholes: MRD126-Bedrock Geology of Ontario, 2011
Wells: Ministry of the Environment, 2010
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10

SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

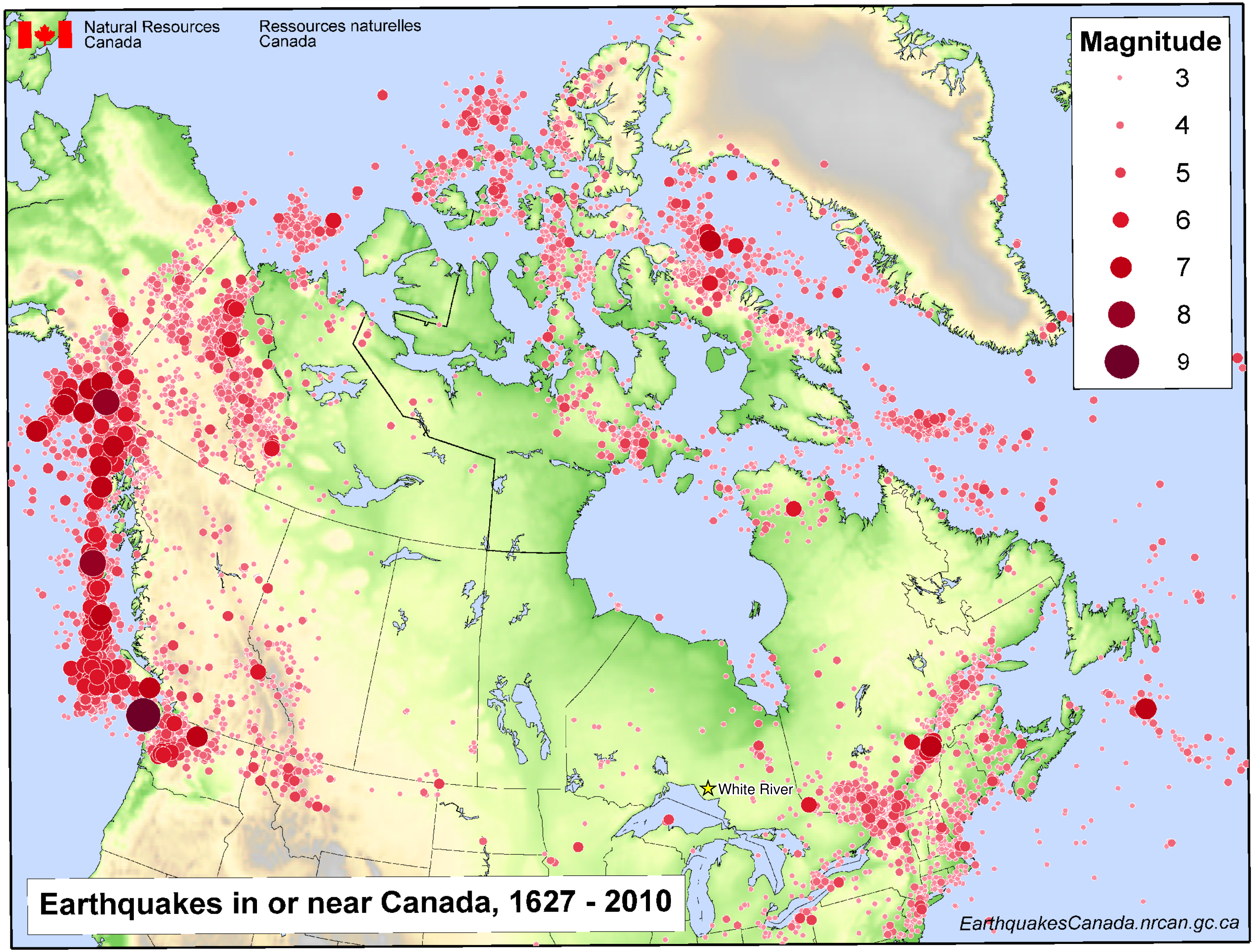
TITLE

Quaternary Geology of White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 3.0
DESIGN	PRM	27 Jan. 2011		
GIS	PM/JB	26 Sep. 2012		
CHECK	JH	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

FIGURE: 3.7



LEGEND

☆ Township of White River

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	**FIGURE: 3.8**	
GIS	PRM	26 Sep. 2012		
CHECK	JF	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

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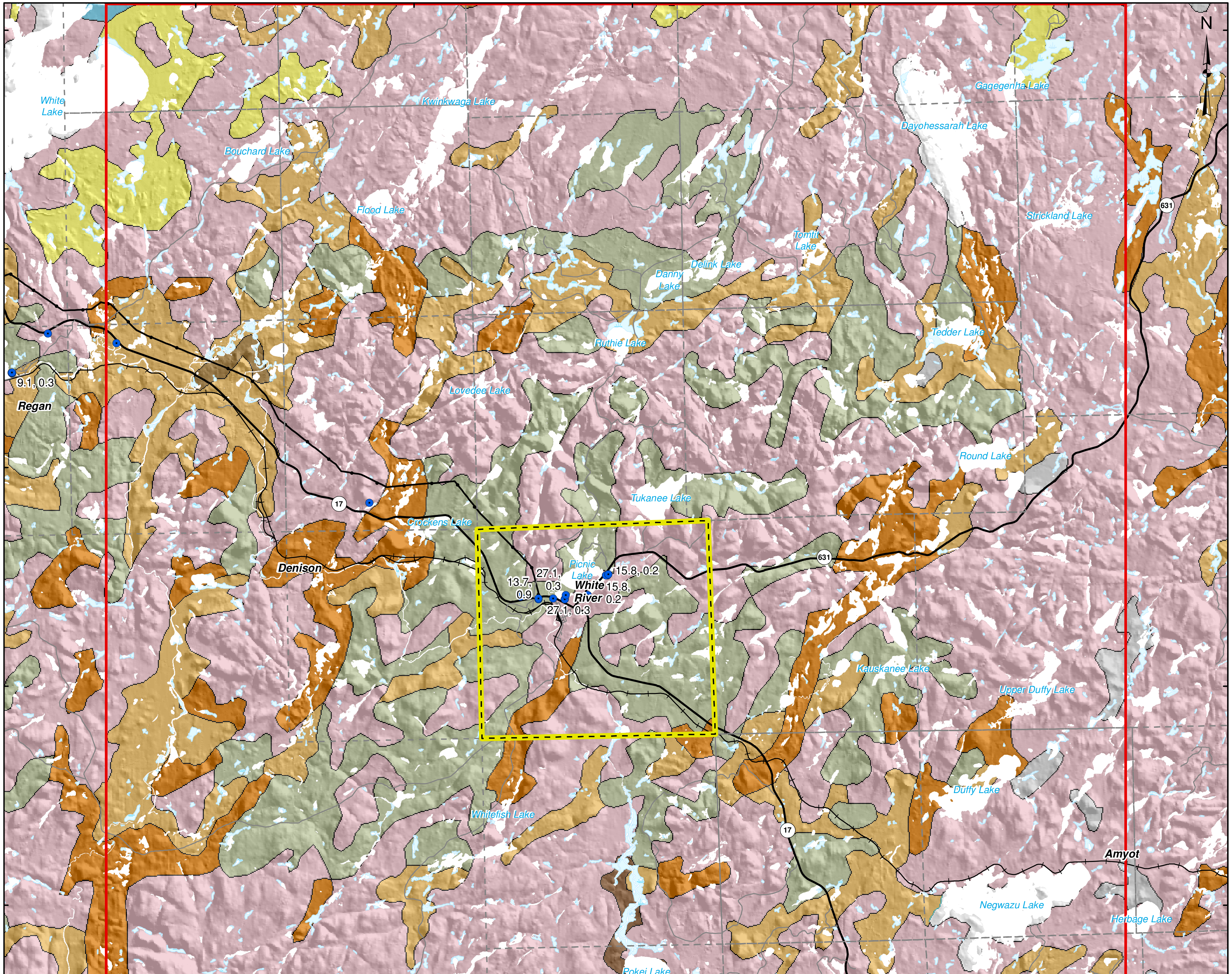

LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Geographic Township Boundary
- Municipal Boundary, Lower Tier
- MOE Well (Depth to Bedrock in meters, Depth to Water - m)
- Main Road
- Local Road
- Railway
- Utility Line
- Wetland Area, Permanent

Quaternary Geology

- 1: Bedrock
- 18: Till
- 22: Glaciofluvial Ice
- 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: Lakes

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2009
Geology: EDS014 - Surficial Geology of Ontario 1:1,000,000, 2000
Wells: Ministry of the Environment, 2010
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10

SCALE 1:180,000 KILOMETRES

PROJECT

NWMO Desktop Level Initial Screening

TITLE

Water Wells of the White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 3.0
DESIGN	PRM	27 Jan. 2011		
GIS	PM/JB	26 Sep. 2012		
CHECK	CM	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

FIGURE: 4.1

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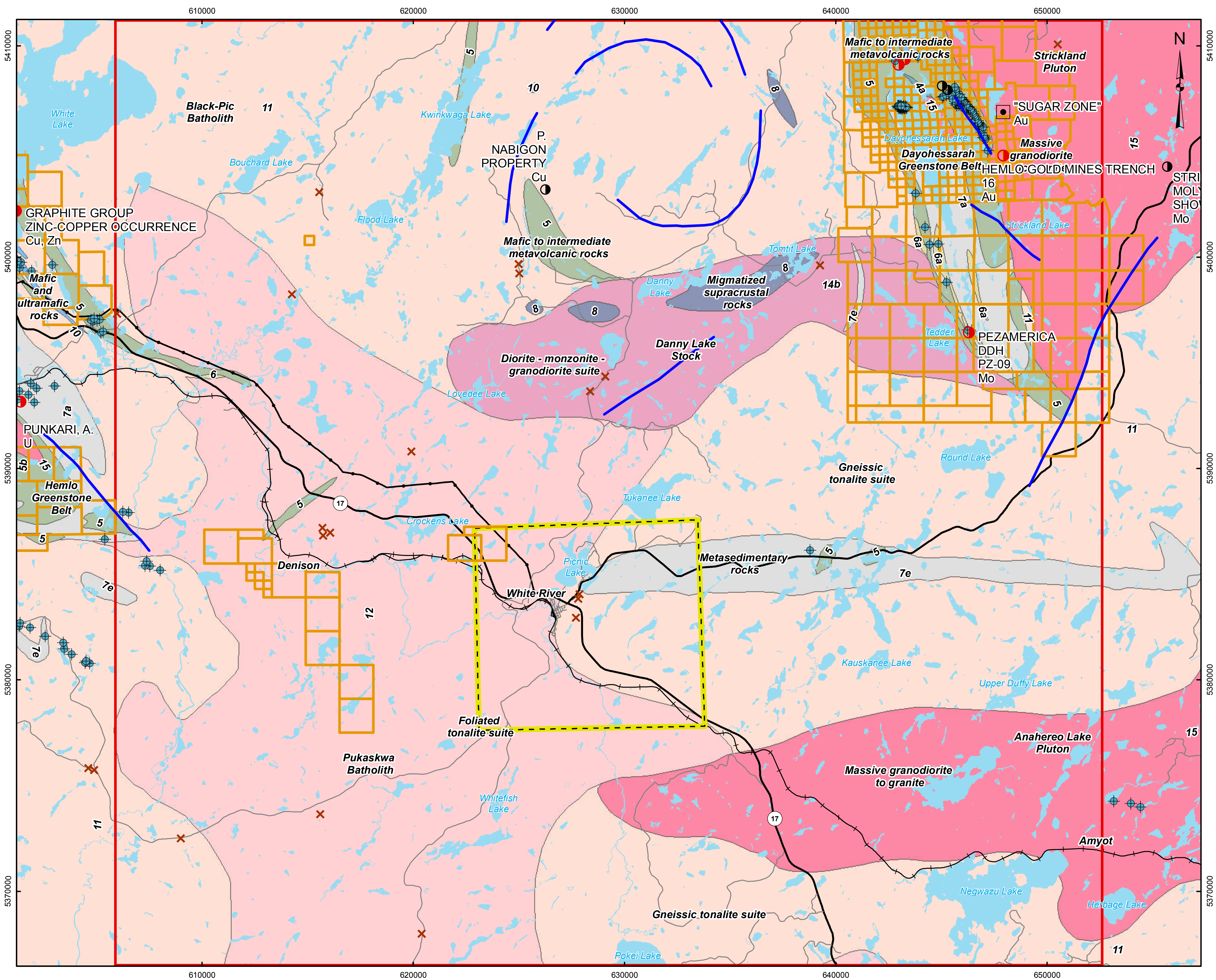

LEGEND

- Municipal Boundary (Township of White River)
- White River Area
- Municipal Boundary, Lower Tier
- Main Road
- Local Road
- Railway
- Utility Line
- Water Area, Permanent
- Diamond Drill Hole
- Discretionary Occurrence
- Occurrence
- Prospect
- Pit or Quarry
- Geological Fault
- Active Mining Claims

Bedrock Geology

- 15 Massive granodiorite to granite
- 14b Granodiorite, granite
- 12 Foliated tonalite suite
- 11 Gneissic tonalite suite
- 10 Mafic and ultramafic rocks
- 8 Migmatized supracrustal rocks
- 7 Metasedimentary rocks
- 7a Paragneisses and migmatites
- 7e Paragneiss and migmatites
- 6 Felsic to intermediate metavolcanic rocks
- 6a Dacitic and Andesitic flows, tuffs and breccias
- 5 Mafic to intermediate metavolcanic rocks
- 5b Basaltic and andesitic flows, tuffs and breccias
- 4a Ultramafic metavolcanic rocks

REFERENCE

Base Data - MNR LIO, obtained 2009-2012, CANMAP v2006.4
Claims: Ministry of Northern Mines and Development August 2012
Mineral Inventory: Mineral Deposit Inventory of Ontario v2, 2004
Geology: MRD126-Bedrock Geology of Ontario 2011
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Ontario Ministry of Natural Resources, © Queens Printer 2009
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16N

5 2.5 0 5 10
SCALE 1:180,000 KILOMETRES

PROJECT
NWMO Desktop Level Initial Screening

TITLE
Mining Claims and Mineral Potential in the White River Area

Golder Associates
Mississauga, Ontario

PROJECT NO. 10-1152-0110			SCALE AS SHOWN	REV. 1.0
DESIGN	PRM	27 Jan. 2011		
GIS	PM/JB	26 Sep. 2012		
CHECK	JH	26 Sep. 2012		
REVIEW	GWS	26 Sep. 2012		

FIGURE: 5.1

G:\Projects\2010\10-1152-0110_NWMO_Initial_Screening\GIS\MXDs\Reporting\Phase12000\MiningClaimsandMineralPotentialintheWhiteRiverArea.mxd

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