NUCLEAR WASTE MANAGEMENT ORGANIZATION

SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Phase 2 Geoscientific Preliminary Assessment, Findings from Initial Field Studies

TOWNSHIP OF SCHREIBER, ONTARIO

APM-REP-06145-0005

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

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies
Township of Schreiber, Ontario

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Prepared for:
Nuclear Waste Management Organization
22 ST. Clair Avenue East, 6th Floor
Toronto, Ontario M4T 2S3

Prepared by:

Geofirma Engineering Ltd
1 Raymond St., Suite 200
Ottawa, Ontario K1R 1A2
Tel: (613) 232-2525
Fax: (613) 232-7149
www.geofirma.com

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Prepared by:	Sean Sterling
Reviewed by:	Kenneth Raven
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EXECUTIVE SUMMARY

In 2013, a Phase 1 geoscientific desktop preliminary assessment was completed by AECOM Canada Ltd. to assess whether the Schreiber area contains general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection process. The assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. The Phase 1 assessment revealed that the Schreiber area contains two general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors.

In 2014, as part of Phase 2 of the preliminary geoscientific assessment of the Schreiber area, NWMO initiated a series of initial geoscientific field studies including the acquisition and interpretation of high-resolution airborne geophysical data and initial geological mapping. The objective of these initial field studies was to advance understanding of the geology of the general potentially suitable areas identified in the Phase 1 geoscientific desktop preliminary assessment, and assess whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping. The Phase 2 preliminary geoscientific assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the two general areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution gravity and magnetic data to better understand the bedrock geology such as geological contacts, depth and extent of rock units, lithological and structural heterogeneity;
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic surveys to identify possible structural features such as fractures, shear zones and dykes;
- Observation of general geological features to confirm/ground truth geologic characteristics, including lithology, structure, bedrock exposures and surface constraints.

The interpretation of the new Phase 2 data and field observations confirmed geological complexities that reduce the likelihood of finding repository sites that would ultimately satisfy NWMO's geoscientific site evaluation factors in the Schreiber area. While the assessment identified two potential candidate areas that could be considered for detailed geological mapping, these areas exhibit a high degree of structural complexity, and have a number of unfavourable geoscientific characteristics. More specifically, both identified areas contain numerous interpreted subsurface fractures that could have an impact on the long-term performance of a repository. Avoiding interpreted subsurface fractures could result in a much larger repository footprint. The space that would be available to accommodate a larger repository footprint in the Schreiber area would be limited because of the relatively small extent of the two identified areas, and the increased structural complexity in the surrounding rocks.

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1 INTRODUCTION

In 2013, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by AECOM Canada Ltd. to assess whether the Schreiber area contained general areas that had the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection process (AECOM, 2013; NWMO, 2010). The desktop preliminary assessment built on an initial screening conducted by Golder Associates in 2011 (Golder, 2011). The preliminary assessment focused on the Schreiber area and its periphery, shown in Figure 1-1.

The Phase 1 Geoscientific Desktop Preliminary Assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. These included: bedrock geology; structural geology; interpreted lineaments; distribution and thickness of overburden deposits; surface conditions; and the potential for economically exploitable natural resources. The consideration of these key geoscientific characteristics revealed that the Schreiber area contained at least two general areas that had the potential to satisfy NWMO's geoscientific site evaluation factors. The two areas are within the western and eastern portions of the Crossman Lake Batholith. In order to facilitate Phase 2 field studies, portions of land were temporarily removed from staking for mineral claims in the two identified general potentially suitable areas. The withdrawal areas are shown in Figure 1-2 which also shows the bedrock geology of the Schreiber area.

In 2014, as part of Phase 2 of the preliminary assessment, NWMO initiated a series of initial geoscientific field studies including the acquisition and interpretation of high-resolution airborne geophysical surveys and initial geological mapping to observe and ground truth general geological features. The objective of these initial field studies is to advance understanding of the geology of the general potentially suitable areas identified in the Phase 1 Geoscientific Desktop Preliminary Assessment, and to assess whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping.

The completed high-resolution airborne surveys included both magnetic and gravity surveys that improved understanding of the geological characteristics of the Schreiber area. The high-resolution surveys provided information on rock type, homogeneity, and the depth and extent of the potentially suitable host rock formations. High-resolution geophysical and remote sensing data were then used to conduct a geophysical and surficial lineament interpretation to identify the presence of potential structural features such as fractures and dykes. Preliminary geological mapping, also referred to as "observing general geological features", was conducted in the Schreiber area to better understand the lay of the land, and to confirm the presence and nature of key geological features such as fractures, rock types, extent of bedrock exposure and surface constraints. The results from the initial field studies are documented in three supporting documents: Geophysics Interpretation report (SGL, 2015); Lineament Interpretation report (SRK, 2015); and Observation of General Geological Features report (Fladgate and Geofirma, 2015).

This report provides the findings of Phase 2 initial field studies conducted in the Schreiber area in 2014 as they relate to whether the Schreiber area contains candidate areas for further field studies, beginning with detailed geological mapping.

The main sections of this report provide: a description of the approach and evaluation factors used to conduct the Phase 2 preliminary geoscientific assessments; a summary of the initial Phase 2 field studies methods and findings; and the approach, rationale and identification of candidate areas for further studies.

2 PRELIMINARY ASSESSMENT APPROACH

The overall preliminary assessment is a multidisciplinary study integrating both technical and community well-being assessments as illustrated in the diagram below. The five components of the preliminary assessment address geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations. A brief description of the project, the assessment approach and findings of the Phase 1 preliminary assessment are documented in the integrated Phase 1 preliminary assessment report (NWMO, 2013).

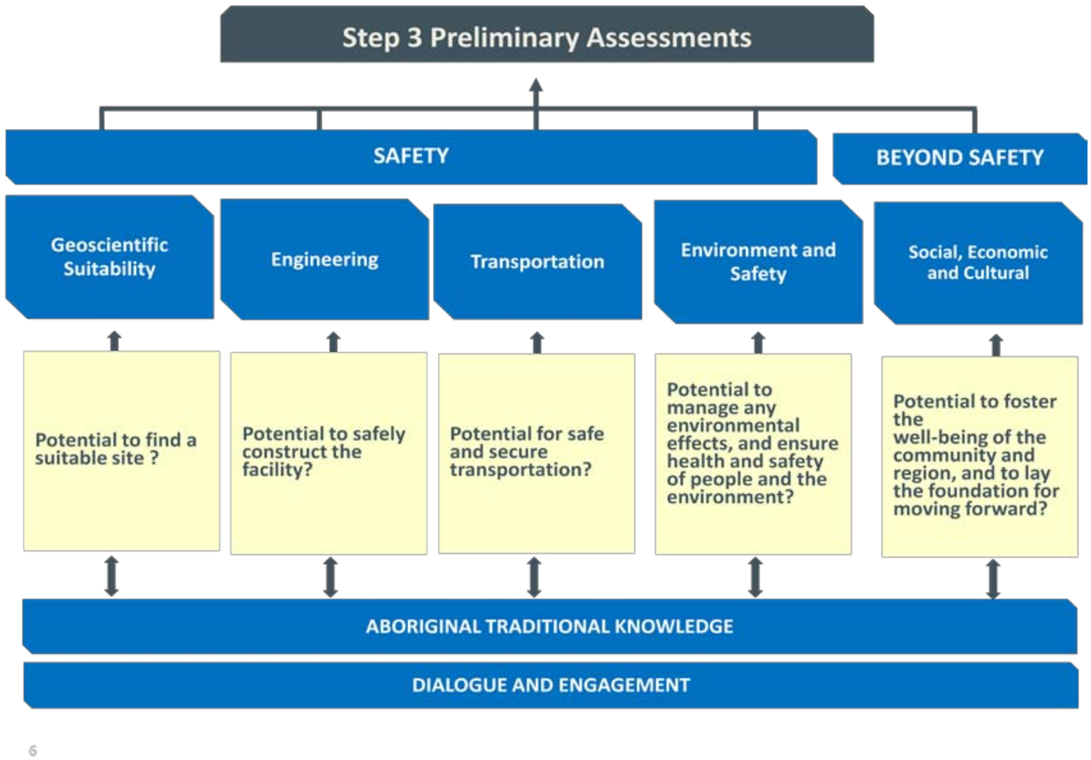

Diagram: The Preliminary Assessment Studies

The objective of the geoscientific preliminary assessment is to assess whether the Schreiber area contains general siting areas that have the potential to meet NWMO's site evaluation factors. The geoscientific preliminary assessment is conducted in two phases:

- ***Phase 1 - Desktop Study.*** For all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment.
- ***Phase 2 - Preliminary Field Investigations.*** For a subset of communities selected by the NWMO, to further assess potential suitability. This phase includes a series of initial field studies such as:
  a) Acquisition and interpretation of high-resolution airborne geophysical data, geophysical and surficial lineament interpretation, and initial geological mapping (referred to as "observing general geological features"). The outcome of these initial field studies is to identify potentially suitable candidate areas for detailed geological mapping;

b) Detailed geological mapping to inform the location of potentially suitable sites for borehole drilling; and

c) Drilling of deep boreholes at a selected location within each community.

The subset of communities considered in Phase 2 of the preliminary assessment was selected based on the findings of the overall desktop preliminary assessment, considering both technical and community well-being factors illustrated in the above diagram.

The Phase 1 Geoscientific Desktop Preliminary Assessment was completed for the Schreiber area in 2013 (AECOM, 2013). Initial Phase 2 field studies, including high-resolution airborne geophysical surveys and observing general geological features were conducted in 2014. This report focuses on summarizing the findings of these initial field studies.

3 GEOSCIENTIFIC SITE EVALUATION FACTORS

As discussed in the NWMO site selection process document (NWMO, 2010), the suitability of potential sites is evaluated in a step-wise manner through a series of progressively more detailed scientific and technical assessments using a number of geoscientific site evaluation factors, organized under five safety functions that a site would need to ultimately satisfy in order to be considered suitable (NWMO, 2010):

- ***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 caused by human activities and natural events?
- ***Long-term resilience to future geological processes and climate change:*** Is the rock formation at the siting area 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 geological and climate change processes such as earthquakes and glacial cycles?
- ***Safe construction, operation and closure of the repository:*** Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
- ***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?

In the Phase 1 geoscientific desktop preliminary assessment of the Schreiber area, the site evaluation factors were applied in two steps. The first step identified two general potentially suitable areas within the Schreiber area using key geoscientific characteristics that could realistically be assessed at the desktop stage based on available information. The second step confirmed that the two identified potentially suitable areas had the potential to ultimately meet all of the safety functions outlined above.

The identification of candidate areas for detailed geological mapping was conducted through a systematic and iterative process based on the updated understanding of the key geoscientific characteristics of the Schreiber area, using the newly acquired Phase 2 data. These key geoscientific characteristics are described in Section 5 and include: bedrock geology; structural geology; lineament analysis; bedrock exposure; protected areas; natural resources; and surface constraints.

4 PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT APPROACH (INITIAL FIELD STUDIES)

The initial Phase 2 geoscientific preliminary assessment included the following key activities:

a) Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the two general areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;

b) Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology (e.g. geological contacts, depth and extent of rock units, lithological and structural heterogeneity, etc.);

c) Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes;

d) Observation of general geological features to confirm/ground truth key geological characteristics, including lithology, structure, bedrock exposures and surface constraints.

The findings from the above activities were analyzed and interpreted in an integrated manner to achieve the two following objectives:

- Update understanding of key geoscientific characteristics that can be realistically assessed at this stage of the assessment to identify candidate areas for detailed mapping; and
- Assess whether it is possible to identify candidate areas for detailed mapping within the two general potentially suitable areas identified in the Schreiber area in the Phase 1 desktop preliminary assessment.

The approach, methods and findings for each of the above activities are described in detail in three supporting documents (SGL, 2015; SRK, 2015; Fladgate and Geofirma, 2015). This section provides a summary of the approach, methods and key results for each activity. The findings are discussed in an integrated manner in Section 5. The identification of candidate areas for additional field work is discussed in Section 6.

4.1 High-Resolution Airborne Geophysical Surveys

The objective of the airborne geophysical surveys was to provide additional information to further assess the geology of the Schreiber area. The interpretation of the data acquired during the airborne surveys can be used to estimate the geometry and thickness of the potentially suitable host rock formation; the nature of geological contacts; bedrock lithology; the degree of geological heterogeneity and the nature of intrusive phases within the batholith in the area; as well as the nature of structural features such as fractures, shear zones and dykes. The newly acquired geophysical data (SGL, 2015) provides higher resolution compared to the data available in the Phase 1 Assessment (Mira, 2013).

Sander Geophysics Limited (SGL) completed a fixed-wing high-resolution airborne magnetic and gravity survey in the Schreiber area between April 12 and April 24, 2014 (SGL, 2015). The survey area included two survey blocks located northeast and northwest of the Township of Schreiber

(Figure 4-1). These survey blocks were designed to cover the two potentially suitable areas identified in the Phase 1 preliminary assessment, and to cover relevant geological features in the area (Figure 1-2).

The airborne survey in the Schreiber area included a total of 3,397 kilometres of flight lines covering a surface area of approximately 174 square kilometres. Flight operations were conducted out of the Greenstone Regional Airport in Geraldton, Ontario using a Britten-Norman BN-2 Islander (Photo 1, below). Data were acquired along traverse lines flown in an east-west direction spaced at 100 metres, and control lines flown north-south spaced at 500 metres. The survey was flown at a nominal altitude of 80 metres above ground level, with an average ground speed of 100 knots (185 kilometres per hour).

Airborne magnetic and gravity data were acquired using equipment on board the plane with very high sensitivity and accuracy. The airborne magnetic data were recorded using a magnetometer sensor mounted in a fibreglass stinger extending from the tail of the aircraft. The airborne gravity data were recorded using a gravimeter, which includes three orthogonal accelerometers that are mounted on a platform inside the cabin of the aircraft. A detailed description of the planning, execution and processing of the survey data is provided in SGL (2015). The interpretation of the survey data included both a geophysics interpretation (Section 4.2; SGL, 2015) and a lineament interpretation (Section 4.3; SRK, 2015).

Photo 1: SGL's Britten-Norman BN-2 Islander

4.2 Geophysics Interpretation

A geophysics interpretation was conducted for the Schreiber area using newly acquired high-resolution magnetic and gravity data sets (SGL, 2015). The assessment of geological contacts and bedrock lithology in the Phase 2 assessment was performed by analyzing the magnetic and gravity data, and comparing the coincidence of magnetic responses with mapped lithology and structures for the Schreiber area. Magnetic anomaly characteristics and interpreted contacts were compared to the current bedrock geologic maps in order to identify similarities and/or changes in the lithological contact locations.

In some cases, the magnetic data provided a refined interpretation of the bedrock geological contacts, especially in areas of limited outcrop exposure (e.g. under overburden and drainage cover). The magnetic data and its vertical derivative products were used for interpreting geological contacts, identifying lithological heterogeneity, and assessing the nature of structural features through the surveyed area. In addition, the gravity data were valuable for interpreting geological contacts between rock units with differences in density. The magnetic and gravity data are shown in Figures 4-2 and 4-3, respectively. At the same time that the magnetic and gravity data were acquired, higher resolution Digital Elevation Model (DEM) topographic data were also generated from the airborne GPS and altimeter data (SGL, 2015), as shown in Figure 4-4. The magnetic, gravity and DEM data were all incorporated into preliminary forward model calculations to estimate the thickness and geometry of the batholith and adjacent greenstone units (SGL, 2015). Findings from the geophysical interpretation are discussed in an integrated manner in Section 5.

4.3 Lineament Interpretation

The purpose of the Phase 2 lineament interpretation was to provide an updated interpretation of the geological and structural characteristics of the potentially suitable bedrock unit located within the survey areas using the newly acquired high-resolution data. A geophysical and surficial lineament study was conducted for the survey areas in the Schreiber area using the high-resolution magnetic and DEM data from the airborne survey, and purchased high-resolution satellite imagery (SRK, 2015).

Lineaments are linear features that can be observed on remote sensing and geophysical data, which may represent geological structures. The presence of these features at depth would need to be confirmed through further field studies such as detailed geological mapping and borehole drilling.

4.3.1 Lineament Interpretation Workflow

The lineament interpretation workflow was designed to limit issues of subjectivity and reproducibility that are inherent to lineament interpretations (SRK, 2015). The workflow follows a set of detailed guidelines involving three stages:

- **Step 1:** Independent lineament interpretation by two separate interpreters for each data set and assignment of certainty level (low, medium, or high);
- **Step 2:** Integration of lineament interpretations for each individual data set, and determination of reproducibility (i.e. presence of the same lineament within each data set (topography, satellite, magnetic) as interpreted by each interpreter);
- **Step 3:** Integration of lineament interpretations for the surficial data sets (topography and satellite imagery) followed by integration of the combined surficial data set with the magnetic data set, with determination of coincidence in each integration step.

Over the course of these three stages, a comprehensive list of attributes for each lineament was compiled (SRK, 2015). The key lineament attributes and characteristics used in the assessment include certainty, length, density and orientation:

- ***Lineament Certainty:*** Certainty (low, medium or high) was defined based on the clarity of the lineament interpreted in the data, which provides confidence in the feature being related to bedrock structure. For example, where a surface lineament could be clearly seen on exposed bedrock, it was assigned a certainty value of high. Where a lineament represented a bedrock feature that was inferred from linear features, such as orientation of lakes or streams or linear trends in texture, it was assigned a certainty value of either low or medium. For magnetic lineaments, a certainty value of high was assigned when a clear magnetic susceptibility contrast could be discerned and a certainty value of either low or medium was assigned when the signal was discontinuous or more diffuse. The certainty classification for all three data sets involved expert judgment and experience of the interpreter. For the purpose of this assessment, emphasis was put on lineaments interpreted with high and medium certainty.

- ***Lineament Length:*** Interpreted lineaments were classified according to their length which is calculated based on the sum of all segment lengths that make up a lineament. It is assumed that longer interpreted lineaments may extend to greater depths than shorter interpreted lineaments. In general, longer interpreted lineaments also tend to have higher certainty values. For the purpose of the assessment, lineaments were classified according to four length bins (shorter than 1 kilometre, between 1 and 2.5 kilometres, between 2.5 and 5 kilometres, and longer than 5 kilometres).
- ***Lineament Density:*** The density of interpreted brittle lineaments was determined by examining the statistical density of individual lineaments using ArcGIS Spatial Analyst. A grid cell size of 50 metres and a search radius of 1.5 kilometres (equivalent to half the size of the longest boundary of the minimum area size of a potential siting area) were used for this analysis. The spatial analysis used a circular search radius examining the lengths of lineaments intersected within the circular search radius around each grid cell.
- ***Lineament Orientation:*** The orientation of interpreted lineaments was expressed in degrees ranging between 0 and 180. Lineament sets are defined by direction clustering of the data. The number of identified lineament sets, and their variation in orientation, provides a measure of the complexity of the potential individual fractures or fracture zones.

The following sections provide a summary of the interpreted lineaments. A more detailed analysis is provided in Section 5.3 and in SRK (2015).

4.3.2 Magnetic Lineaments

Magnetic lineaments were interpreted using the new high-resolution magnetic data, which provide an improvement to the overall resolution and quality of magnetic data compared with the data available during the Phase 1 preliminary assessment. Lineaments interpreted using the magnetic data are typically less affected by the presence of overburden than surficial lineaments, and more likely reflect potential structures that may or may not have surficial expressions. Magnetic lineaments interpreted with medium and high certainty in the survey area in the Schreiber area are shown on Figure 4-5. In general, the magnetic lineaments show a relatively uniform density in the eastern and western portions of the Crossman Lake batholith, with the exception of a lower density area in the northwest part of the western block. This lower density area, however, may be related to the high topographic variability and its effect on airborne acquisition of magnetic data. As a result, there is some uncertainty in the interpreted lineament density in this area (SGL, 2015; SRK, 2015).

A more detailed analysis of magnetic lineaments interpreted within the vicinity of each area is provided in Sections 5.3 and 6.

4.3.3 Surficial Lineaments

Surficial lineaments were interpreted using newly acquired high-resolution topographic (DEM) data from the airborne survey (SGL, 2015), and purchased high-resolution satellite imagery (SRK, 2015). The satellite imagery data contained a cell resolution of 0.46 m, which was a significant improvement compared to the lower resolution data (20 m) used during the Phase 1 preliminary assessment.

Surficial lineaments were interpreted as linear traces along topographic valleys, escarpments, and drainage patterns such as river streams and linear lakes. These linear traces may represent the expression of fractures on the ground surface. However, it is uncertain whether surficial lineaments represent actual structures and if so, whether the structures extend to significant depth. Figure 4-6 shows Phase 2 surficial lineaments interpreted for the Schreiber area. The distribution of overburden is shown in Figure 4-7. A more detailed analysis of surficial lineaments interpreted within the vicinity of each potentially suitable area is provided in Sections 5.3 and 6.

4.4 Observing General Geological Features (Initial Geological Mapping)

An initial geological mapping campaign was conducted by Fladgate Exploration Consulting Corporation and Geofirma Engineering Ltd. in September 2014 to observe general geological features in the Schreiber area (Fladgate and Geofirma, 2015). These observations were conducted at select locations to better understand the lay of the land and to confirm the presence and nature of key geological features in the area (e.g. Photos 2 and 3), including: bedrock character (lithology, structure, magnetic susceptibility, and rock strength); fracture character; bedrock exposure and other surface constraints. A detailed description of the approach, methods and observations is provided by Fladgate and Geofirma (2015). This section provides an overview of the mapping planning, logistics and use of local and traditional knowledge. The findings from the initial observations are discussed in an integrated manner with findings from other initial Phase 2 field data throughout Section 5.

Over a period of seven mapping days, two teams of two geologists working in parallel visited the western and eastern portions of the Crossman Lake batholith (Fladgate and Geofirma, 2015). A local guide provided logistical support and alternated daily between the two teams. A total of 145 locations within and in the vicinity of the airborne survey blocks were observed during this time (Figures 4-8 and 4-9). Several GIS data sets were used as base maps for the Phase 2 initial geological mapping, including georeferenced historical geological outcrop mapping, high-resolution satellite imagery, and high-resolution geophysical data (Fladgate and Geofirma, 2015).

Photo 2: Observing General Geological Features in the Crossman Lake batholith in the Schreiber Area

Photo 3: Example of Granodiorite from the Crossman Lake batholith

4.4.1 Mapping Plans and Logistics

Planning of the Phase 2 initial geological mapping involved a review of all available information for the Schreiber area, including access (Fladgate and Geofirma, 2015). The planning also included the development of a comprehensive list of source data, equipment and task requirements for the observation of the key geological features (Fladgate and Geofirma, 2015).

The observations incorporated the use of a digital data capturing method to allow for seamless integration of the observations into a GIS platform. In addition, hand-sized rock samples were collected to provide representative examples of the different rock types observed in the field. Field magnetic susceptibility measurements were obtained from fresh surfaces of outcrop using a KT-10 magnetic susceptibility metre (Fladgate and Geofirma, 2015). Preliminary geomechanical characterization of the bedrock was undertaken by visual estimation of fracture spacing (primarily joints) for block size determination and a simple field-based hammer test for intact rock strength (Fladgate and Geofirma, 2015).

The initial geological mapping of the Crossman Lake batholith was conducted using various means of transportation. In the eastern portion, the central area was accessible by 4x4 vehicle traversing existing roads and trails, while areas to the north and south of the access road required foot access only. The extreme southern area of the eastern portion was extremely remote and required helicopter transport. In the western portion of the batholith, helicopter transport was required throughout because there are no existing roads (Fladgate and Geofirma, 2015).

Observations made during the initial geological mapping were generally consistent with previous mapping that indicated that the majority of rocks in the western portion of the Crossman Lake batholith are intrusive rocks that fall into the granitoid subclass (i.e. granodiorites and granites) (AECOM, 2013). In general, observations made during initial geological mapping confirmed the existing understanding of bedrock exposure in the area, which indicates that exposure is good to very good (Fladgate and

Geofirma, 2015; AECOM, 2013). Observations related to the presence and character of structural features is discussed in Section 5.

4.4.2 Local and Traditional Knowledge Activities

As part of NWMO's promise to develop partnerships with First Nation and Métis people, there is a commitment to interweaving local Traditional Knowledge in all phases of NWMO's work. Traditional Knowledge involves all aspects of Aboriginal people's unique understanding, relationship and how they connect the land to their way of life. This unique understanding influences the way in which Aboriginal people use the land. Prior to the commencement of mapping activities, information sharing meetings and a ceremony involving NWMO staff and mapping contractors along with participating members of local Aboriginal communities took place. The ceremony reminded both participating members of the local Aboriginal and non-Aboriginal communities, contractors and NWMO staff that as humans, we are dependent on the land for sustaining life.

Through their knowledge of the land, local Aboriginal and non-Aboriginal people greatly enhanced the planning of mapping activities. Meetings held provided an opportunity to work collaboratively on planning to ensure activities would be carried out in a manner that was respectful of the land and local trap lines. Open dialogue was maintained during the execution of mapping activities. To facilitate this open dialogue, local First Nation guides were hired to provide logistical support and to bring local knowledge of the land.

5 KEY GEOSCIENTIFIC CHARACTERISTICS

The following subsections provide a description of the key geoscientific characteristics that were used to identify areas for detailed geological mapping based on both the Phase 1 preliminary assessment and the newly acquired field data during initial Phase 2 field work. The updated description focuses on the geoscientific characteristics of the general potentially suitable areas that were identified in the Phase 1 Geoscientific Desktop Preliminary Assessment (AECOM, 2013). These include the western and eastern portions of the Crossman Lake batholith (Figure 1-2).

5.1 Bedrock Geology

The bedrock geology of the Schreiber area was described in detail in the Phase 1 Geoscientific Desktop Preliminary assessment based on publically available reports and geological maps, as well as from the Phase 1 geophysical interpretation (AECOM, 2013; Mira, 2013). The Crossman Lake batholith is mapped as a single-phase granitic intrusion occupying the majority of the northern portion of the Schreiber area. The sections below provide an updated description of the bedrock geology of the western and eastern portions of the Crossman Lake batholith, as well as an updated description of mafic dykes in the Schreiber area based on newly acquired field data.

5.1.1 Western Portion of the Crossman Lake Batholith

The western portion of the batholith has been characterized as massive granite, with local variations (Carter, 1981; Carter, 1982). Similarly, the field observations made during the Phase 2 initial geological mapping in the western portion of the batholith identified the rock as a massive to weakly foliated, medium grained, occasionally fine grained, equigranular granodiorite to granite (Fladgate and Geofirma, 2015). The two phases of intrusion (granodiorite and granite) were not identified as separate mappable units (Fladgate and Geofirma, 2015).

The results from the Phase 2 interpretation of high-resolution magnetic data show a highly variable response that defines distinct areas within the western survey area (Figure 4-2, SGL, 2015). A prominent feature is a curved band of high magnetic variability in the northernmost part of the survey area. Although regional bedrock geology maps identify this area as a continuation of the batholith, the magnetic results indicate this area comprises significant lithological heterogeneity that may indicate an extension of the metasedimentary and metavolcanic rocks from the adjacent greenstone belt from the east. Despite this unmapped unit being identified in the magnetic data, the rock density contrast of the unit compared to the Crossman Lake batholith does not appear to be sufficient to produce a response in the gravity data (Figure 4-3). It is also possible that this anomaly represents an alteration zone on the edge of the batholith, or different phases of intrusion.

In the northwestern portion of the survey area, the magnetic data exhibit a circular area with a uniform quiet and weak response, which may indicate an area of relative lithological homogeneity. A relative lack of interpreted lineaments was observed for this circular area (SRK, 2015), which may be related to the high topographic variability and its effect on the acquisition of airborne magnetic data. In contrast, the southern half of the western portion of the Crossman Lake batholith shows a complex magnetic response (SGL, 2015). This half of the western portion of the batholith is characterized by mapped faults and dykes (OGS, 2011), as well as numerous interpreted potential faults and dykes of many orientations (SRK, 2015).

Gravity data in the western Crossman Lake batholith show a broad low response that generally coincides with the circular area in the magnetic data, which is interpreted to be the deepest portion of the batholith (SGL, 2015). The low gravity response transitions into a pronounced gravity high in the northeast direction defining a distinct boundary associated with the greenstone belt units. This boundary can be roughly inferred using the gravity data, or traced with improved confidence using the first vertical derivative of horizontal derivative of the gravity data (SGL, 2015). A gradual increase in the gravity anomaly in a southern direction implies that the batholith may become progressively shallower towards the Whitesand batholith, or that the Whitesand batholith rocks may have a slightly higher rock density. There is also a very gradual increase in the gravity anomaly to the north of the western portion of the Crossman Lake batholith at its boundary with the metasedimentary rocks of the Quetico subprovince, which implies that the rock density contrast between the batholith and the metasedimentary rocks is small.

Prior to the Phase 2 assessment, the depth of the Crossman Lake batholith was unknown, but was believed to extend well below typical repository depths. In order to develop a rough approximation of the depth of the batholith, preliminary 2.5D forward modelling was conducted by SGL (2015). The preliminary modelling used the newly acquired high-resolution geophysical data and readily available information on the mapped bedrock geology at surface to provide a preliminary image of the geometry and subsurface extent of the batholith. The modelling indicated that the batholith is particularly deep in the central portion of the western area, with maximum estimated depths reaching approximately 7 km. This central area also corresponds to the broad low gravity response. Other parts of the western portion of the Crossman Lake batholith were interpreted to range in thickness from approximately 3.4 to 3.8 kilometres, and show evidence of gradual thinning towards the south and the east. The preliminary modelling assumed the batholith to be underlain by greenstone belt units. Additional modelling assuming gneissic basement bedrock, with a lower bedrock density than the greenstone belt unit, resulted in an overall increase in the estimated thickness of the Crossman Lake batholith.

5.1.2 Eastern Portion of the Crossman Lake Batholith

The eastern portion of the batholith has been generally characterized as massive granite to tonalite, with local variations (Carter, 1981; Carter, 1982). The initial field observations made during the Phase 2 preliminary geological mapping identified two phases of granodiorite. The first phase is weakly foliated, medium to coarse grained, and inequigranular, while the second is massive to weakly foliated, medium grained, occasionally fine grained, and equigranular (Fladgate and Geofirma, 2015). Granitic aplitic and pegmatite dykes and sills were locally observed and comprised up to 15% of the rock volume in some outcrops. Along the mapped boundary between the batholith and the greenstone belt unit to the east, the geology was observed to be lithologically heterogeneous in a broad zone west of the mapped contact, where the host granodiorite includes rafts of greenstone material (Fladgate and Geofirma, 2015).

The results from the Phase 2 interpretation of high-resolution magnetic data acquired over the eastern portion of the Crossman Lake batholith show a less variable internal response compared to the western portion of the batholith (Figure 4-2; SGL, 2015). A subtle variation in the magnetic response within the eastern portion of the Crossman Lake batholith may be indicative of a different phase. The batholith in this area is cross-cut by a prominent network of long and linear magnetic highs and lows corresponding to potential faults and dykes (SGL, 2015). A prominent circular shaped high magnetic anomaly identified in the west of the eastern portion of the Crossman Lake batholith may reflect a sliver of greenstone beneath the surface, or an isolated unit of granodiorite with higher magnetite content. The southeastern corner of the eastern portion of the batholith shows a high magnetic anomaly that broadly corresponds to a wedge of greenstone belt material. This anomaly suggests that the greenstone belt may extend further south and west than indicated by previous mapping.

Gravity data in the eastern portion of the Crossman Lake batholith show a central low that transitions into pronounced gravity highs towards the north and south into the greenstone belt units (Figure 4-3). The northern boundary is marked by a sharp gradient in the gravity data, which suggests that the batholith contact is near vertical adjacent to the greenstone belt units (SGL, 2015). In contrast, the southern boundary exhibits a smooth gradation in the gravity data. This may suggest that the greenstone belt units extend under the batholith rather than defining a vertical contact.

Based on preliminary modelling conducted by SGL (2015) using the newly acquired high-resolution geophysical data, the depth of the eastern portion of the Crossman Lake batholith is approximately 2.0 kilometres at the shallowest point. Model results indicate that the batholith thins gradually towards the northern boundary of the batholith, adjacent to the contact with the greenstone belt units. However, north of this boundary the batholith is modelled to extend under the greenstone belt units to a maximum depth of 4.5 kilometres. Similar depths were estimated based on additional modelling with a gneissic basement bedrock with a lower bedrock density.

5.1.3 Mafic Dykes in the Crossman Lake Batholith

Several suites of mafic dykes have been mapped at the regional scale in the Schreiber area, including northwest-trending Matachewan dykes, east-trending Keweenawan dykes, northwest- to northeast-trending Marathon dykes and potentially northeast trending Biscotasing dykes. No dykes from any of these swarms were previously mapped in either of the western or eastern portions of the Crossman Lake batholith in the Schreiber area. However, the initial Phase 2 field work identified dykes in these portions of the batholith (Fladgate and Geofirma, 2015). Dykes were interpreted in the high-resolution magnetic data as linear magnetic highs, and in some cases interpreted dykes were along-strike with previously mapped dykes (SGL, 2015; SRK, 2015).

In the western portion of the batholith, the Phase 2 lineament interpretation identified 8 potential dykes (Figure 4-5; SRK, 2015). Dykes were also identified at two locations visited during the preliminary geological mapping. A black, foliated dyke with amphibole (Station 14TLG046) and a green, massive, and unzoned, mafic dyke (Station 14SK039) were observed to crosscut the main lithology in the western portion of the batholith (Figure 4-8). Interpreted dykes were most evident in the eastern portion of the Crossman Lake batholith where segmented linear magnetic highs transect the entire central part of the area in a north-northeasterly orientation (SRK, 2015). In the eastern portion of the batholith, the lineament interpretation identified 27 potential dykes (Figure 4-5; 2015). The preliminary geological mapping noted several locations where three to five metre wide mafic dykes were interpreted to represent the surface expressions of magnetic features identified in the lineament interpretation (Fladgate and Geofirma, 2015; SRK, 2015). Field observations also identified green, massive and unzoned mafic dykes at several locations in the eastern portion (Stations 14SK020, 14SK021, 14SK023; Figure 4-9). Field observations in the eastern portion noted that rock quality was poorer in one mafic dyke compared to the rock quality of the host granitoid rocks where tighter fracture spacing was observed (Fladgate and Geofirma, 2015).

5.2 Structural Geology

For the purpose of identifying areas for additional fieldwork, the preliminary assessments focused on assessing the presence and significance of major structural features such as faults and shear zones. The Phase 1 preliminary assessment (AECOM, 2013) noted large regional-scale faults that have been mapped in proximity to the Schreiber area at varying distances from the eastern and western portions of the Crossman Lake batholith. The Mid-continent rift is located approximately 20 kilometres south of the eastern and western portions of the Crossman Lake batholith (AECOM, 2013). The Gravel River fault is located approximately 18 and 30 kilometres west-northwest of the eastern and western portions of the Crossman Lake batholith, respectively. The Wawa-Quetico subprovince boundary is located roughly 1 and 5 kilometres north of the eastern and western portions of the Crossman Lake batholith, respectively. These features are located outside the survey area where high-resolution geophysical data were acquired and interpreted (Figure 4-1).

Several kilometre-scale faults and dykes have been previously mapped within the Schreiber area. These features were interpreted in the Phase 2 lineament analysis (SRK, 2015) and some were observed during the preliminary geological mapping (Fladgate and Geofirma, 2015). The initial geological mapping included direct observation of some of these structures, though most of the sites visited were in topographically higher regions between these features, which themselves tended to define linear topographic lows. In general, the features observed during the initial mapping represent an outcrop-scale manifestation of the regional-scale fracture pattern (SRK, 2015). Additional results from the initial geological mapping are included in the discussion of lineaments below.

5.3 Lineament Analysis

This section provides an integrated analysis of interpreted lineaments (SRK, 2015) for the two general potentially suitable areas in the Schreiber area, using the newly acquired high-resolution magnetic, topographic and satellite data (Section 4.2).

For the purpose of the analysis, and as outlined in Section 6, magnetic lineaments with high and medium certainties were given emphasis, as these lineaments are considered most likely to represent potential bedrock structures that may exist at depth. Surficial lineaments were also considered, in particular in areas where the large variation in topography may have hindered the magnetic measurements (SRK, 2015). Surficial lineaments are particularly useful given that overburden cover is generally low throughout the Schreiber area.

5.3.1 Western Portion of the Crossman Lake Batholith

Magnetic lineaments interpreted in the western portion of the Crossman Lake batholith (SRK, 2015) are shown on Figure 4-5. In general, the magnetic lineaments show a uniform density in the western portion of the Crossman Lake batholith, with the exception of a lower density area in the northwest. The higher density areas are associated with tight lineament spacing up to 0.6 kilometres when medium and high certainty magnetic lineaments are considered, with a slightly wider spacing of up to 1 kilometre when considering lineaments with highest certainty. The lower density area exhibits wider lineament spacing up to 1.0 kilometres when medium and high certainty magnetic lineaments are considered, with spacing of up to 1.5 kilometres when using lineaments with highest certainty. This lower density area is likely related to the high topographic variability and its effect on airborne acquisition of magnetic data. As a result, there is some uncertainty in the lineament density in this area (SGL, 2015; SRK, 2015). Length analysis of magnetic lineaments shows that the longer lineaments (greater than 2.5 kilometres) are broadly distributed across the western portion of the Crossman Lake batholith and predominantly trend northwesterly and north-northeast. These longer lineaments also tend to coincide with major topographic features. The shorter lineaments have more variable orientations across the western portion of the Crossman Lake batholith.

Surficial lineaments interpreted in the western portion of the Crossman Lake batholith are shown on Figure 4-6. In general, these lineaments show a uniform density with some local variation. The relatively uniform lineament density throughout may be attributed, in part, to the extensive bedrock exposure throughout, which makes surficial lineaments readily mappable. Surficial lineaments exhibit very tight spacing less than 0.4 kilometres, when medium and high certainty surficial lineaments are considered, and exhibit a spacing of less than 1km kilometres when using lineaments with highest certainty. Both long and short lineaments trend in roughly northwesterly, northeasterly and north directions. At this stage of the assessment, it is uncertain if surficial lineaments represent real bedrock structures, and if so, how far they extend to depth, particularly the shorter lineaments.

Observations made during the initial geological mapping (Section 4.4) identified three dominant outcrop scale fracture sets throughout the western portion of the Crossman Lake batholith. These fracture sets, including joints, veins and faults were observed to be steeply dipping with north-northeast, west and northwest orientations. In addition, a set of sub-horizontal sheet joints were identified (Fladgate and Geofirma, 2015). Fracture spacing within the western portion of the Cross Lake batholith is characterized predominantly as very blocky (10-40 cm) to blocky (30-100 cm), with local blocky-disturbed (3-10 cm) conditions. Quartz, hematite and epidote were observed to be the dominant fracture infilling minerals, though not all fractures host all mineral phases. In one instance a north-northeast-trending fracture exhibits a sinistral fault offset of a west-trending fracture. In the areas visited, the orientations of fractures observed in the field were broadly consistent with the dominant structural orientations identified in the Phase 2 lineament analysis (SRK, 2015). However, given the limited data set of field observations at this stage, it is too early to draw any specific conclusions based on this outcome.

5.3.2 Eastern Portion of the Crossman Lake Batholith

Magnetic lineaments interpreted in the eastern portion of the Crossman Lake batholith are shown on Figure 4-5. In general, the magnetic lineaments show a uniform density throughout the eastern portion of the Crossman Lake batholith, with the exception that the density in the centre of the area is somewhat more elevated. The highest density area has tight lineament spacing up to 0.4 kilometres between the medium and highest certainty magnetic lineaments, and spacing of less than 0.9 kilometres when considering lineaments with highest certainty. In areas of lower lineament density, the spacing between medium and high certainty magnetic lineaments is up to 0.8 kilometres with spacing of up to 1.5 kilometres between lineaments with highest certainty. Length analysis of magnetic lineaments shows that the longer lineaments (those greater than 2.5 kilometres) are broadly distributed across the entire eastern portion of the batholith, and predominantly trend northwesterly, north and north-northeasterly (Figure 4-5). The northwesterly longer lineaments coincide with major topographic features (SRK, 2015). The shorter lineaments predominantly trend westerly across the eastern portion of the Crossman Lake batholith (Figure 4-5).

Surficial lineaments interpreted in the eastern portion of the Crossman Lake batholith are shown on Figure 4-6. In general, these lineaments show a uniform density with some local variation. The relatively uniform lineament density throughout may be attributed, in part, to the extensive bedrock exposure throughout, which makes surficial lineaments readily mappable. The higher density area is associated with very tight lineament spacing less than 0.25 kilometres when medium and high certainty magnetic lineaments are considered, with spacing of less than 0.4 kilometres when considering lineaments with highest certainty. The lower density area exhibits slightly wider average lineament spacing up to 0.75 kilometres when medium and high certainty magnetic lineaments are considered, with spacing increasing up to 1.0 kilometres when using lineaments with highest certainty. The long lineaments trend predominantly northwesterly, while the short lineaments trend predominantly in northwest and north-northeast orientations. At this stage of the assessment, it is uncertain if surficial lineaments represent real bedrock structures, and if so, how far they extend to depth, particularly the shorter lineaments.

Observations made during the initial geological mapping (Section 4.4) identified three dominant outcrop scale fracture sets throughout the eastern portion of the Crossman Lake batholith (Fladgate and Geofirma, 2015). These fracture sets, including joints and faults (with various types of mineral infilling) were observed to be steeply dipping with north, west-northwest, and northwest orientations (Fladgate and Geofirma, 2015). In the areas visited, the observed steeply-dipping fracture sets are broadly consistent with the orientations observed in the Phase 2 lineament analysis, in particular for the longer and more dominant interpreted lineament orientations (SRK, 2015). Hematite, chlorite, biotite and epidote were observed to be the dominant fracture infilling minerals, though not all fractures host all mineral phases. Fracture spacing within the eastern portion of the Crossman Lake batholith is characterized predominantly as blocky (30-100 cm), with local massive (>100 cm) and blocky-disturbed (3-10 cm) conditions. In one instance a west-northwest-trending fracture was observed to exhibit a dextral fault offset of a north-northeast-trending fracture. Elsewhere, similarly west-northwest oriented shear bands also exhibit dextral offsets.

The field observation of a dextral fault character for at least some west-northwest-trending fractures in the eastern portion of the Crossman Lake batholith is consistent with relationships evident in previously mapped structures and the lineament interpretation in the Schreiber area. For example, an unnamed west-northwest-trending fault that crosses the northern part of the eastern survey block dextrally offsets the contact between the Crossman Lake batholith and the greenstone belt rocks to its north (Figure 4-1). In addition, the magnetic data shows that two parallel north-northeast-trending interpreted dyke lineaments are also offset dextrally from south to north across this same mapped unnamed fault. Intact rock strength, as observed in the field, was found to be decreased in proximity to this unnamed fault relative to areas distal to the fault.

5.4 Bedrock Exposure

The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. At this stage of the assessment preference was given to areas with greater mapped bedrock exposures. The extent of bedrock exposure in the Schreiber area is shown on Figure 4-7. Areas mapped as bedrock terrain are assumed to be covered, at most, with a thin veneer of overburden and are therefore considered amenable to geological mapping. This applies to the majority of the Schreiber area covered by both the western and eastern portions of the Crossman Lake batholith. Only a large north-trending broad valley in the northwestern area of the western portion of the batholith (in the Bath Lake area) shows any appreciable overburden cover.

Initial Phase 2 preliminary geological mapping confirmed the presence of good bedrock exposure and low overburden cover across most of both portions of the batholith, especially the areas of highest topography (Fladgate and Geofirma, 2015). There was some variability in amount of overburden cover within some of the larger valleys

5.5 Protected Areas

All provincial parks, conservation reserves and provincial nature reserves in the Schreiber area were excluded from consideration (AECOM, 2013). There are five protected areas in the Schreiber area (Figure 1-1), four of which are located near the Lake Superior coast and one on the western boundary of the area. Collectively they occupy a combined total of approximately 22.1 square kilometres. The Phase 2 preliminary assessment confirmed that the candidate areas are outside of protected areas.

5.6 Natural Resources

Areas with known potential for exploitable natural resources such as the rocks of the greenstone belts were excluded from further consideration (AECOM, 2013). The granitic intrusions in the Schreiber area have low potential for economically exploitable natural resources. In addition to the information gathered during the Phase 1 preliminary assessment (AECOM, 2013), the newly acquired Phase 2 geophysical data was used to identify geophysical anomalies that may be indicative of rock units that have mineral potential.

The Phase 2 high-resolution magnetic data provided a more detailed understanding of the bedrock geology of the western and eastern portions of the Crossman Lake batholith, and surrounding units. Areas have been interpreted to potentially reflect inclusions of metasedimentary and metavolcanic rocks of greenstone belt in both the western and eastern portions of the Crossman Lake batholith. The potential greenstone belt continuation in the western portion of the batholith is particularly notable due to its proximity to the past producing Winston Lake mine that was located within the same broad package of rocks to the northeast (Figure 5-1). In the eastern portion of the Crossman Lake batholith, the geophysics interpretation suggests that the contacts of the greenstone belt may extend further into the area than previously mapped (SGL, 2015). In addition, a prominent circular shaped high magnetic anomaly identified in the west of the eastern portion of the Crossman Lake batholith may reflect a sliver of greenstone beneath the surface.

In addition to the information gathered during the Phase 1 preliminary assessment (AECOM, 2013), the mineral resources and claim maps were also updated as part of the Initial Phase 2 assessment (Figure 5-1). At this stage of the assessment, areas of active mining claims located in geologic environments judged to have low mineral resource potential were not systematically excluded from consideration as candidate areas for detailed mapping.

5.7 Potential Surface Constraints

Areas of obvious topographic constraints (high density of steep slopes), large water bodies (wetlands, lakes), and areas of poor accessibility were considered for the identification of areas for further field studies. While areas with such constraints were not explicitly excluded from consideration as a candidate area for detailed mapping, they are identified as potential surface constraints that would need to be considered. Considerable topographic relief and topographic variation is a prominent characteristic of the Schreiber area (Figure 4-4). Deep valleys cross-cut both blocks and most water bodies occur as long and linear lakes surrounded by moderate to steep slopes (Figures 1-1 and 4-4). Only the Bath Lake area in the western portion of the Crossman Lake batholith has any appreciable overburden cover.

Preliminary geological mapping conducted as part of initial Phase 2 field work documented that access and surface constraints vary across the Crossman Lake batholith (Fladgate and Geofirma, 2015). Access to the western portion of the batholith is difficult. There are no roads or rail corridors that directly access this area and the interior lakes are generally considered to be too short to allow for safe float plane landing and take-off. Additionally, near vertical cliffs and adjacent valleys characterize a very rugged topography in the southern portion of the western area. The observation team accessed the area by helicopter and even using this mode of transportation there were only sparse, readily-available, safe helicopter landing locations.

Access to the eastern portion of the batholith, at least the majority of the central part, is significantly easier. Road access is excellent with a system of logging roads crossing the area from east to west with several trails/old road spurs north and south of the main access road. Steep valleys are present within the eastern portion of the batholith, but with care they are generally passable on foot. The extreme southern end of the eastern portion of the batholith is only accessible via helicopter.

6 CANDIDATE AREAS FOR DETAILED GEOLOGICAL MAPPING IN THE SCHREIBER AREA

This section describes how the key geoscientific characteristics and constraints described in Section 5 were applied to further assess the suitability of the Schreiber area and determine whether it is possible to identify candidate areas for further field studies, beginning with detailed geological mapping. The assessment was conducted in a systematic and iterative process based on the updated understanding of the key geoscientific characteristics and constraints discussed in Section 5, using the following general approach:

a) **Bedrock Geology:** Identify areas with the most favourable geological settings in terms of rock type, lithology and homogeneity, using newly acquired interpreted magnetic and gravity data, as well as initial field observations. The estimated depth and extent of the potentially suitable host rock formation was also considered.

b) **Structural Geology:** Refine the location and extent of the areas based on updated understanding of the structural geology based on the newly interpreted magnetic, gravity and lineament data, as well as initial field observations. The refinements were focused on identifying bounding structures that could potentially define favourable rock volumes, taking into account the nature and complexity of prominent structural geological features in the area such as faults, dykes, shear and deformation zones, and geological boundaries.

c) **Lineament Analysis:** Use lineament analysis (geophysical and surficial) to identify most favourable structural domains for hosting a repository, using the following approach:

- Identify areas with lower lineament density, as these areas have a higher potential to contain structurally favourable rock volumes for hosting a repository. In identifying the potentially suitable areas, emphasis was put on magnetic lineaments, as their interpretation is relatively unaffected by the presence of overburden. Surficial lineaments were also considered, particularly in areas with greater bedrock exposure and/or areas with low magnetic susceptibility of the rocks.
- Emphasis was also put on lineaments which were interpreted as high and medium certainty, and on longer lineaments as they are considered more likely to extend to greater depth.
- At this stage of the assessment, all interpreted lineaments were conservatively assumed to be potentially permeable features (i.e. hydraulically conductive), noting that many of these interpreted lineaments may be sealed due to the higher rock stresses at depth and/or the presence of mineral infillings.

d) **Protected Areas:** The general potentially suitable areas identified in the Phase 1 preliminary assessment were all outside protected areas such as provincial parks, conservation reserves and provincial nature reserves (AECOM, 2013). The initial Phase 2 assessment confirmed that identified candidate areas for detailed geological mapping remain outside of protected areas.

e) **Natural Resources:** In addition to the information gathered during the Phase 1 preliminary assessment (AECOM, 2013), the newly acquired Phase 2 geophysical data were used to identify geophysical anomalies that may be indicative of rock units that have mineral potential. Mineral resources and claim maps were also updated as part of the initial Phase 2 assessment.

f) **Overburden:** The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. At this stage of the assessment, preference was given to areas with better bedrock exposure, as indicated by available Quaternary mapping (AECOM, 2013) and by preliminary field observations, as these areas are more amenable to detailed geological mapping.

g) **Potential Surface Constraints:** Areas of obvious topographic constraints (high density of steep slopes), large water bodies (wetlands, lakes), and accessibility are identified as potential constraints that would need to be considered in the selection of a repository site. Accessibility was documented during the preliminary field observations (Fladgate and Geofirma, 2015).

The interpretation of the new Phase 2 field data confirmed the presence of geological complexities that reduce the potential for identifying candidate areas that would ultimately meet NWMO's geoscientific site evaluation factors. The iterative consideration of the above key geoscientific characteristics and constraints identified two candidate areas that could be considered for detailed geological mapping. However, as discussed in the following sections (Sections 6.1 and 6.2) these two areas exhibit a relatively high degree of structural complexity, and have a number of unfavourable geoscientific characteristics.

The two areas are located within the western and eastern portions of the Crossman Lake batholith, and are shown on Figures 6-1 and 6-2. The figures show interpreted magnetic and surficial lineaments, respectively, along with other geoscientific constraints such as geology, protected areas, water bodies and active mining claims. The legend in each figure also shows a 2 x 3 kilometre box which illustrates the approximate required underground repository footprint.

6.1 Candidate Area for Detailed Geological Mapping in the Western Portion of the Crossman Lake Batholith

The general location of the candidate area that could be considered for detailed geological mapping in the western portion of the Crossman Lake batholith is located in the northwest of the potentially suitable area identified in the Phase 1 preliminary assessment and is approximately 21 square kilometres (Figures 6-1 and 6-2).

The area is located in a circular region that exhibits a generally quiescent magnetic response and a broad gravity low, which may indicate an area of relative lithological homogeneity (Figures 4-2 and 4-3). The area north of the candidate area was avoided as the high-resolution geophysical data show that the greenstone rocks might be wrapping into the area (Figure 4-2). The region south of the candidate area was also avoided since it shows a higher degree of structural complexity, evidenced by the presence of large scale structures (readily identifiable in the high-resolution magnetic data) that correlate to mapped faults and major topographic features (Figures 4-1 and 4-2). As discussed in Section 5.1.1, preliminary geophysical modelling conducted as part of this assessment indicated that the Crossman Lake batholith in the western portion of the batholith has an estimated thickness of approximately 3.4 to 3.8 kilometres (SGL, 2015), which is sufficient for the purpose of a deep geological repository.

The general location and extent of the identified candidate area for detailed geological mapping was also guided by the density of interpreted magnetic and surficial lineaments. As shown in Figure 6-1 and discussed in Section 5.3.1, the density of magnetic lineaments in the candidate area is generally lower than in other areas of the batholith. The spacing of high and medium certainty magnetic lineaments in the candidate area is up to 1.0 kilometre (Figure 6-1). The observed lower density of magnetic lineaments in this area may be related to the locally higher topographic variability and its effect on the acquisition of airborne magnetic data (SRK, 2015), rather than to an actual absence of structures in the rock. The higher density of surficial lineaments suggests that there may be more magnetic lineaments in the candidate area than were interpreted. As shown in Figure 6-2, the density of surficial lineaments is generally uniform over the entire western portion of the Crossman Lake batholith, including the candidate area. The spacing between surficial lineaments with high and medium certainty over the identified candidate area is less than 0.4 kilometres. No dyke lineaments were identified in this candidate area (Figure 6-1); however, dyke lineaments were identified in other locations within the western survey area.

Overall, both the lineament analysis and observations made during preliminary geological mapping highlight a high degree of structural complexity of the fracture network in the western portion of the Crossman Lake batholith. The lineament analysis indicates that the magnetic and surficial lineaments comprise a wide range of orientations within the western portion of the Crossman Lake batholith. The most prominent orientations include a broad range of west-northwest to north-northwest trending lineaments. The fracture orientations observed during initial geologic mapping were broadly consistent with these dominant structural orientations. Fracture spacing within the candidate area was characterized predominantly as very blocky (10-40 cm) to blocky (30-100 cm), with local blocky-disturbed (3-10 cm) conditions. Quartz, hematite and epidote were observed to be the dominant fracture infilling minerals, though not all fractures hosted all mineral phases. In one instance a north-northeast-trending fracture exhibited a sinistral fault offset of a west-trending fracture.

The interpreted spacing between both magnetic and surficial interpreted lineaments indicates that a typical 2 x 3 kilometre repository underground footprint will potentially contain numerous significant fractures (Figure 6-1 and 6-2). Analysis of interpreted lineaments and initial field observations suggest that the identified candidate area has a relatively high degree of structural complexity which would greatly increase the level of effort and data required to adequately characterize the area.

Access to the identified candidate area is difficult with no direct access by existing roads or trails. Initial field observations throughout the area confirmed the presence of good bedrock exposure and low overburden cover across most of the area, especially in the areas of highest topography. Only a large north-trending broad valley (in the Bath Lake area) shows any appreciable overburden cover. The identified candidate area contains no significant surface water constraints, is outside of protected areas and has a low potential for natural resources, although claims are present in the northeast of the area (Figure 6-1).

In summary, while a candidate area for detailed mapping has been identified in the western portion of the Crossman Lake batholith, the area exhibits a high degree of structural complexity, and has a number of unfavourable geoscientific characteristics. The candidate area contains numerous interpreted subsurface fractures that may have a negative impact on the long-term performance of a repository. Avoiding fractures would result in a much larger repository footprint. The space that would be available to accommodate a larger repository footprint would be limited because of the relatively small extent of the identified area, and the increased structural complexity in the surrounding rocks.

6.2 Candidate Area for Detailed Geological Mapping in the Eastern Portion of the Crossman Lake Batholith

The general location of the candidate area that could be considered for detailed geological mapping in the eastern portion of the Crossman Lake batholith is located in the central portion of the potentially suitable area identified in Phase 1 preliminary assessment and is approximately 37 square kilometres (Figures 6-1 and 6-2).

The identification of this candidate area was guided by the density of interpreted magnetic and surficial lineaments. As shown in Figure 6-1 and discussed in Section 5.3.2, the density of magnetic lineaments in the selected area is marginally lower than in other areas of the batholith, but remains fairly high. The spacing between magnetic lineaments with high and medium certainty in the candidate area is up to 0.8 kilometres, with spacing of up to 1.5 kilometres between lineaments with highest certainty. As shown in Figure 6-2, the density of surficial lineaments is uniform over the entire area in the Crossman Lake batholith. The spacing between surficial lineaments in the candidate area is up to 0.75 kilometres when medium and high certainty magnetic lineaments are considered, with spacing increasing up to 1.0 kilometre when considering lineaments with highest certainty. Eleven dyke lineaments were identified in the candidate area (Figure 6-1), with dominant north-northeast and northwest-trending orientations.

The candidate area boundaries were refined to avoid unfavourable geology and mapped faults. The northern boundary was refined to avoid a mapped west-northwest fault that transects the entire eastern portion of the Crossman Lake batholith (Figures 4-1 and 6-1). The area between this mapped west-northwest fault and the greenstone belt to the north was also avoided due to its small size. The eastern boundary of the candidate area is bounded by the Syenite Lake fault (Figures 4-1 and 6-1). The eastern boundary was also defined by the edge of a high magnetic anomaly, which indicated that the greenstone belt contact with the Crossman Lake batholith may be further south and west than currently mapped (Figures 4-2 and 6-1). The southern boundary of the candidate area was refined to avoid the mapped greenstone belt (Figures 4-1 and 6-1). The western boundary of the candidate area was defined by an unnamed north-trending mapped fault which extends along the length of the area (Figures 4-1 and 6-1). Based on the available information and the geophysical modelling conducted as part of this assessment, the Crossman Lake batholith in this area has an estimated thickness of approximately 2.0 kilometres or more (SGL, 2015), which is sufficient for the purpose of a deep geological repository. .

Overall, both the lineament analysis and field observations highlight the high degree of structural complexity of the fracture network in the eastern portion of the Crossman Lake batholith. The geophysical and surficial lineaments comprise a wide range of orientations in the eastern portion of the Crossman Lake batholiths, including the candidate area. The most prominent orientations include a broad range of west-northwest to north trending lineaments with one dominant west-northwest-trending set. Results from initial geological mapping were broadly consistent with the results from the Phase 2 lineament analysis, especially the longer and more dominant interpreted lineament orientations. Hematite, chlorite, biotite and epidote were observed to be the dominant fracture infilling minerals, though not all fractures host all mineral phases. Fracture spacing within the candidate area was characterized predominantly as blocky (30-100 cm), with local massive (>100 cm) and blocky-disturbed (3-10 cm) conditions. West-northwest-trending faults and shear zones in the eastern portion of the Crossman Lake batholith were observed to exhibit dextral offsets.

Similarly to the area identified in the western portion of the batholith, the interpreted spacing between both magnetic and surficial interpreted lineaments indicates that a typical 2 x 3 kilometre repository underground footprint will potentially contain numerous significant subsurface fractures (Figure 6-1 and 6-2). Analysis of interpreted lineaments and initial field observations suggest that the identified candidate area has a relatively high degree of structural complexity which would increase the level of effort and data required to adequately characterize the area.

The area has no active mining claims (Figure 6-1). However, as discussed in Section 5.6, greenstone belts with mineral potential have been identified in the Schreiber area. The Phase 2 studies identified some uncertainty in the mapped distribution of greenstone belt rock in the eastern survey area (Section 5.1.2). For example, in the western portion of the candidate area there is a prominent circular shaped high magnetic anomaly which may reflect a sliver of greenstone belt units beneath the surface (Figures 4-2 and 6-1). In the southernmost portion of the candidate area it is possible that the contact zones between the Crossman Lake batholith and greenstone belts may be broader and more lithologically heterogeneous than mapped. In addition, field observations identified rafts of greenstone material included in the host granodiorite well into the Crossman Lake batholith north of the candidate area (Fladgate and Geofirma, 2015).

Access to the identified candidate area is good in the northeastern part of the area through an existing road and a well-marked and regularly traveled system of logging roads. Access is more difficult to the west and south of the area due to the absence of roads. Good bedrock exposure was observed in the area consistent with available Quaternary mapping. The candidate area contains no significant surface water constraints and is outside of protected areas (Figure 6-1).

In summary, while a candidate area for detailed mapping has been identified in the eastern portion of the Crossman Lake batholith, the area exhibits a high degree of structural complexity, and has a number of unfavourable geoscientific characteristics. The candidate area contains numerous interpreted subsurface fractures and dykes that may have a negative impact on the long-term performance of a repository. Avoiding fractures would result in a much larger repository footprint. The space that would be available to accommodate a larger repository footprint would be limited because of the relatively small extent of the identified area, and the increased structural complexity in the surrounding rocks.

7 SUMMARY OF INITIAL PHASE 2 GEOSCIENTIFIC FINDINGS FOR THE SCHREIBER AREA

This report provides the findings of the initial Phase 2 geoscientific studies conducted in the Schreiber area in 2014. These studies were conducted to advance understanding of the geology in the Schreiber area, and to assess whether it is possible to identify potentially suitable candidate areas for further field studies, beginning with detailed geological mapping. The assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over the two general areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution gravity and magnetic data to better understand the bedrock geology such as geological contacts, depth and extent of rock units, lithological and structural heterogeneity;
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic surveys to identify possible structural features such as fractures, shear zones and dykes;
- Observation of general geological features to confirm/ground truth geologic characteristics, including lithology, structure, bedrock exposures and surface constraints.

The interpretation of the new Phase 2 data and field observations confirmed geological complexities that reduce the likelihood of finding repository sites that would ultimately satisfy NWMO's geoscientific site evaluation factors in the Schreiber area.

While the assessment identified two potential candidate areas that could be considered for detailed geological mapping, these areas exhibit a high degree of structural complexity, and have a number of unfavourable geoscientific characteristics. More specifically, both identified areas contain numerous interpreted subsurface fractures that could have an impact on the long-term performance of a repository. Avoiding interpreted subsurface fractures would result in a much larger repository footprint. The space that would be available to accommodate a larger repository footprint in the Schreiber area would be limited because of the relatively small extent of the two identified areas, and the increased structural complexity in the surrounding rocks.

8 REFERENCES

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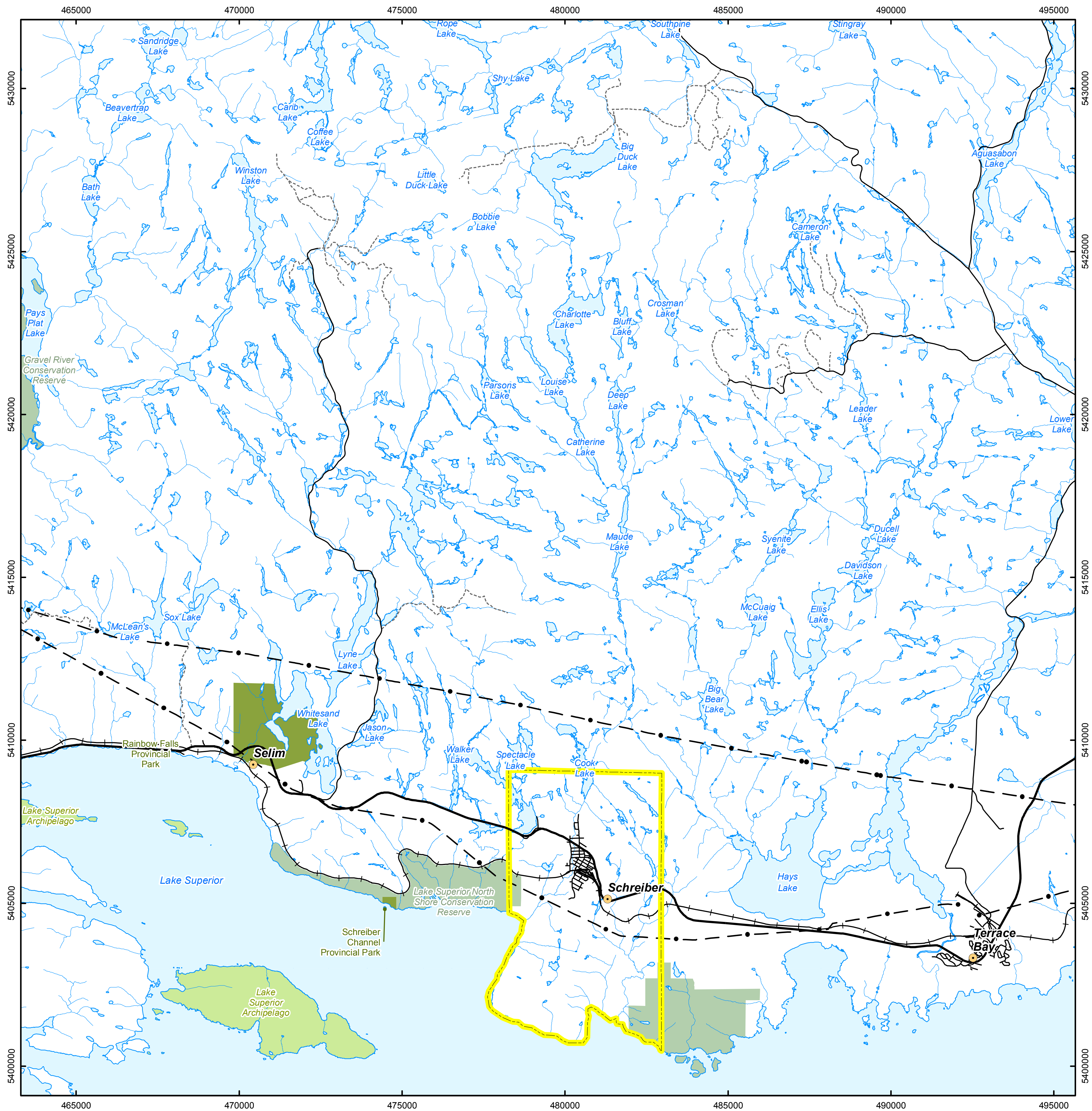
9 REPORT SIGNATURE PAGE

Respectfully submitted,

Geofirma Engineering Ltd.

Sean Sterling, P.Eng., P.Geo.
Senior Geoscientist

Kenneth Raven, P. Eng., P.Geo.
Principal



LEGEND

- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Watercourse
- Waterbody
- Conservation Reserve (Recommended)
- Conservation Reserve
- Provincial Park

SCALE 1:130,000

0 1 2 4 6 8
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
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NORTH

PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

The Schreiber Area

FIGURE 1-1

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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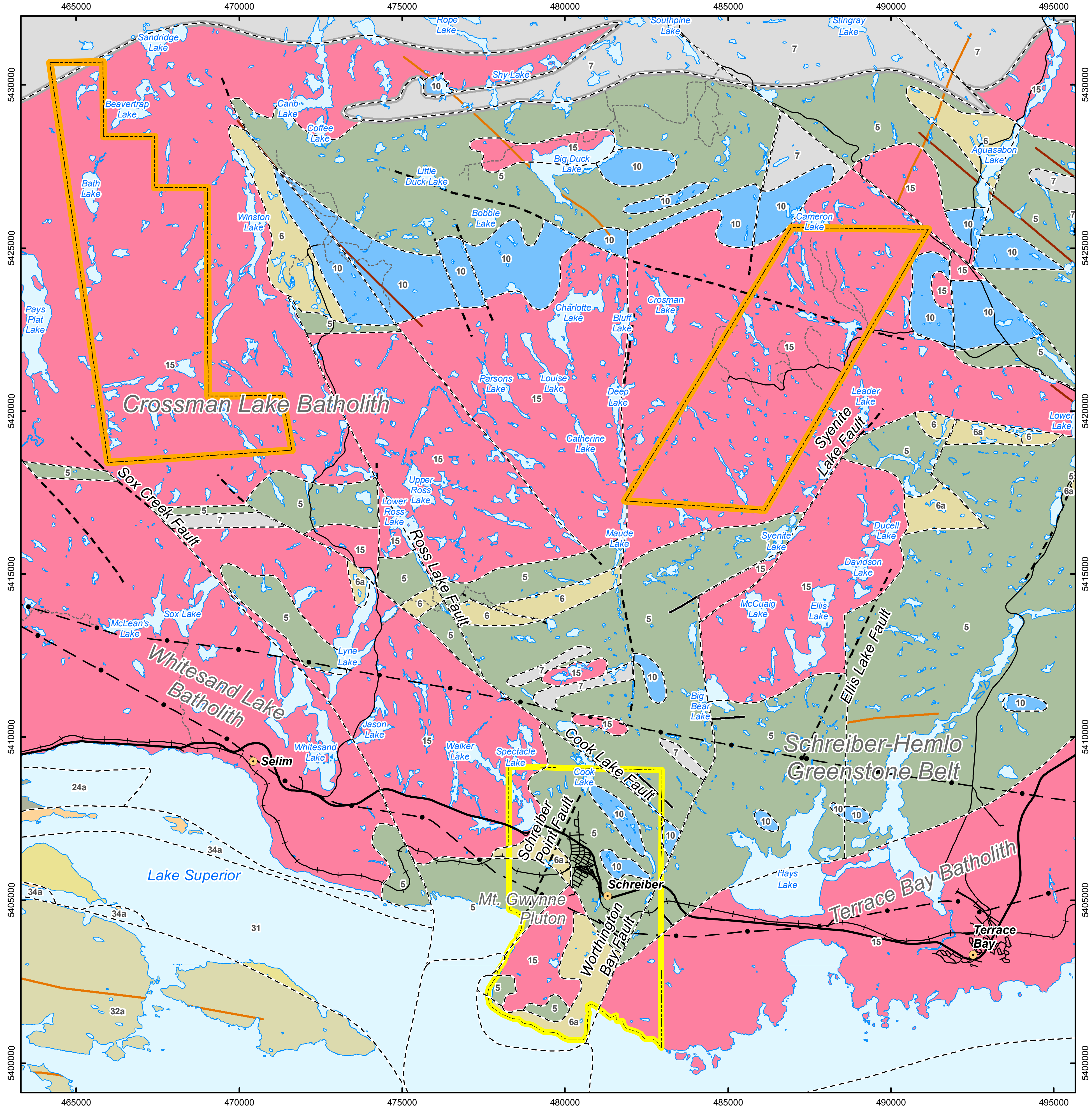

LEGEND

- Withdrawn Area
- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and untramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

INDEX MAP

SCALE 1:130,000

0 1 2 4 6 8
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
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NORTH

PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Land Withdrawn to Facilitate Phase 2 Studies in the Schreiber Area

FIGURE 1-2

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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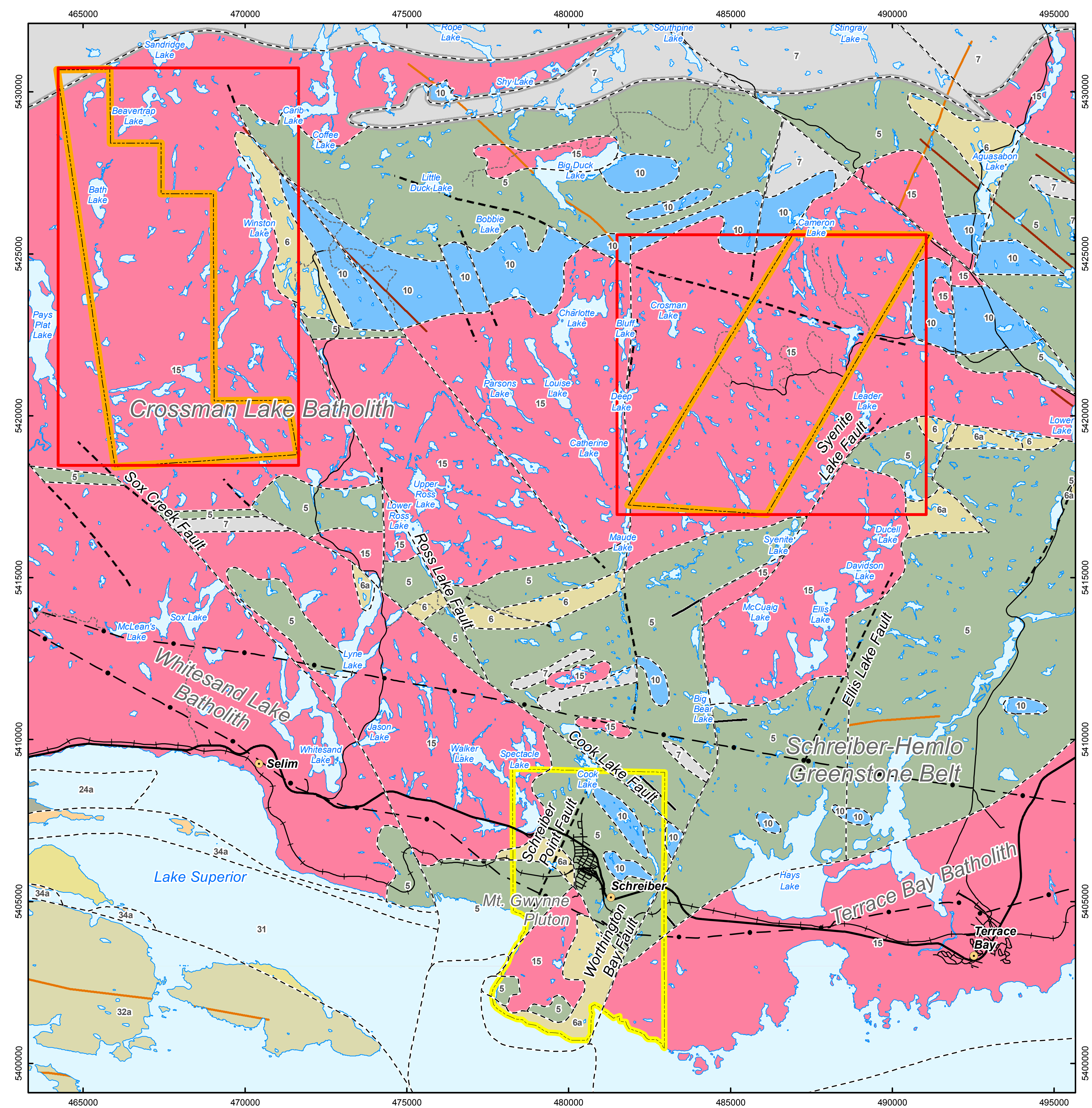

LEGEND

- Airborne Survey Block
- Withdrawn Area
- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

INDEX MAP

SCALE 1:130,000

0 1 2 4 6 8
Kilometers

NORTH

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
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Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Airborne Survey Blocks in the Schreiber Area

FIGURE 4-1

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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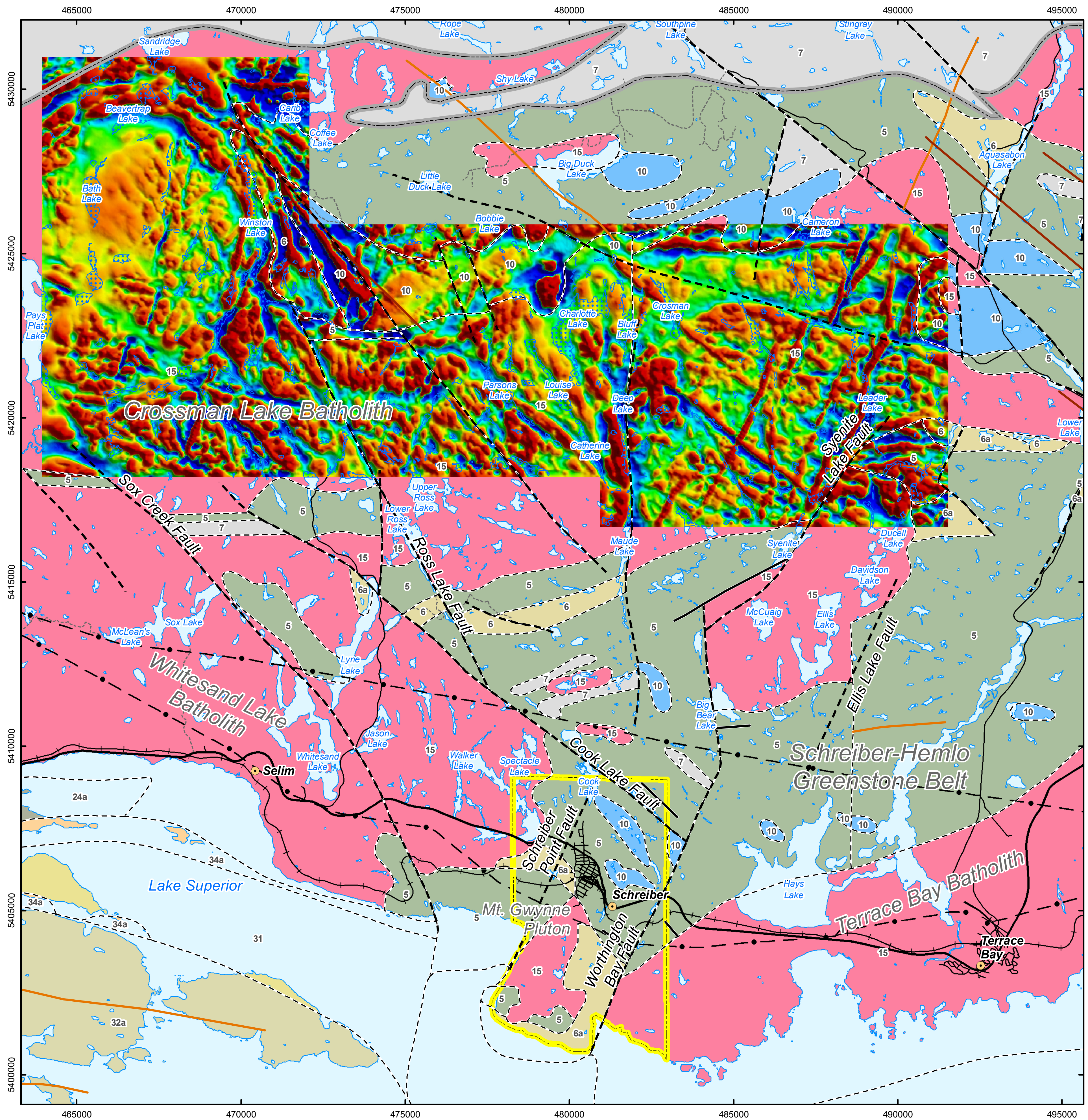


LEGEND

- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody (within magnetic data extents)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

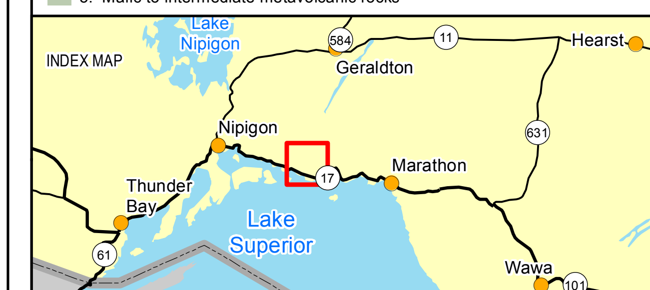
First Vertical Derivative (nT/km)

1211.7
590.6
381.9
267.6
192.3
135.3
91.2
58.2
28.8
3.3
-19.3
-40.4
-61.5
-82.3
-103.2
-124.2
-145.5
-168.4
-194.0
-222.3
-254.7
-293.7
-343.3
-410.9
-530.7

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and untramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

INDEX MAP



SCALE 1:130,000

0 1 2 4 6 8
Kilometers

NORTH

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Geophysical Data - SGL 2015
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Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Magnetic Data in the Airborne Survey Blocks for the Schreiber Area

FIGURE 4-2

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

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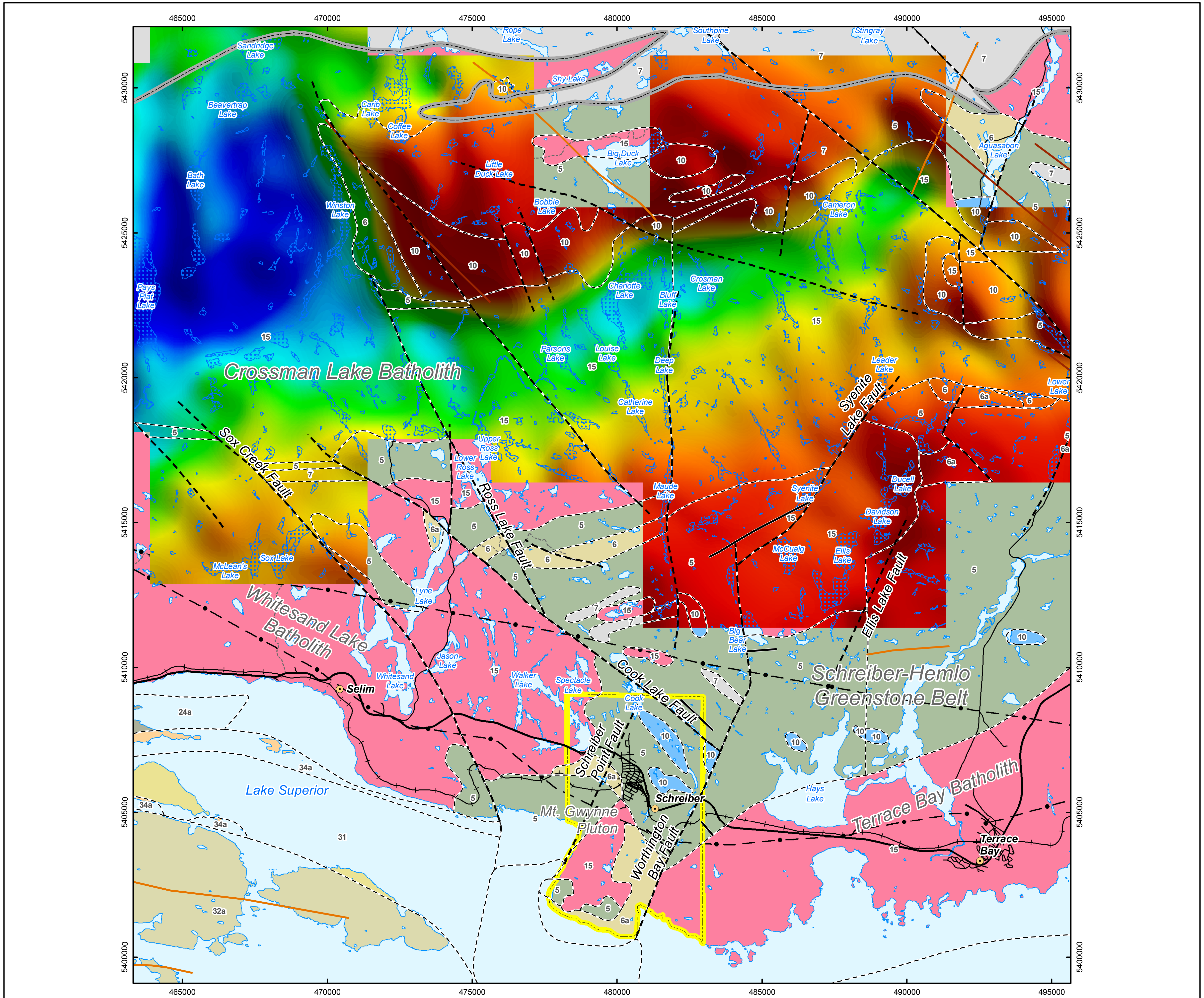

LEGEND

- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody (within gravity data extents)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Bouger Gravity (mGal)

-47.6, -53.5, -58.8, -60.9, -62.5, -63.8, -65.1, -66.4, -67.6, -68.5, -69.2, -70.0, -70.6, -71.2, -72.0, -72.7, -73.5, -74.0, -74.5, -74.9, -75.3, -75.7, -76.1, -76.5, -76.9, -77.2, -77.7, -78.4, -79.1, -80.0, -80.7, -81.9

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and untramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

SCALE 1:130,000

0 1 2 4 6 8 Kilometers

NORTH

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Geopgysical Data - SGL 2015
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Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE **Gravity Data in the Airborne Survey Blocks for the Schreiber Area**

FIGURE 4-3

DESIGN: ADG
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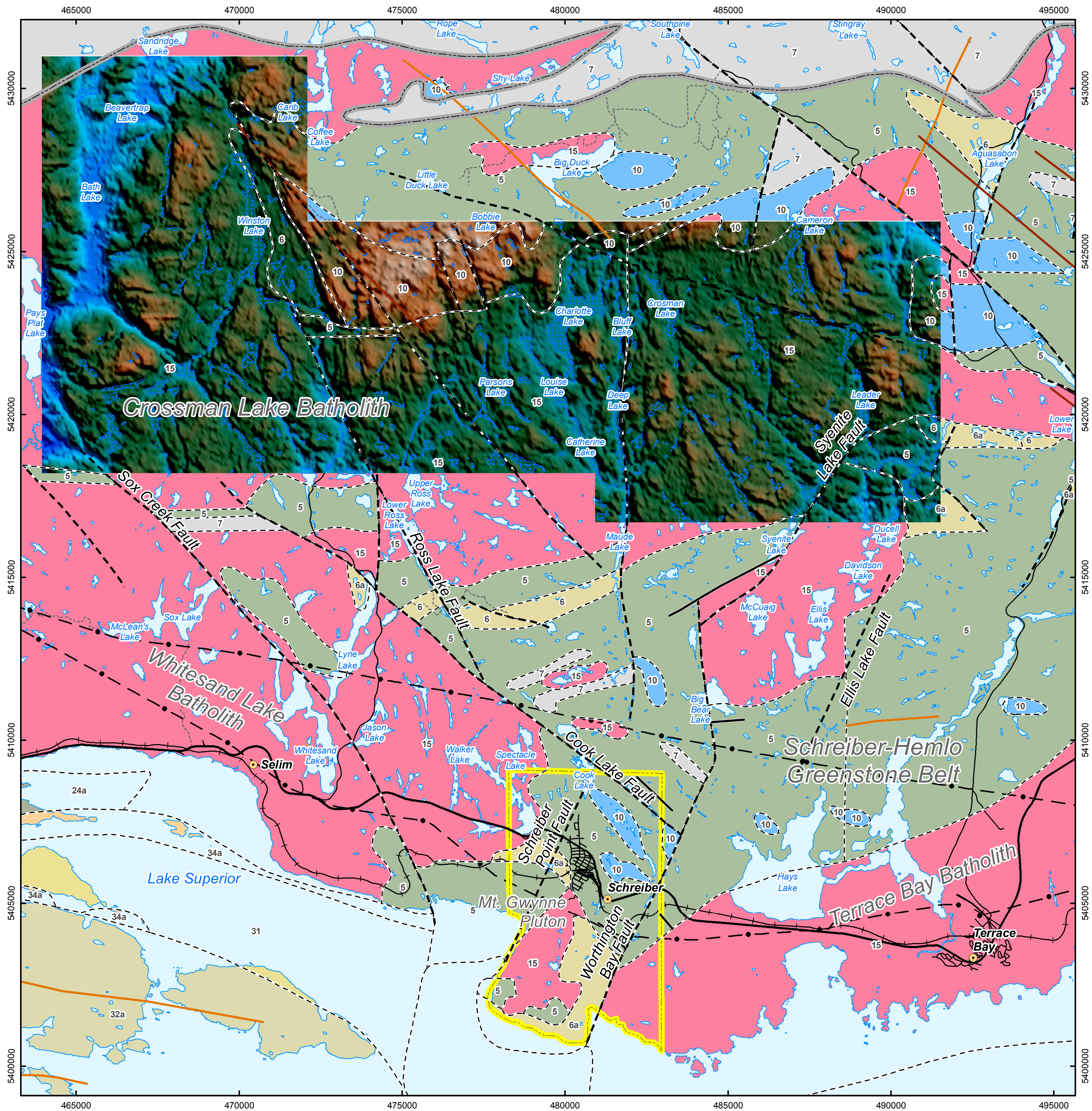
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd



LEGEND

- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody (within DEM extents)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Elevation (mAMSL)

586.2, 575.0, 563.9, 552.7, 541.5, 530.4, 519.2, 508.0, 496.8, 485.7, 474.5, 463.3, 452.2, 441.0, 429.8, 418.6, 407.5, 396.3, 385.1, 374.0, 362.8, 351.6, 340.4, 329.3, 318.1, 306.9, 295.8, 284.6, 273.4, 262.2, 251.1, 239.9

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
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- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

SCALE 1:130,000

0 1 2 4 6 8
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
DEM - SGL 2015
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Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Digital Elevation Model (DEM) Data in the Airborne Survey Blocks for the Schreiber Area

FIGURE 4-4

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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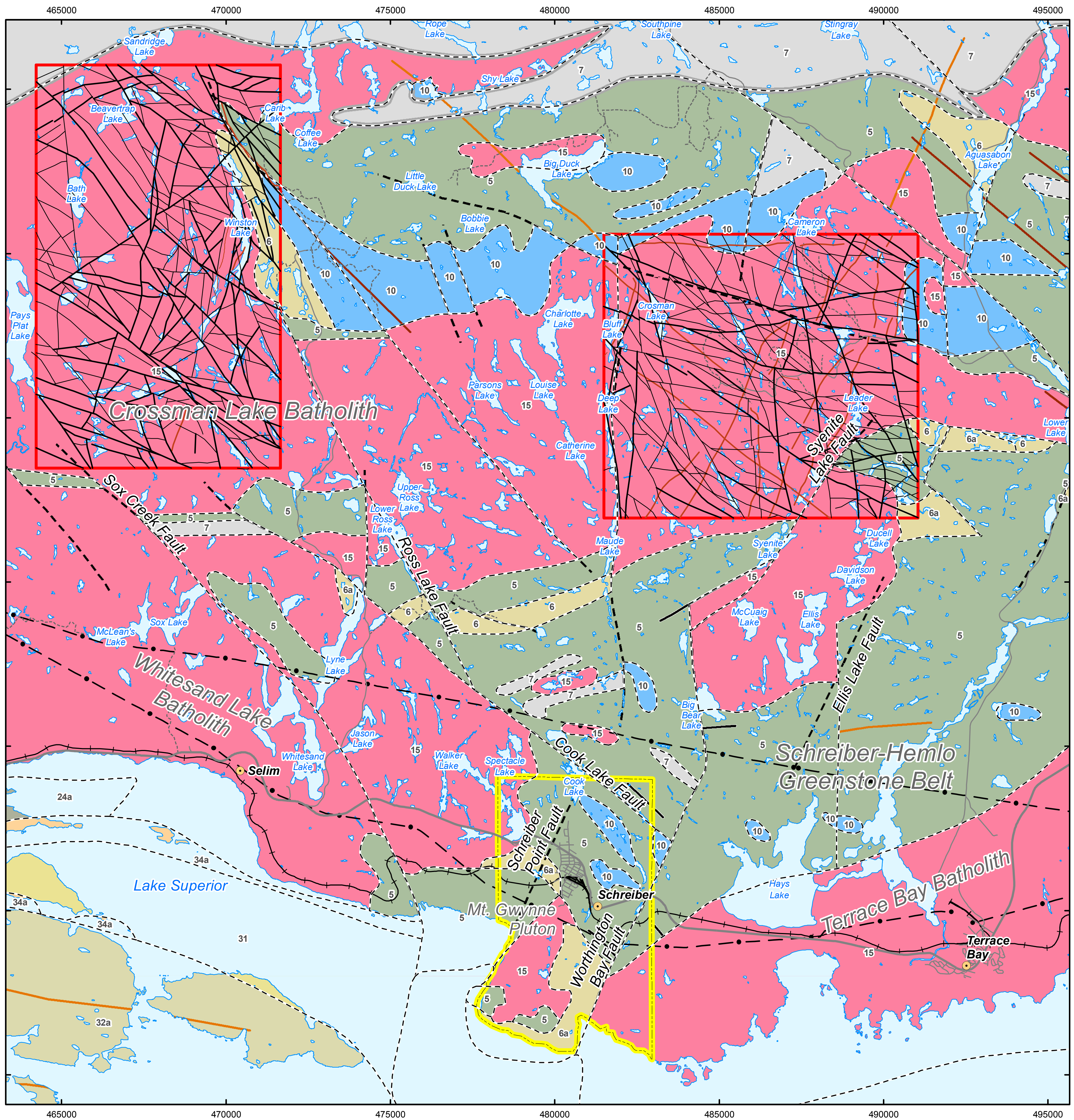


LEGEND

- Airborne Survey Block
- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Magnetic Lineaments

- Medium Certainty
- High Certainty

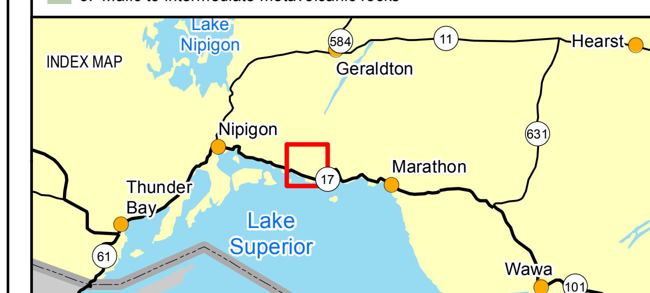
Dyke Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

INDEX MAP



SCALE 1:130,000

0 1 2 4 6 8 Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Lineaments - SRK 2015
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PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Magnetic Lineaments in the Airborne Survey Blocks with Medium and High Certainty

FIGURE 4-5

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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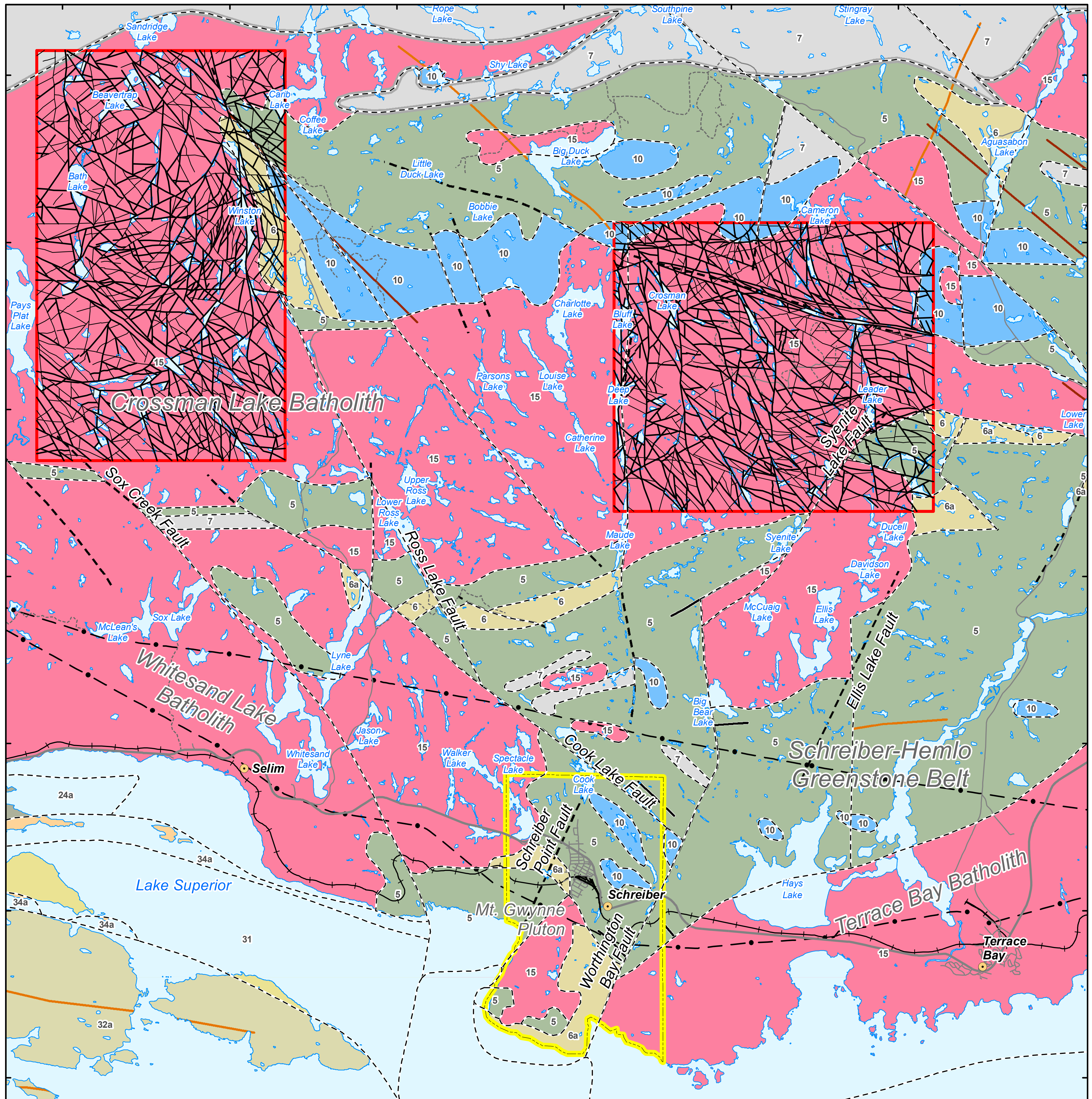

LEGEND

- Airborne Survey Block
- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

SCALE 1:130,000

0 1 2 4 6 8 Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Lineaments - SRK 2015
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PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment Findings from Initial Field Studies

TITLE

Surficial Lineaments in the Airborne Survey Blocks with Medium and High Certainty

FIGURE 4-6

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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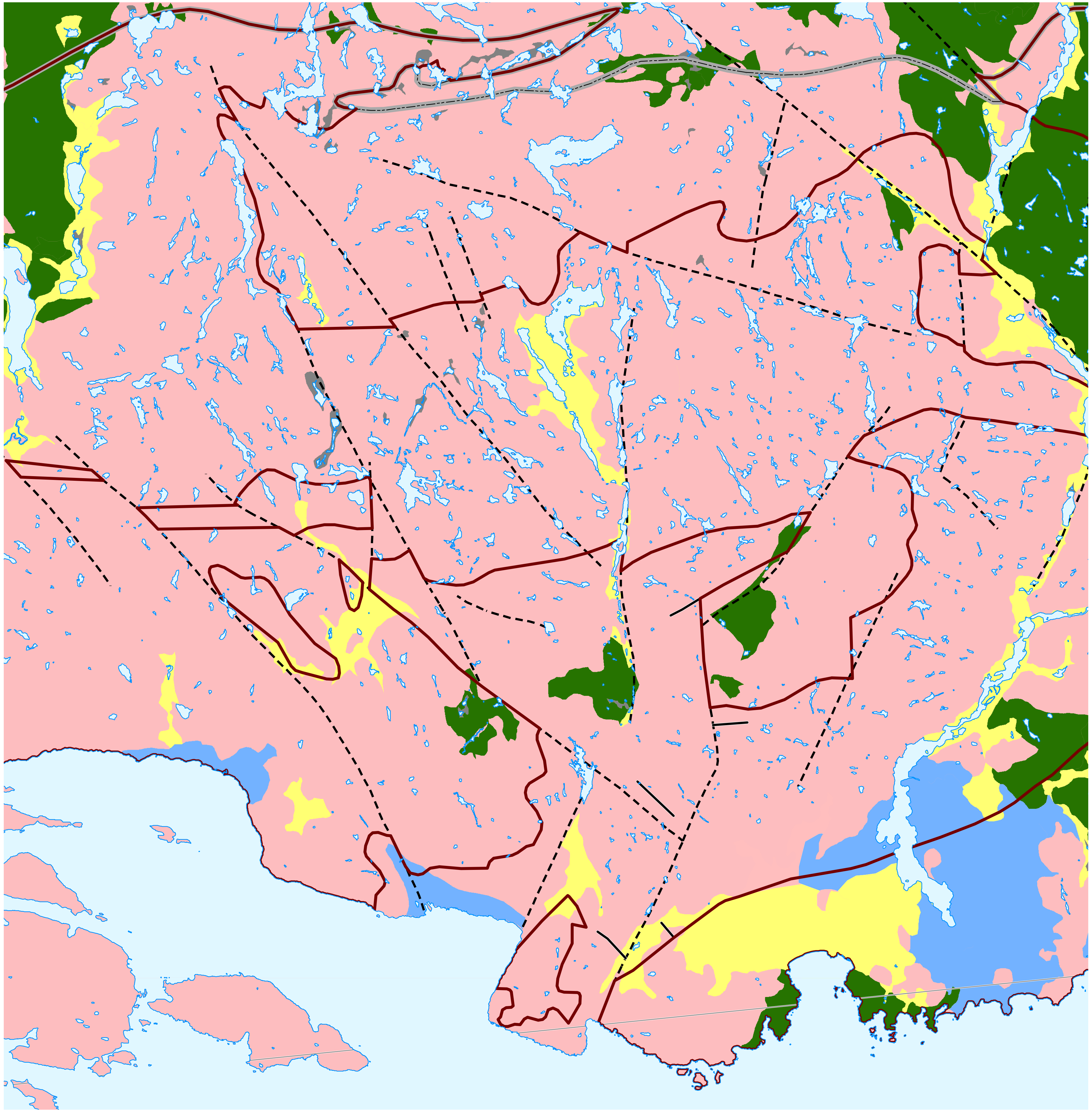

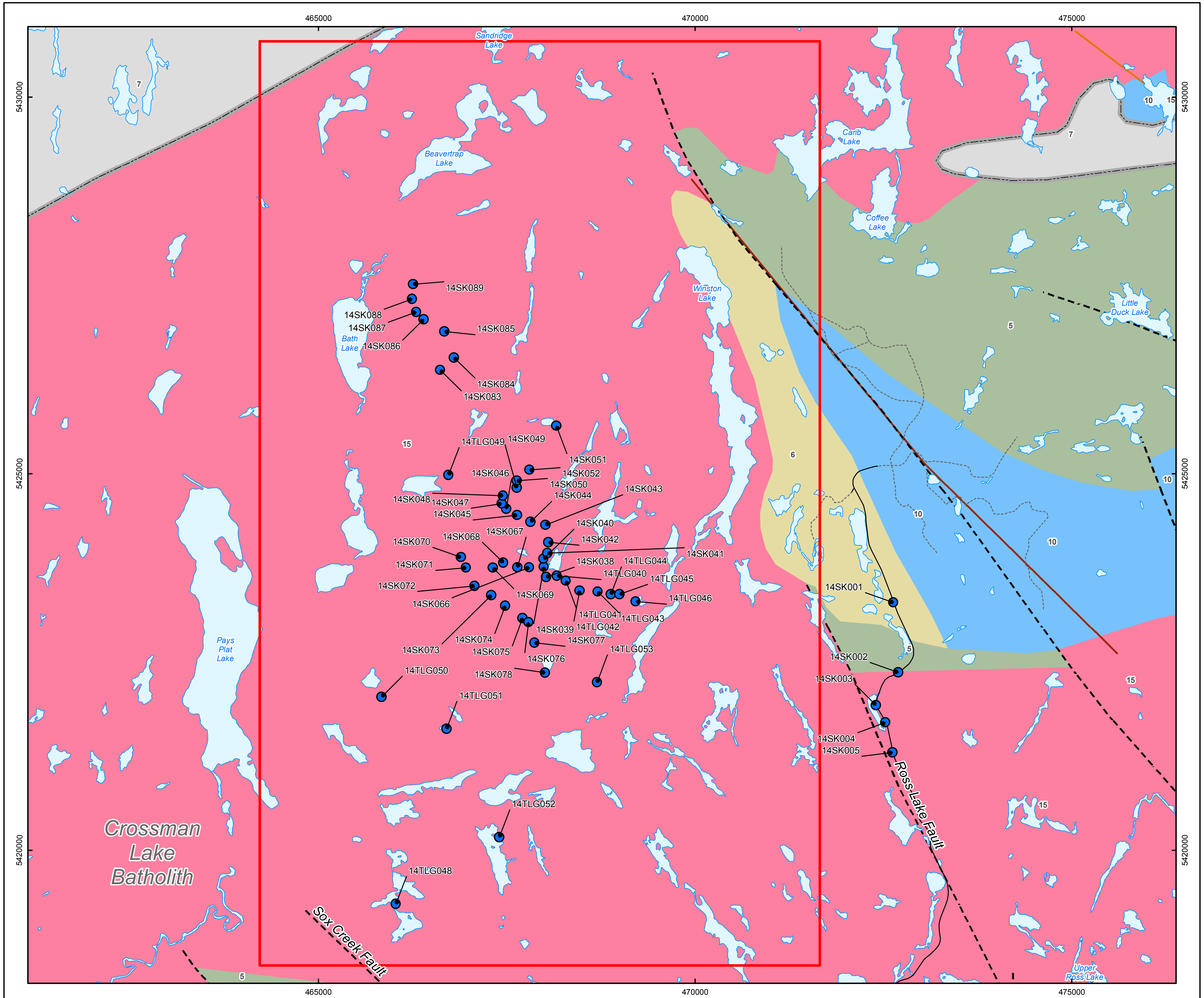

LEGEND

- Outcrop Mapping Location
- Airborne Survey Block
- Local Road
- Digitized Trail
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Bedrock Geology

- 15. Massive granodiorite to
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic
- 5. Mafic to intermediate metavolcanic

INDEX MAP

SCALE 1:50,000

0 0.5 1 2 3 4
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE:Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Mapping Locations: FLADGATE 2015
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PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

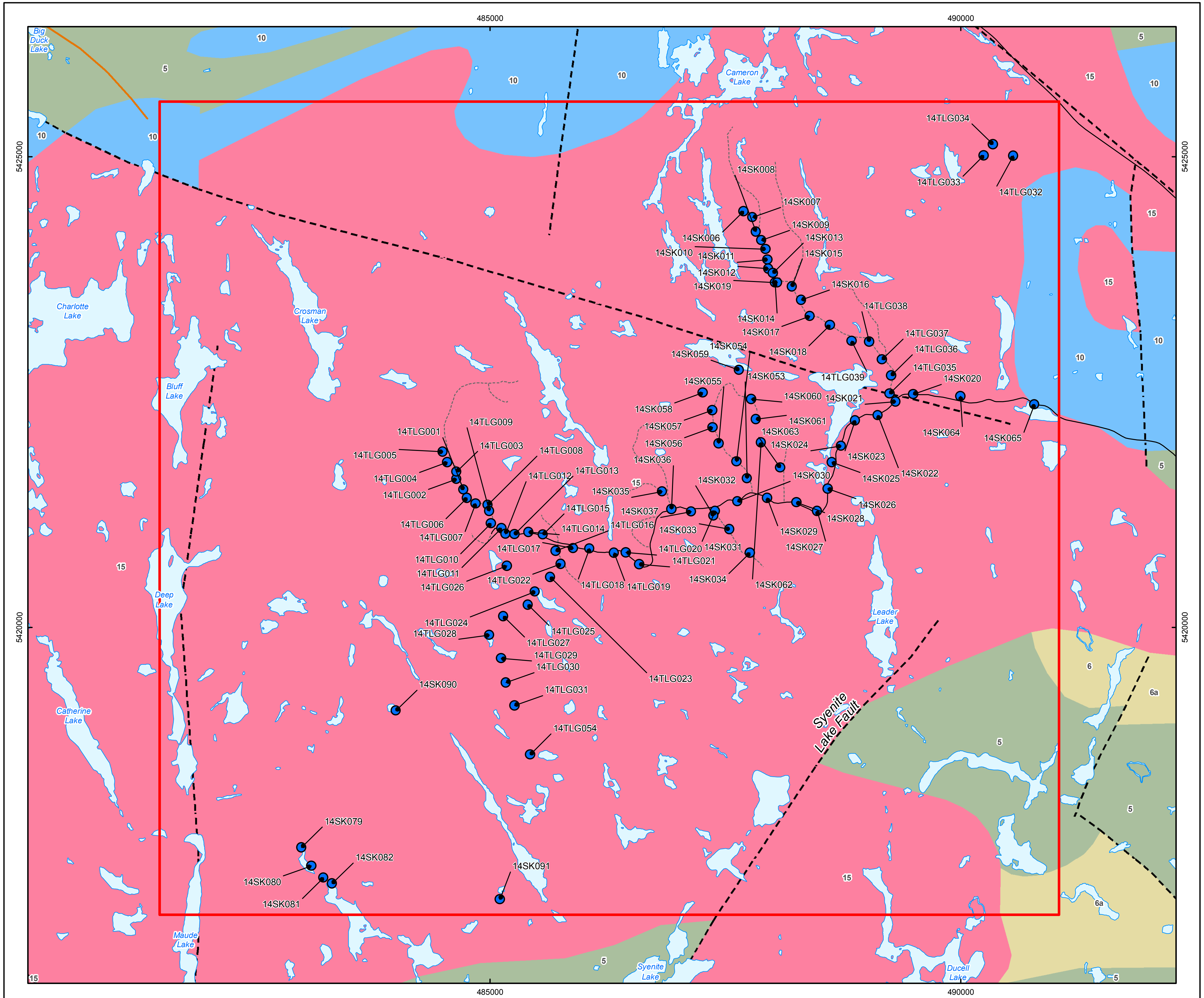
Outcrop Mapping Locations in the Western Portion of the Crossman Lake Batholith

FIGURE 4-8

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd



LEGEND

- Outcrop Mapping Location
- Airborne Survey Block
- Local Road
- Digitized Trail
- Waterbody
- Fault

Dykes

- Dyke (other)

Bedrock Geology

- 15. Massive granodiorite to granite
- 10. Mafic and untramafic rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

SCALE 1:40,000

0 250 500 1,000 1,500 2,000 Meters

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Natural Earth 2015
Digitized Trail - Fladgate, Geofirma 2015
OGS MRD126 - Revision 1
Mapping Locations: FLADGATE 2015
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Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Outcrop Mapping Locations in the Eastern Portion of the Crossman Lake Batholith

FIGURE 4-9

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

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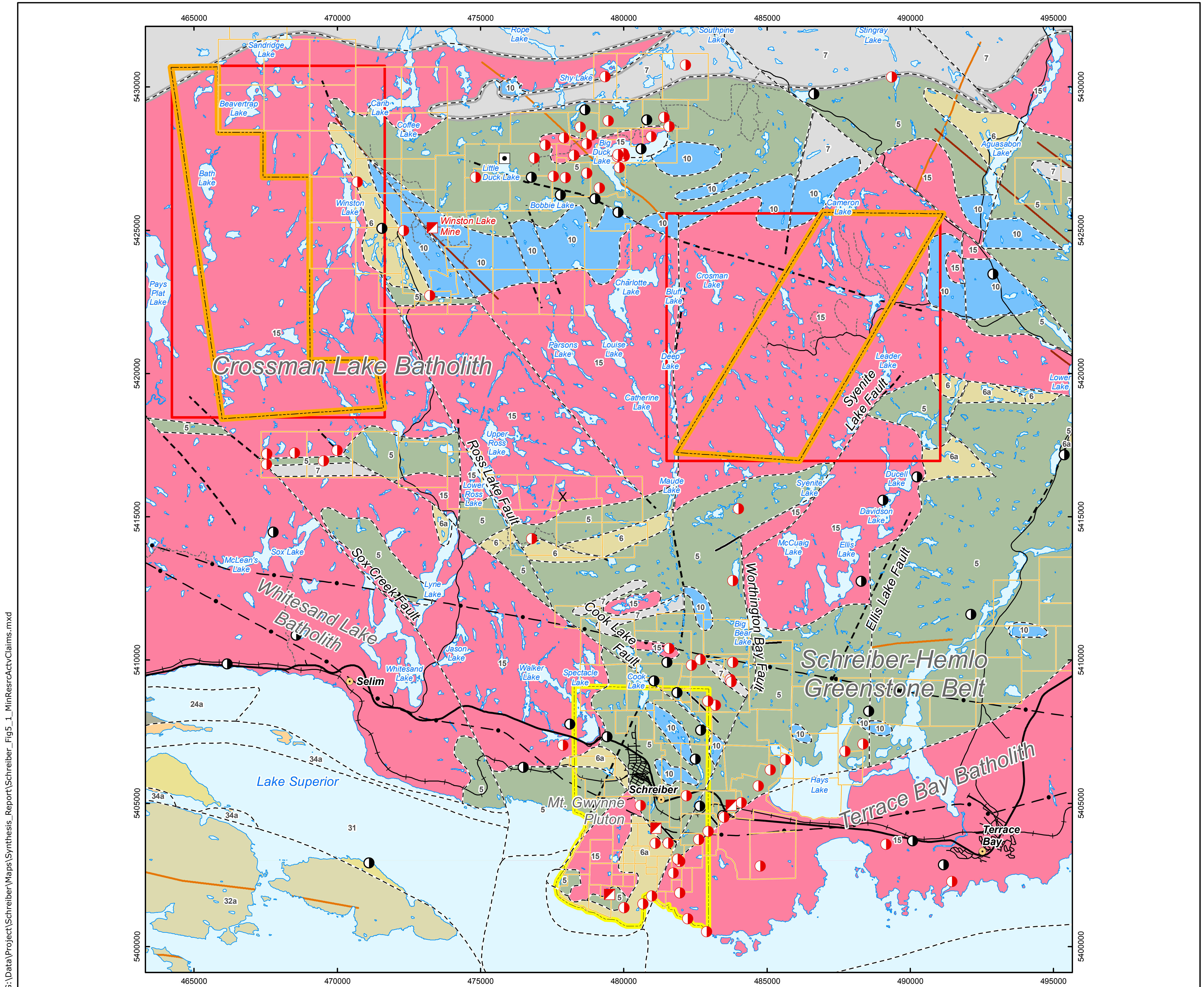

LEGEND

Mineral Occurrences (MDI-2014)*

- Developed Mineral Prospect With Reserves
- Discretionary Occurrence
- Mineral Occurrence
- Past Producing Mine Without Reserves
- Prospect
- Active Claim (February 2015)**
- Withdrawn Area
- Airborne Survey Block
- Community
- Main Road
- Local Road
- Digitized Trail
- Railway
- Transmission Line
- Municipal Boundary (Township of Schreiber)
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Bedrock Geology

- Bedrock Geology Outline
- 34a. Mafic dykes and related intrusive rocks (Keenawan age) (Circa 1.1 to 1.2 Ga)
- 32. Osler Gp., Maminsa Point Fm., Michipicoten Island Fm.
- 31. Sibley Gp.
- 24a. Animikie Gp.
- 15. Massive granodiorite to granite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

SCALE 1:130,000

0 1 2 4 6 8 Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Digitized Trail - Fladgate, Geofirma 2015
* OGS 2014. Mineral Deposit Inventory—2014; Ontario Geological Survey.
** Ontario Ministry of Northern Development, Mines and Forestry, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
OGS MRD126 - Revision 1
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NORTH

PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Mineral Occurrences and Active Mining Claims in the Schreiber Area

FIGURE 5-1

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0
DATE: 2/23/2015

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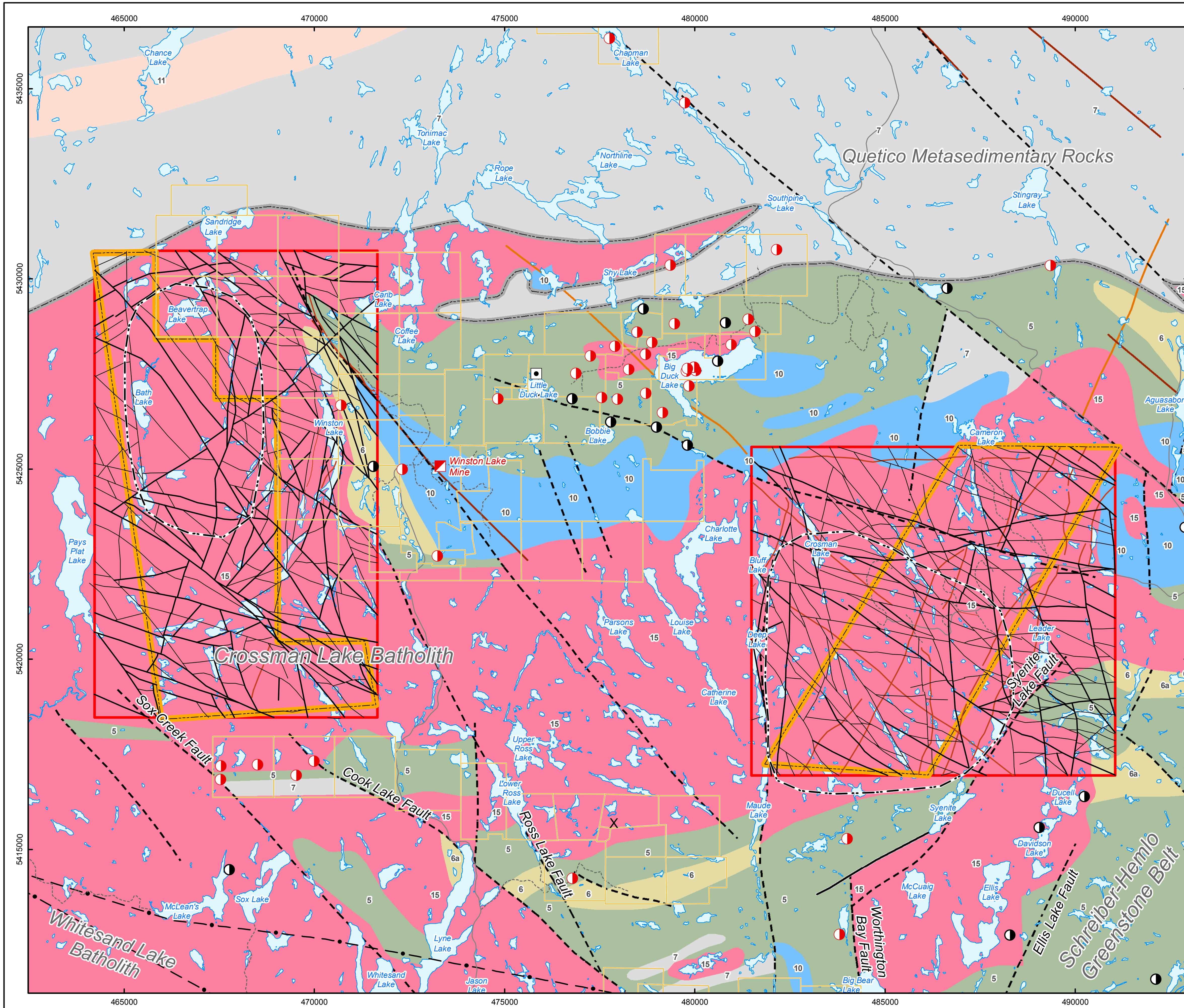

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LEGEND

Mineral Occurrences (MDI-2014)*

- Developed Mineral Prospect With Reserves
- Discretionary Occurrence
- Mineral Occurrence
- Past Producing Mine Without Reserves
- Prospect
- Active Claim (February 2015)**
- Candidate Area for Phase 2 Detailed Mapping
- Withdrawn Area
- Airborne Survey Block
- Local Road
- Digitized Trail
- Transmission Line
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Magnetic Lineaments

- Medium Certainty
- High Certainty

Dyke Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- 15. Massive granodiorite to granite
- 11. Gneissic tonalite suite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

Approximate Underground Repository Footprint (3 X 2 KM)

SCALE 1:100,000

0 1 2 4 6 8
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Digitized Trail - Fladgate, Geofirma 2015
Lineaments - SRK 2015
* OGS 2014. Mineral Deposit Inventory—2014; Ontario Geological Survey.
** Ontario Ministry of Northern Development, Mines and Forestry, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

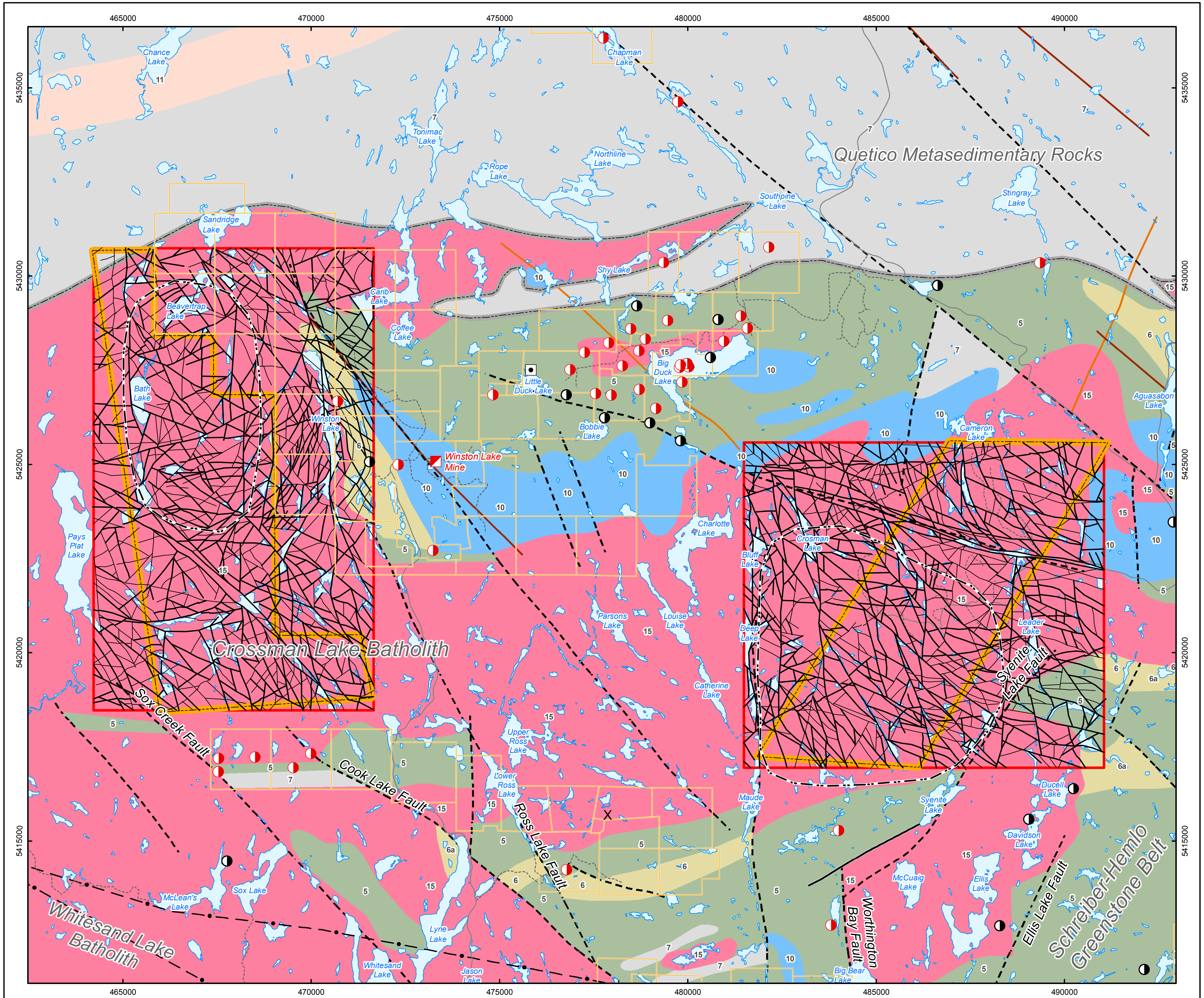
Candidate Areas in the Western and Eastern Portions of the Crossman Lake Batholith Over Magnetic Lineaments with Medium and High Certainty

FIGURE 6-1

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/24/2015

Geofirma Engineering Ltd



LEGEND

Mineral Occurrences (MDI-2014)*

- Developed Mineral Prospect With Reserves
- Discretionary Occurrence
- Mineral Occurrence
- Past Producing Mine Without Reserves
- Prospect
- Active Claim (February 2015)**
- Candidate Area for Phase 2 Detailed Mapping
- Withdrawn Area
- Airborne Survey Block
- Local Road
- Digitized Trail
- Transmission Line
- Waterbody
- Quetico/Wawa Subprovince Boundary
- Iron Formation
- Fault

Dykes

- Matachewan Mafic Dyke
- Dyke (other)

Surficial Lineaments

- Medium Certainty
- High Certainty

Bedrock Geology

- 15. Massive granodiorite to granite
- 11. Gneissic tonalite suite
- 10. Mafic and ultramafic rocks
- 7. Metasedimentary rocks
- 6. Felsic to intermediate metavolcanic rocks
- 6a. Dacitic and Andesitic flows, tuffs and breccias
- 5. Mafic to intermediate metavolcanic rocks

Approximate Underground Repository Footprint (3 X 2 KM)

SCALE 1:100,024

0 1 2 4 6 8
Kilometers

PROJECTION: UTM NAD83 Zone 16N
SOURCE: Base Data - MNR LIO, obtained 2009-2013
Digitized Trail - Fladgate, Geofirma 2015
Lineaments - SRK 2015
* OGS 2014. Mineral Deposit Inventory—2014; Ontario Geological Survey.
** Ontario Ministry of Northern Development, Mines and Forestry, Mining Lands Section: Ontario Mining Land Tenure Spatial Data. 2015
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PROJECT No. 10-214-10.40

Phase 2 Geoscientific Preliminary Assessment
Findings from Initial Field Studies

TITLE

Candidate Areas in the Western and Eastern Portions of the Crossman Lake Batholith Over Surficial Lineaments with Medium and High Certainty

FIGURE 6-2

DESIGN: ADG
CAD/GIS: ADG
CHECK: KGR
REV: 0

DATE: 2/23/2015

Geofirma Engineering Ltd

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