APPENDIX M

HYDROGEOLOGY

M-1 Hydrogeology
M-2 Amec Memorandum

NOTE TO READER
APPENDIX M

In April 2015, Treasury Metals submitted an Environmental Impact Statement (EIS) for the proposed Goliath Gold Project (the Project) to the Canadian Environmental Assessment Agency (the Agency) for consideration under the Canadian Environmental Assessment Act (CEAA), 2012. The Agency reviewed the submission and informed Treasury Metals that the requirements of the EIS Guidelines for the Project were met and that the Agency would begin its technical review of the submission. In June 2015, the Agency issued a series of information requests to Treasury Metals regarding the EIS and supporting appendices (referred to herein as the Round 1 information requests). The Round 1 information requests included questions from the Agency, other federal and provincial reviewers, First Nations and other Aboriginal peoples, as well as interested stakeholders. As part of the Round 1 information request process, the Agency requested that Treasury Metals consolidate the responses to the information requests into a revised EIS for the Project.

Appendix M to the revised EIS (Hydrogeology) includes information related to the hydrogeology for the area surrounding the Project, and the predicted effects of the Project on groundwater. The appendix includes the following two components:

- M-1: Hydrogeology: This study presents the investigation and groundwater modelling for the area surrounding the proposed Project. The information presented in this appendix was used for describing the existing hydrogeological conditions (Section 5.6 of the revised EIS), as well as the assessment of potential Project effects on groundwater quality (Section 6.10 of the revised EIS) and groundwater quantity (Section 6.11 of the revised EIS).
- M-2: A memorandum from Amec Environment & Infrastructure dated September 29, 2014 providing a framework for a groundwater level and quality monitoring program for the Goliath Gold Project.

No changes have been made to this appendix from the original EIS issued in April 2015. To aid the reader, bookmarks for each component are provided in the electronic copy of this appendix.

As part of the process to revise the EIS, Treasury Metals has undertaken a review of the status for the various appendices. The status of each appendix to the revised EIS has been classified as one of the following:

- **Unchanged**: The appendix remains unchanged from the original EIS, and has been re-issued as part revised EIS.
- **Modified**: The appendix remains relatively unchanged from the original EIS, and has been re-issued with relevant clarification.
- **Re-written**: The appendix has been substantially changed from the original EIS. A re-written appendix has been issued as part of the revised EIS.

- **Discarded**: The appendix is no longer required to support the EIS. The information in the original appendix has been replaced by information provided in a new appendix prepared to support the revised EIS.
- **New**: This is a new appendix prepared to support the revised EIS.

The following table provides a listing of the appendices to the revised EIS, along with a listing of the status of each appendix and their description.

List of Appendices to the Revised EIS		
Appendix	Status	Description
Appendix A	Modified	Table of Concordance
Appendix B	Unchanged	Optimization Study
Appendix C	Unchanged	Mining Study
Appendix D	Re-written	Tailings Storage Facility
Appendix E	Unchanged	Traffic Study
Appendix F	Re-written	Water Management Plan
Appendix G	Discarded	Environmental Baseline
Appendix H	Unchanged	Acoustic Environment Study
Appendix I	Unchanged	Light Environment Study
Appendix J	Unchanged	Air Quality Study
Appendix K	Unchanged	Geochemistry
Appendix L	Discarded	Geochemical Modelling
Appendix M	Unchanged	Hydrogeology
Appendix N	Unchanged	Surface Hydrology
Appendix O	Discarded	Hydrologic Modeling
Appendix P	Unchanged	Aquatics DST
Appendix Q	Re-written	Fisheries and Habitat
Appendix R	Re-written	Terrestrial
Appendix S	Re-written	Wetlands
Appendix T	Unchanged	Socio-Economic
Appendix U	Unchanged	Heritage Resources
Appendix V	Unchanged	Public Engagement
Appendix W	Unchanged	Screening Level Risk Assessment
Appendix X	Re-written	Alternatives Assessment Matrix
Appendix Y	Unchanged	EIS Guidelines
Appendix Z	Unchanged	TML Corporate Policies
Appendix AA	Modified	List of Mineral Claims
Appendix BB	Unchanged	Preliminary Economic Assessment
Appendix CC	Unchanged	Mining, Dynamic And Dependable For Ontario's Future
Appendix DD	Re-written	Aboriginal Engagement Report
Appendix EE	Unchanged	Country Foods Assessment

List of Appendices to the Revised EIS		
Appendix	Status	Description
Appendix FF	Unchanged	Photo Record Of The Goliath Gold Project
Appendix GG	Modified	TSF Failure Modelling
Appendix HH	Unchanged	Failure Modes And Effects Analysis
Appendix II	Unchanged	Draft Fisheries Compensation Strategy and Plans
Appendix JJ	New	Water Report

APPENDIX M-1

HYDROGEOLOGY

TREASURY METALS INC.

HYDROGEOLOGICAL PRE-FEASIBILITY/EA SUPPORT STUDY GOLIATH PROJECT

Submitted to:
Treasury Metals

by:

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TB124004

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GLOSSARY

BH	borehole
BMS	biotite-muscovite schist
CEQG	Canadian Environmental Quality Guidelines
ha	hectare
km	kilometres
masl	metres above sea level
mbgs	metres below ground surface
mbbs	metres below bedrock surface
m	metres
MOE	Ontario Ministry of the Environment
MNR	Ontario Ministry of Natural Resources
MSS	muscovite-sericite schist
m/s	metres per second
m^3/s	cubic metres per second
mm	millimetres
mm/year	millimetres per year
PAG	potentially acid generating
PWQO	Provincial Water Quality Objectives
RQD	rock quality designation
TMA	Tailings management area
UTM	Universal Transverse Mercator
WRSA	waste rock storage area
WWIS	water well information system
WWR	water well record
ZOI	zone of influence

1.0 INTRODUCTION

This report has been prepared by AMEC Environment and Infrastructure, a division of AMEC Americas Limited (AMEC), for Treasury Metals Inc. (referred to further as Treasury Metals in this report). Treasury Metals is located in the Kenora Mining Division, approximately 125 km east of the City of Kenora and 20 km east of the City of Dryden (Figure 1).

The project area of relevance to the groundwater investigation is bounded to the west and south by the Thunder and Wabigoon Lakes, to the north by the Lola Lake Provincial Nature Reserve and to the east by Hartman Lake (Figure 1). Further reference to 'project area' in this report relates specifically to this area.

This report summarises background information on the project area, including location, exploration history and nearby groundwater users in Section 2.0. Section 3.0 details the basic geology and hydrology of the project area. Section 4.0 considers the hydrogeology of the project area, which includes a field investigation comprising packer testing, installation of piezometers, groundwater quality wells and review of water level data collated by Treasury Metals. The hydrogeological understanding derived from this investigation provides the basis for the construction of a numerical groundwater flow model that is suitable for making predictions on changes to the groundwater flow environment in the project area caused by open pit and underground mining and associated large infrastructure. The construction and calibration of this groundwater flow model is described in Section 5.0. This section also details the results of model predictions for the groundwater inflows to the proposed open pit and underground mine, an estimate of the zone of influence (ZOI) of groundwater level drawdown caused by mine dewatering, estimates of flow depletion at sensitive creeks and estimates of leakage to groundwater from the tailings management and waste rock stockpile areas (TMA and WRSA respectively). A summary of anticipated effects to groundwater is provided in Section 6.0.

2.0 BACKGROUND INFORMATION

2.1 Goliath Site Exploration History

The gold mineralisation at Goliath was originally discovered by Teck Exploration Ltd following a period of diamond drilling from 1990 to 1998, which from 1996 was part of a joint venture with Corona Gold (ACA Howe, 2012). During this period of investigation the main gold deposits were discovered: Main Zone and C Subzone. The latter part of the 1990-1998 exploration program also involved the excavation of a trench, construction of portal and underground workings (Page et al., 1998) that comprised a ramp 275 m in length to 35 metres below ground surface (mbgs) and approximately 220m of lateral drifting along the Main Zone (Page et al., 1998). The location of the portal is shown on Figure 2. The dewatering associated with the 1998 excavations is discussed further in Section 4.2.1.

In 2008 Treasury Metals commenced an exploration program of diamond drilling that has totalled more than 90 km of drilling up to the end of 2012.

2.2 Physiographic Setting

The project area lies within the Wabigoon Basin. The Upper English Basin Watershed lies immediately to the northeast of the project area. The area is characterised by gently undulating topography with elevations generally between 370 and 430 metres above sea level (masl). Topography has been strongly influenced by glaciation, which on higher ground has left bedrock exposed (or with limited overburden cover, further referred to as bedrock knolls in this report) and in lower lying areas has thicker sedimentary deposits primarily of glacial origin. Nevertheless, the overburden thickness is generally thin (<10 m) and mostly of glaciolacustine origin associated with pro-glacial Lake Agassiz. In the north-eastern part of the project area a regionally mapped end-moraine occurs, which is known at the Hartman Moraine.

There are no large creeks within the project area. The project site is drained primarily by the Blackwater Creek. To the east of the proposed mine, the area is primarily drained by Hughes Creek and Nuggett Creek. All these creeks drain to Wabigoon Lake (regulated between 368.50 and 369.23 masl; MNR, 2013), the most prominent water body in the project area, to the south of the project site. There is also some drainage from several creeks to Thunder Lake (mean lake level of 373.5 masl; DST, 2005) to the west, the closest of which are Little Creek and the Hoffstrom's Bay Tributary. To the north of Hoffstrom's Bay Tributary there is a larger watershed that also drains to Thunder Lake through several small creeks that are downstream from Lola Lake Provincial Park. These are further referred to as 'Thunder Lake Tributary #2 and #3', going from north to south.

2.3 Proposed Mining and Dewatering Activities

The proposed Goliath mine will consist of an open pit and an underground mine. The open pit is elongated in shape trending east-west along the zone of mineralisation (see Section 3.1.3).

The open pit will be approximately 1.4 km long and have a maximum width of 360 m and a footprint of approximately 34 ha (Figure 2). In detail the open pit comprises three coalesced sub-pits, which increase in depth towards the east; the western sub-pit has a depth of 110 m (~ 290 masl) and the eastern, deepest sub-pit has a depth of 160 m (~ 240 masl).

The stopes and internal developments of the underground mine will be located directly underneath the open pit. It will extend to a depth of 600 m (~ -200 masl). The ramp access to the underground mine will be located immediately to the north of the open pit.

The TMA will be located to the north-east of the proposed mine, covering the top part of Blackwater Tributary #2 (Figure 2). The TMA will have an area of approximately 75 ha and dams on all four sides to an elevation of 420 masl (WSP, 2014). A water treatment pond would be located at the south-western corner of the TMA.

The WRSA will be located on north side of the open pit and have an area of approximately 69 ha and will also include filling of the central and western sub-pit. It is understood from Treasury Metals that the WRSA will accommodate a proportion of potentially acid generating (PAG) rock.

Treasury Metals is currently investigating the principal recipient of discharge water; Blackwater Creek is the water course closest to the site that may receive discharge water.

2.4 Groundwater Users

An assessment has been made of the occurrence of private water wells within a 5 km radius of the proposed open pit using the geographic location data from the Ontario Ministry of the Environment's (MOE) water well information system (WWIS). A total of 139 wells were identified within this area based on the UTMs provided on WWIS. The locations of the wells were checked where necessary against the more detailed water well records (WWR) obtained from the MOE, particularly if the well plotted in open water or at significant distance from any roads. Ten wells were moved to more appropriate locations based on the location maps provided in the WWRs. A further ten were removed from the data set as the location maps clearly located them outside of the project area (generally in Dryden or on the west side of Wabigoon Lake) or had no well location map to substantiate the unlikely location of the well. Figure 3 shows the location of resultant water wells in relation to the proposed open pit and property held by Treasury Metals. The majority of these wells (~70%) derive their water from the shallow bedrock. The closest water wells outside of Treasury Metal property are on Thunder Lake at approximately 1.5 km from the proposed open pit. Otherwise there are no wells within 2 km distance of the proposed open pit, with the majority located in Wabigoon over 3 km to the south. There are no wells to the north or east of the proposed open pit that are not located on Treasury Metals property.

2.5 Background Information used in preparing this report

Background information used in preparing this report includes the following:

- RQD (Rock Quality Designation) data of 90 km of cored borehole obtained by Treasury Metals;
- Treasury Metals N-S cross sections of the mineralisation at 1:1000 scale between 528750 E and at 526400 E at 25 m intervals, dated November 2011;
- Selected geologic information provided by Treasury Metals from their 3D resource model;
- 1:100,000 Geological Survey of Canada (GSC) surficial geology map by Cowan and Sharpe (1991) and 1:100,000 Ontario Geological Survey (OGS) terrain geology map (Roed, 1980) – both used to determine the extent and type of overburden cover;
- 1:20,000 OGS bedrock geology map by Beakhouse and Pigeon (2003) – also used to determine the bedrock type and also to provide information on areas where overburden is absent;
- A number of reports/papers on the regional overburden geology by the GSC and/or published by GSC authors (Pullan and Hunter, 1988; Sharpe et al., 1992; Minning et al., 1994);
- MOE water well records;
- Bathymetric maps of Thunder and Wabigoon Lake produced by the Ontario Ministry of Natural Resources (MNR);

In addition to the above data a number of Treasury Metals and Teck Exploration reports on the property (ACA Howe, 2012; Caracle Creek, 2008a & 2008b; Page et al., 1998; Emdin, 1998; see Section 9.0 for full references), which include all relevant available information on the 1998 exploration workings. Previous hydrology baseline reports (Klohn Crippen Berger, 2012a; DST, 2014) and where relevant fisheries reports (DST, 2005; Klohn Crippen Berger, 2012b; MNR, 2013) were utilized to help understand the groundwater-surface water interactions. Furthermore, information on the site was obtained through discussions with Treasury Metals employees familiar with the site and project history.

3.0 GEOLOGY AND SURFACE WATER HYDROLOGY OF PROJECT AREA

The following section provides a brief description of the project area and geology and surface water hydrology based on the reports listed in Section 2.5 above and new information that has become available from recent exploration operations, hydrogeological investigations starting in 2012 and continuing through 2013 and a geotechnical drilling program undertaken in 2014.

3.1 Geology

3.1.1 Overburden Geology

A regional overview of the overburden geology is provided by Minning et al. (1994). The surficial deposits of the project area are predominantly glacial in origin. The project area and surrounding region has been subject to a number of glaciations, however, the surficial deposits are considered mainly associated with the last (Pleistocene; Late Wisconsian) glaciation (Minning et al., 1994). The surficial deposits of the project area are broadly subdivided into two main deposit types, specifically:

1. In the north east predominantly sandy and coarser grained deposits including boulders of the Hartman Moraine; a major regionally mapped end moraine trending north-west – south-east and marked by a ridge at an elevation of 430-450 masl. Figure 10 of Minning et al. (1994) indicates this moraine is located running parallel to the north-eastern shore of Thunder Lake. The north-eastern extent of the watersheds of Blackwater and Hughes Creek is formed by the Hartman Moraine;
2. In the south-west predominantly clay and silt referred to as rhythmites by Minning et al. (1994) deposited in pro-glacial Lake Agassiz. In the Wabigoon basin, Minning et al. (1994) have estimated the maximum water level elevation of Lake Agassiz at 430 masl. Progressively finer sediments would be expected in the deeper parts of the Wabigoon Basin towards the south-west.

The overburden geology in the area of the proposed Goliath Mine has been mapped by the OGS at 1:100,000 (Figure 4), which is documented by Roed (1980), and by the GSC at 1:100,000 (Cowan & Sharpe, 1991). Broadly speaking these maps are in agreement with fine grained glaciolacustrine deposits mapped in the topographically lower areas to the south of the proposed open pit with some outcrops (bedrock knolls) occurring at higher ground. A kame sand and gravel deposit is located by both maps to the south-east, trending south-west towards Wabigoon (Figure 4). However, in the area of the proposed open pit and to the north-east, Cowan and Sharpe (1991) map sandy deposits, whereas the OGS map (Roed, 1980) indicates a continuation of the finer grained clay and silt deposits (Glaciolacustrine Plain; Figure 4**)** within the Blackwater Creek watershed with sand and gravel deposits (Glaciofluvial Outwash, Figure 4) associated with the Hartman Moraine occurring further north-east of the proposed open pit where the topography rises above 430 masl.

More detailed geological data have been assembled on the overburden (or the absence thereof), which comprise:

- Nine groundwater quality wells drilled by Treasury Metals in May 2013 (See Appendix A for borehole logs);
- Twenty geotechnical boreholes drilled by Treasury Metals in March 2014 (See Appendix B for borehole logs);
- Lithological data from the MOE water well records;
- Bedrock outcrop mapping undertaken by Treasury Metals indicating areas with no or very limited overburden in the immediate vicinity of the proposed mine;
- Areas of bedrock outcrop digitized from the 1:20,000 mapping of Beakhouse and Pigeon (2003); and
- Exploration boreholes which provide data on overburden thickness.

These data have been kriged to generate an overburden thickness map of the project area, which is displayed in Figure 4. Where overburden is present at lower elevations (away from bedrock knolls), borehole data indicate this to be on average around 7.5 m thick, with the thickness rarely exceeding 15 m (7% of boreholes) and no boreholes showing an overburden thickness greater than 40 m. The deposits comprise mainly clay with subordinate silt (i.e. clay; silty clay, layered clay and silt). A relatively thin basal sand may occur at the bottom of the clay (~40% of MOE wells, Treasury Metals 2013 groundwater quality wells and 2014 geotechnical holes) that is on average around 3 – 4 m thick.

These data tend to confirm the broad distribution of overburden as indicated by the OGS 1:100,000 map in that fine grained deposits (clay, silty clay, layered clay and silt) of glaciolacustrine origin extend to the north of the proposed open pit. The main exception to this is the area at the top of the watershed of the upper western branch of Blackwater Creek (referred to as 'Blackwater Tributary #2'); an as indicated in Figure 4 and shown in detail by two south-west to north-east cross sections (Figure 5).

Figure 5a shows a cross section starting from the area to the immediate south of the proposed open pit through the area proposed for the TMA towards the Hartman Moraine. In the south-western part of the section, where elevations are below 395 masl, the overburden is predominantly clay from surface to bedrock. To the north-west of BH14-07A, where elevations increase above 395 masl, the composition of the overburden begins to show coarsening upward transition from a clay and silt rich sediment to a sand-clay/silt-sand sequence. The sand and silty sand at surface is of variable thickness, but approaches 10 m thickness in places. Beneath this thinner clay and/or silt is largely present, with some occurrence of the basal sand above the bedrock.

Figure 5b shows a cross section starting from the area to the immediate north of the proposed open pit through the area proposed for the WRSA towards the Hartman Moraine. This shows a similar transition from predominantly clay below 395 masl in the south-west to a sand-clay/silt-sand sequence in the northeast. The transition occurs at the cluster of four holes (BH14-17, BH14-18, BH14-19 and BH14-21).

Above 395 masl there are boreholes with no surficial sand that record predominantly clay overburden to the east and west of Blackwater Tributary #2 (BH2A (404 masl) and BH14-02 (408 masl) both at 404 masl to the east of the section line of Figure 5a; and BH1A (404 masl) on the section line of Figure 5b). It would appear that the transition to coarser grained deposits at surface above 395 masl is localized and found mainly in the area around Blackwater Tributary #2.

Although the exact sedimentological interpretation for the purposes of this study is to a degree academic, the transition at 395-400 masl to sand-clay/silt-sand is likely to correspond with a localized change from basinal deposition of fine-grained deposits in Lake Agassiz to coarser grained shore-front/shallow water deposition from a small glaciofluvial fan in front of the Hartman Moraine to the north-east at the edge of the project area. This broadly follows the interpretation of sedimentary history given by Minning et al. (1994). Some of the near-surface sand deposits, particularly those close to Blackwater Tributary #2 (e.g. BH3A) may actually be Holocene deposits of alluvial origin that rework the older Pleistocene glacial deposits.

To the west of the project area seismic studies have been undertaken by the GSC that have detected the occurrence of buried gravel and sand filled channels of up to 60 m thick. One has been located to the north of Dryden (Pullan and Hunter, 1990), and also in Wabigoon Lake to the south of Dryden (Sharpe et al., 1992), both outside of the project area. These type of features are of some potential hydrogeological significance if located close or within the project site. Buried channels are difficult to detect from surface mapping as they often have no topographic expression and are covered with clay. However, within the project area borehole data has not revealed any such features. Given the density of drilling undertaken by Treasury Metals around the project site, the existence of gravel and sand filled buried channels within the immediate vicinity of the proposed open pit, TMA and WRSA can be ruled out with a reasonable degree of certainty.

3.1.2 Regional Bedrock Geology

The Goliath Project is located in the Wabigoon Subprovince of the Archaean Lake Superior Province of north-western Ontario. Much of the bedrock belongs to the Thunder Lake Assemblage comprising upper greenschist to lower amphibolite grade metamorphic rocks formed from a felsic volcanogenic-sedimentary complex. The layering in the metasedimentary rocks dips at about 70-80° to the south-south-east. The southern part of the project site is underlain by the Thunder River Mafic Metavolcanic rocks. The OGS map of the area is shown in Figure 6.

The Wabigoon Fault, a structure of regional geological significance that strikes east-west, is located approximately two to three kilometres to the south of the project site as indicated by the Beakhouse and Pigeon 1:20,000 map. It is conjectured to run to the west along the land between Thunder and Wabigoon Lake. A granitic/granodioritic intrusion occurs along strike from the Wabigoon Fault approximately four kilometres to the south southeast of the project site in the vicinity of Hartman Lake.

3.1.3 Local Bedrock Geology

Within the local area of the proposed open pit three major rock groupings are recognised in the Thunder Lake Assemblage according to ACA Howe (2012):

1. The Hanging-wall Unit comprising quartz ± feldspar-porphyry intrusive rocks and metasedimentary rocks;
2. The Central Unit of approximately 100-150 m true thickness, which comprises intensely deformed and variably altered muscovite-sericite schist (MSS) and biotite-muscovite schist (BMS) with minor metasedimentary rocks; and
3. The Foot-wall Unit comprising predominantly metasedimentary rocks with some porphyritic units and minor felsic gneiss and schist.

These are shown in a schematic cross section in Figure 7. The gold and silver mineralisation is contained within the Central Unit. A detailed description of the mineralisation is provided in ACA Howe (2012) of which a summary is provided here. The mineralisation strikes east-west over a length of 2300m parallel to the main compositional layering. Mineralisation and elevated gold and silver concentrations are mainly associated with highly altered MSS (quartz-sericite alteration). The most extensive mineralisation occurs in the Main Zone, which is up to 30 m thick. Mineralisation above (to the south) and below (to the north) are referred to as the Hanging Wall Zone (H and H1 Subzones) and Foot-wall Zone (B, C and D Subzones). According to Treasury Metals geologists the deformation zone is thought to follow a magnetic anomaly (see Caracle Creek 2008a; Beakhouse and Pigeon, 2003) running from the area between Wabigoon and Thunder Lake east/north-eastwards towards Lola Lake (Figure 6).

Three phases of deformation are recognised in the area (Table 1, Caracle Creek, 2008b). The primary foliation is parallel to the metasedimentary compositional layering steeply dipping to the south-southeast. This is interpreted as being formed during the first (D_1) phase of deformation, which has been characterised as entirely ductile. The second phase of deformation (D_2) is marked by localized deformation of the primary foliation in the form of steeply plunging isoclinal folds, which are associated with much higher silver and gold concentrations. Although predominantly ductile, there are some vein structures associated with this deformation that have been interpreted as indicating the deformation event partly straddling the brittle-ductile transition (Caracle Creek, 2008b). The final phase of deformation (D_3) postdates the main phases of metamorphism and unlike the earlier deformation events is characterized entirely by brittle faulting and fractures filled with quartz, chlorite, feldspar, carbonate and/or gouge. These structures are predominantly small scale structures (e.g. microfaults with displacements on a centimetre scale). The exception is a single northwest striking fault (the NW Fault) that can be correlated between many of the exploration boreholes. The NW Fault is a shallow, north-eastward dipping reverse fault with approximately 5-10m of displacement. Although the strike slip has not been quantified, it appears that the main mineralized zones have not been greatly offset (Caracle Creek, 2008b). The NW Fault is illustrated in Figure 8, which was generated by Treasury Metals from their 3D resource model. It shows the intersection of the NW Fault with the Main Zone of mineralisation.

3.2 Hydrology of the Project Area

The surface water hydrology has been investigated by Klohn Crippen Berger (2012a) and subsequently by DST (2014) as part of baseline studies for the Goliath Project. An overview of the surface water hydrology data is provided in this report as it provides semi-quantitative information on the groundwater discharge (as derived from low-flow creek gauging), which is relevant to estimating the recharge to the groundwater system. The groundwater recharge is one of the important parameters that will determine the zone of influence from groundwater level drawdown caused by mine dewatering.

Environment Canada has operated a number of climate stations in the vicinity of Dryden. Presently Dryden Regional (No. 6032125) is the only the active station. It is located at Dryden Regional Airport approximately 13 km west from the project site with a daily record starting at the end of 2010. There are earlier records for two other inactive stations at Dryden Airport (No. 6032119 and 6032120) with records from 1970 to 2005 and 1999 to 2007 respectively. Based on data from these stations it can be concluded that the project area is characterised by relatively low precipitation; the 1971-2000 climate normal for the Dryden Airport No. 6032119 climate station is 701 mm of which 76% is rainfall. The Hydrological Atlas of Canada (Environment Canada, 1978) estimates the Dryden area experiences around 600 mm/year of lake evaporation and around 500 mm/year of evapotranspiration (potential) with similar lake evaporation estimated at Rawson Lake (No. 6036904) 80 km south-west of the project area. This basic hydrologic data shows that there is limited effective precipitation (precipitation minus evapotranspiration) that will discharge to streams and/or recharge the groundwater system.

As briefly summarised in Section 2.2 the project site is primarily drained by the Blackwater Creek, which flows to the south to Wabigoon Lake. Little Creek and Hoffstrom's Bay Tributary drain the remainder of the project site, but they flow to the west to Thunder Lake. The watersheds of these creeks lie predominantly on fine-grained glaciolacustrine sediments (Figure 4). Other creeks within the project area are Hughes Creek to the east draining to Wabigoon Lake and tributaries from Lola Lake Provincial Nature Reserve to the north draining westwards to Thunder Lake (Thunder Lake Tributary #2 and #3).

Spot gauging has been undertaken by Klohn Crippen Berger (2012a) from the end of 2010 to 2011 and in 2012 onwards by staff from Treasury Metals under guidance from DST (2014). In 2012 DST reviewed all the surface water monitoring stations with gauging on some creeks discontinued (Hughes and McHugh Creek) and other sites replaced or relocated. DST (2014) provides detailed information on the gauging program from 2012 onwards. Table 2 summarises all spot gauging data of creeks undertaken in the project area up to the end of 2013 and Figure 9 shows the spot gauging locations in the project area.

The gauging has been undertaken during relatively dry years. Total precipitation at the Dryden Regional climate station was 369 mm in 2011. This was a very dry year regionally across north-west Ontario. At Blackwater and Little Creek flowing conditions were only recorded during the freshet in 2011; otherwise these two creeks had no flow or not enough flow to allow accurate measurement. This is a clear indication that there are no significant aquifers within the watersheds of these two creeks as otherwise some baseflow could be expected during very dry conditions.

Total precipitation at the Dryden Regional climate station was 598 mm in 2012 and 518 mm in 2013. Although both years are below the 1971-2000 climate normal (701 mm), flows recorded during 2012 and 2013 may be typical of more average conditions. Both in 2012 and 2013 the recorded precipitation as snowfall accounted for less than 15% percent of the total precipitation. Typically snowfall accounts for around 25% or more of total precipitation indicating that snowfall is underestimated at the Dryden Regional station. In both 2012 and 2013 flowing conditions were recorded at all gauging stations when measurements were made. This is consistent with observations from Treasury Metals staff who have observed continuous flow in creeks for most of the time in the project area. Exceptions are Little Creek, which freezes solid in winter and the upper reaches of Blackwater Creek (significantly above gauging station TL1a), which also freeze solid and/or have intermittent flow.

All the gauging stations used since 2012 have had water level loggers installed and the spot gauging data have been used by DST (2014) to determine stage-discharge relationships to generate continuous flow records for ice-free conditions (April – November). Overall moderately correlated stage-discharge curves were generated (DST, 2014). Most of the spot gauging data used for the correlations stem from 2013 and the generated flow records for this year are likely to be the most accurate. No elevation surveys were undertaken between 2012 and 2013; results for 2012 may be less accurate if vertical movement of the gauge had occurred over the 2012/13 winter (DST, 2014).

Table 3 shows the estimated minimum daily flows for 2012 and 2013 based on the daily flow records derived by DST (2014) from stage-discharge curves. Overall there is moderate consistency between the two years for most gauging stations, the main exception being HS6 where the 2012 results are unrealistically high, which is most likely due to changes in elevation of the gauge between 2012 and 2013 (e.g. frost heave). The best estimates of minimum daily flows are expected to come from TL1a, HS5 and HS7, which show the best correspondence at low flows between spot gauging results and the stage-discharge curve (see Figures 3.1 to 3.7 of DST (2014)).

The minimum daily flows provide a quantitative indication of groundwater discharge and by inference also groundwater recharge. Table 3 also shows the minimum daily flows as mm/year (i.e. normalised by the gauge watershed area) for reference, as this is the unit typically used for groundwater recharge. The gauging stations with watershed areas dominated by clay and bedrock knolls (JCTa, HS3 (Blackwater Creek), HS5 (Hoffstrom's Bay Tributary) and HS6 (Little Creek)) have values in the range of 0 – 10 mm/year. The gauging stations with watershed areas dominated by sand at surface (HS4 and HS7 Thunder Lake Tributaries) have values in the range 50 – 100 mm/year. TL1a (the upper reach of Blackwater Creek) also has a relatively high value for 2013; this part of the Blackwater Creek watershed has a higher proportion of sand at surface than the downstream Blackwater Creek gauging stations. However, these differences between 2012 and 2013 may have been caused by beaver activity as Blackwater

Creek is known to have extensive beaver ponds, dams and active lodges (Klohn Crippen Berger, 2012b).

The minimum daily flows derived from the gauging reported by DST (2014) have been used to indicate acceptable ranges for groundwater recharge for the calibration of the groundwater model (Table 8).

4.0 PROJECT AREA HYDROGEOLOGY

Hydrogeological data were collected on the property from spring 2012 to the beginning of 2014. The program of investigation was designed by AMEC, which included selection of:

- existing exploration boreholes for packer testing;
- three new hydrogeology bedrock boreholes for packer testing and installation of two nested vibrating wire piezometers (VWPs) in two boreholes at depth in the bedrock. An additional consideration for location was Treasury Metals' exploration objectives to infill gaps between exploration boreholes;
- packer testing intervals and depths for installing VWPs;
- eight monitoring wells in overburden and shallow bedrock for groundwater quality sampling and groundwater level monitoring;
- nine existing exploration holes for regular water level monitoring.

The packer testing and drilling of shallow monitoring wells was undertaken by TBT Engineering. The VWPs were installed by Treasury Metals staff under instruction from AMEC. Ongoing data collection from installed monitoring wells and piezometers was undertaken by Treasury Metals staff, including collection of groundwater quality samples. In addition to these investigations twenty geotechnical boreholes were drilled in March 2014, which provide additional information on the overburden as discussed in Section 3.1.1.

4.1 Overburden/Shallow Bedrock Hydrogeology

A summary of the overburden geology of the project area is provided in Section 3.1.1. From a hydrogeological perspective, these surficial deposits can be subdivided into the following five units:

1. Clay – fine-grained glaciolacustrine deposits of dominantly clay composition (clay, silty clay, layered clay and silt) occurring in the Glaciolacustrine Plain (Figure 4). They are the dominant overburden deposit at elevations generally below 430 masl and the most common overburden deposit in the project area. They occur to the south of the project site and also to the north of the site within the watershed of the Hoffstrom's Bay Tributary. The clay is expected to act as an aquitard and provide little or no baseflow to creeks (e.g. Little Creek, Hoffstrom's Bay Tributary and the lower reaches of Blackwater Creek, see Section 3.2). The effectiveness of this unit as an aquitard in the project area is expected to increase south-westwards towards the deeper part of the Wabigoon Basin;
2. Basal Sand – a discontinuous sand layer at the base of the clay that when present is on average 3-4 m thick;
3. Bedrock knolls – bedrock exposure or very thin sand. These occur at higher elevations above 395-400 masl and are scattered throughout the Glaciolacustrine Plain (Figure 4);
4. Sand-Clay/Silt-Sand – generally silty sand overlying a largely continuous clay/silt overlying the basal sand. These occur in the north-eastern part of the Glaciolacustrine

Plain above 395-400 masl towards the edge of the Hartman Moraine largely at the top of Blackwater Tributary #2 watershed (Figure 4). The upper sand provides some baseflow to Blackwater Creek (Section 3.2);

5. Sand and Gravel – the coarser glacial deposits within the project area that include the Glaciofluvial Outwash deposits associated with the Hartman Moraine and the Kame deposit south-east of the project site (Figure 4). The Glaciofluvial Outwash deposits provide baseflow to the unnamed tributaries to Thunder Lake (Section 3.2) and are likely to be a reasonable aquifer.

Slug testing of the majority of the groundwater quality wells was conducted by Treasury Metals staff under direction from AMEC in February 2014. Not all the sites were accessible due to snow cover. In total hydraulic conductivity was estimated for five wells of which one was a nested well (BH3A shallow and deep).

Rising-head slug tests were conducted by pumping the groundwater level down to 2 – 6 m below the static groundwater level. Changes in groundwater levels were recorded manually at regular intervals using a standard water level tape. The slug tests were analyzed using the Bouwer and Rice (1976) method. The results of the slug testing are summarized in Table C 1 (Appendix C). Printouts of the analyses using AQTESOLV software (Duffield 2007) are also presented in Appendix C.

The results range between 4.6E-07 m/s and 1.3E-06 m/s with a geometric mean of 9.2E-07 m/s and an arithmetic mean of 9.8E-07 m/s. The majority of wells tested are screened to clay and sand immediately above the contact with the bedrock (as inferred by auger refusal) or straddles the contact of the basal sand with the bedrock. None of the tested wells intercepted significant sand at the contact with the bedrock, the maximum interval tested was 1.5 m of silty sand at BH6A. One of the wells (BH5A) is reported to be screened to clay only, however, this is considered to be anomalous, as much lower hydraulic conductivities would be expected (of the order of 1E-08 m/s is typical for silty clays with clays being 1E-09 m/s or lower; see Freeze and Cherry, 1979).

Overall the majority of values obtained appear to be representative of the overburden bedrock contact when silty sand is present. The values of around 1E-06 m/s are consistent with the range reported by Freeze and Cherry (1979) for silty sand.

It should be noted that higher hydraulic conductivities may be expected if the basal sand comprises coarser grained sand deposits, which is possible where the basal sand is better developed and thicker. At the Rainy River Gold Project, a site with an equivalent Lake Agassiz depositional setting, but a better developed basal sand, it was assessed to have a hydraulic conductivity in the range 1E-06 m/s to 1E-04 m/s, with a best estimate value 5E-05 m/s (see values for Pleistocene Lower Granular Deposits (PLGD) in Tables 3-2 and Table 3-6 from AMEC, 2013a). Relatively high hydraulic conductivities are expected to occur in sand and gravel units located in the kame deposit in the south-east of the project area and in the Glaciofluvial Outwash deposits to the north and north-east.

One of the wells (BH3A shallow) is screened entirely to the near surface silty sand within the watershed of the upper western with an estimated hydraulic conductivity of 7.1E-07 m/s. This is located in the watershed of the Blackwater Tributary #2, where the sand-clay/silt-sand unit occurs. Given the potential finer grained nature of the sand of the upper part of this unit, it may be expected to have a hydraulic conductivity of the order of 1E-06 m/s similar to the basal sand tested within the project area.

4.1.1 Groundwater Flow Directions

Groundwater levels in the groundwater quality wells and also a selection of open exploration boreholes were measured in 2013. Table 4 provides a summary of groundwater level measurements undertaken through 2013 to early 2014. Groundwater levels have also been measured once in the four 2014 geotechnical holes where shallow standpipes have been installed. Water levels measured were consistently within 7 m of ground surface and on average within 3 m of ground surface. Groundwater level fluctuations are typically of the order of 1 to 2 m. Two of the exploration holes measured (TL11155 and TL13320) were flowing intermittently and two of the 2014 geotechnical holes (BH14-11 and BH14-21) had water levels at surface after the 2014 freshet.

Figure 10 shows the groundwater levels measured in July 2013 for all monitoring wells – the exception is the 2014 Geotechnical holes for which 2014 data is plotted. Overall it appears that groundwater levels are relatively close to surface and approximately follow topography. Groundwater flow from the project site follows the surface drainage with flow both to the west towards Thunder Lake and to the south towards Wabigoon Lake. Discharge conditions along Blackwater Creek are indicated by the proximity of holes with flowing conditions (TL11155, TL13320) and the upward vertical gradient shown between BH3A-D and BH3A-S.

4.2 Bedrock Hydrogeology

The local bedrock geology, described in Section 3.1.2, is dominated by an east-west structural trend, which from south to north, and structurally from top to bottom comprises:

- The Hanging-wall Unit;
- The Central Unit, which contains the most highly altered rock types and all the zones of mineralisation, including the Main Zone; and
- The Foot-wall Unit, which lies structurally above the mineralised zones.

The hydrogeological investigation has been planned to assess any systematic patterns in hydrogeological properties across and along this structural trend, specifically:

- Any variation in hydraulic conductivity associated with the mineralised zones (i.e. high degree of deformation and high degree of sericite alteration) within the central unit;
- Any variation in hydraulic conductivity across the footwall and hanging wall unit and notable changes in hydraulic conductivities associated with the NW Fault.

As the proposed open pit trends east-west along the main structural trend, information on the hydrogeology along and across the dominant structural grain is important for the estimation of the drawdown of the proposed open pit. In addition the closest wells outside of Treasury Metals property that are potentially impacted lie along this structural trend on Thunder Lake (Section 2.4).

4.2.1 Historic Information

Historic information on the geology of the site comes mainly from exploration drilling as explained in Section 2.1. However, the latter part of the 1990-1998 exploration program involved the excavation of a trench, construction of portal (Figure 2) and underground workings (Page et al., 1998) that comprised a ramp 275m in length to 35 mbgs and approximately 220 m of lateral drifting along the Main Zone (Page et al., 1998). Information on these excavations are given in the report by Emdin (1998) of which the main details on dewatering and environmental management are provided here, given their relevance to the hydrogeology of the site. Water inflow was reported as minimal in the ramp in general throughout the sampling programme. Few seeps were intersected within the ramp, but most were reported as draining within 24 to 48 hours. One zone of higher inflow was noted in one of the lateral drifts into the Main Zone of mineralisation (MSS). Although there are no pumping records, an indication of the limited pumping is given from site records. Throughout the dewatering period, starting approximately at the beginning of June 1998 and ending the middle of August 1998 there were no discharges made to the surface water environment with all pumped groundwater contained within two settling ponds (each of approximately $20m^2$ area but unknown depth).

Overall, this information, suggests competent rock that does not produce significant amounts of water consistent with normal shield bedrock geology as encountered at other mine sites located in the Lake Superior Province. However, there is some indication from the inflows encountered in the Main Zone, that this may have overall higher hydraulic conductivities than the foot-wall and hanging-wall bedrock.

4.2.2 RQD Data

The RQD is determined from the natural number of breaks per core run expressed as a percentage. Treasury Metals have collected RQD data for just under 300 boreholes based on 3 m core runs totalling over 90 km of borehole length, with individual boreholes ranging from 70 to 900 m in length. The total average RQD of these holes was 88%, which may be described as ‘good core quality’ and ‘very sparsely fractured’ (the quality descriptions for an RQD of 75-90%). The basic statistics of the RQD data are shown in
Table 5 according to depth intervals. This demonstrates a relative uniformity with depth along borehole with average RQD values well above 80%, even for the interval within 50m of top of bedrock, where higher RQDs may be expected due to weathering and/or near-surface fracturing. There is a systematic increase of the RQD with greater depth; at > 400 m down borehole the average RQD exceeds 90% which would be described as ‘excellent core quality’ and ‘unfractured’. As groundwater flow in the bedrock will predominantly occur through

fractures, the broad increase of the RQD data is an indicator that the hydraulic conductivity is likely to decrease with depth. This is broadly supportive of the packer testing data discussed below.

4.2.3 Packer Testing Data

Packer testing has been performed to estimate hydraulic conductivity in the bedrock and at along the east-west structural trend. The packer testing has been undertaken in two ways:

- In existing exploration boreholes with a single packer being moved progressively upwards. For this method, the testing interval gets progressively larger until at the end the full saturated length of the borehole is tested.
- In boreholes drilled in part for hydrogeological purposes with the bottom of the hole tested as the borehole is advanced.

The locations of the packer tested boreholes are shown in Figure 11 together with the mapped mineralized zones and the NW Fault. Summary details of the packer tested boreholes are shown in Table 6.

The results of the packer tests are given in Appendix D and are shown on Figure 12 to Figure 14. Figure 12 and Figure 13 show the results for each borehole separately. These are all formatted to show:

- on the left hand side the packer tests results in a semi-log plot with a vertical scale to either 300 or 600 mbgs depending on borehole depth. The 'whiskers' indicate the packer test interval;
- on the right hand side the RQD and any intersections with the main mineralised zones (Main Zone and C Subzone) and any mapped faults (i.e. the NW Fault).

All the packer test results are combined in Figure 14 for the six boreholes tested.

Packer Testing Results in Existing Exploration Boreholes, April 2012, Figure 12
Packer testing was completed by TBT Engineering under instruction by AMEC between April 18th and April 24th, 2012 in three existing exploration boreholes; from west to east TL10111, TL0855, and TL11195. These are all inclined boreholes that were drilled to the north through the Hanging-wall Unit into the mineralised zones within the Central Unit (Table 6). One of them intersects the NW Fault (TL11195).

Single packer tests were completed at the end of drilling; a packer was progressively raised above the bottom and rising head tests were performed by monitoring the recovery of the water within the packer interval after a brief period of pumping.

Estimated hydraulic conductivities were in the range of 1E-08 to 2E-06 m/s. The range of hydraulic conductivities estimated at TL0855 and TL11195 were narrow; the range at TL0855 was 1.2E-08 to 3E-08 m/s and the range at TL11195 was 1.4E-08 to 2.3E-08 m/s. TL10111 shows a trend of decreasing hydraulic conductivity with increasing test interval from 1.6E-06 m/s at the base of the borehole to 1.6E-08 m/s for the full length of the hole.

The method of testing of these boreholes can mask discrete variations in the hydraulic conductivity as the derived hydraulic conductivity is an average of the estimated test section transmissivity (the direct output of the analysis of the rising head test). The averaging is obviously greater for longer sections. However, as the bottom of the test section is always the end of hole, a 'differential' hydraulic conductivity can be estimated for the non-coincident part of two successive tests of different length. This calculation assumes:

- there is horizontal flow in both test intervals (already an assumption for the estimation of the test interval hydraulic conductivity and transmissivity);
- consequently, the arithmetic mean is a reasonable approximation for up-scaling (or down-scaling) the hydraulic conductivity.

The calculation does not provide physically realistic answers if the shorter test interval has a greater transmissivity than the longer overlapping test interval (it implies a negative differential hydraulic conductivity). This could occur because:

- the basic assumption of horizontal flow does not apply; and/or
- there is compound error associated with the uncertainties of the results of the two separate tests used for the calculation of the differential hydraulic conductivity.

The latter is more likely for lower values of hydraulic conductivity as the rising head testing methodology using a packer installation has limited accuracy at hydraulic conductivities much lower than 1E-08 m/s (see Beauheim et al., 2007 for an overview packer testing methodologies for low permeability testing). It has been assumed that the non-coincident part of two successive tests has a very low hydraulic conductivity (~1E-09 m/s) when the shorter test interval has a greater transmissivity than the longer test interval.

The differential hydraulic conductivities are plotted in Figure 12 as a grey dashed line. The following conclusions are drawn for the results of the individual boreholes:

- At TL11195 there appears to be no significant intervals with hydraulic conductivities much greater than 1E-08 m/s. However, elevated hydraulic conductivities associated with the NW Fault and the Central Unit cannot be fully ruled out as these all occur towards the base of the borehole and are included within even the shortest test interval. During the testing of this borehole gas discharge was noted with rotten egg odour indicating hydrogen sulphide, which is normally generated in groundwater from sulphate under reducing conditions. This requires a source of sulphur, which is present in the mineralised zones of the central unit or could be introduced to the borehole via the NW Fault, which also intercepts the mineralized zones. In both cases it indicates some active groundwater flow at depth, possibly associated with the mineralised zones in the Central Unit;

- At TL0855 there is some indication of higher hydraulic conductivities around 1E-07 m/s above 150 mbgs. Otherwise hydraulic conductivities are around 1E-08 m/s;
- At TL10111 there are elevated hydraulic conductivities (~1E-06 m/s) in the Central Unit, just beneath the Main Zone. The calculation of the differential hydraulic conductivity emphasizes that this discrete location is the main inflow zone for this particular borehole; outside this inflow hydraulic conductivities are at least an order of magnitude lower.

The main conclusion from the initial testing of existing exploration was the indication that more permeable zones (up to around 1E-06 m/s) are present in the Central Unit. The anecdotal information from the construction of the portal also indicates groundwater flow occurring associated with the mineralized zones (Section 4.2.1). Further hydraulic testing was undertaken to assess any trends along the main east-west structural trend associated with the mineralised zones, as detailed below.

Packer Testing Results in New Hydrogeology Boreholes, February 2013, Figure 13

Packer testing was completed by TBT Engineering under instruction by AMEC between February 7th and February 18th, 2013 in three hydrogeological boreholes; from west to east TL13321, TL13315, and TL13317. TL13321 is located at the western end of the mineralised zone and has been drilled inclined to the northwest through the Hanging-wall and Central Units into the Foot-wall Unit. TL13315 was drilled inclined to the south through the Foot-wall into the Central Unit, whereas TL13317 was drilled inclined to the north through the Hanging-wall Unit into the Central Unit.

Single packer tests were completed as drilling progressed; the test interval was delimited by the packer at the top of the interval and the end of drilling at the bottom of the interval. Packer testing of these holes was completed between the 7th and 18th of February, 2013. Test intervals were usually 30 – 40 m in length. Most tests consisted of rising head tests where the recovery to static water level conditions was observed after a brief period of pumping within the test interval. One constant head test was completed at TL13321 between 18 and 27 mbgs because groundwater was not encountered in the test interval. This was done by maintaining a constant head within the test interval then measuring the flow out of the hole for a set period of time, and repeating the test by consecutively increasing the applied head and then decreasing it.

Recorded hydraulic conductivities were in the range of 1E-08 to 1E-06 m/s. Hydraulic conductivities of the bedrock are higher near the surface (1E-06 m/s) and generally decrease with depth (1E-08 m/s towards 300 mbgs). The intersections with the mineralized zones may produce higher hydraulic conductivities. At TL13315 values of approximately 1E-07 m/s were estimated at 225 – 255 mbgs at an intersection with the C Subzone, which is relatively high given depth below surface. Elevated hydraulic conductivities also occur in TL13317 at 168 – 210 mbgs where values are close to 1E-07 m/s at the intersection with the Main Zone. Otherwise test results coincident with the mineralized zones do not depart greatly from the general trend of decreasing hydraulic conductivity with depth. At TL13321 the hydraulic conductivity with depth is more typical; however, here the intersection with the mineralized zones is close to surface where higher hydraulic conductivities may be expected.

Combined Packer Testing Results, Figure 14
The combined test results show a trend of decreasing hydraulic conductivity with depth. The follow categories can be identified:

- Shallow bedrock close to surface that has a hydraulic conductivity of around 1E-06 m/s that is likely associated with near-surface weathering and fracturing;
- Intermediate bedrock where the hydraulic conductivity decreases from 1E-07 to 1E-08 towards a depth of 400 mbgs (i.e. approximately 0 masl). This depth is chosen with reference to the RQD data where this is consistently greater than 90%.

The main exceptions are within the Central Unit, where in some boreholes (TL13315 and TL10111 in particular) there are elevated values of hydraulic conductivity in close proximity or at intersections with mineralized zones as discussed above. These hydraulic conductivities, combined with other anecdotal data, suggest the Central Unit hydraulic conductivities may be around half an order to an order of magnitude higher than the Foot-wall and Hanging-wall Unit at the typical test interval used in this study.

4.2.4 Vibrating Wire Piezometer Installation

Vibrating wire piezometers (VWPs) have been installed in two of the three boreholes (TL131117 and TL131121) that were drilled for hydrogeological purposes. The piezometers were installed using the fully grouted methodology (Mikkelsen & Green, 2003). In each of these boreholes two vibrating wire piezometers have been installed:

- One shallow piezometer at around 60 mbgs;
- One deep piezometer within or below the Central Unit.

These piezometers were installed to assess to presence of vertical head gradients across the Central Unit. The full details of these VWP installations are given in Table 7 and locations of the boreholes with VWPs are shown in Figure 11. Groundwater pressures have been measured at these piezometers since their installation in February 2013 through 2013. All piezometers show a maximum after the freshet of followed by a gradual decline of 1 to 1.5 m towards the winter of 2013/14. Table 7 shows the maximum and minimum heads measured during the monitoring period. Both sets of nested piezometers show downward vertical gradients, which is consistent with the location of the project being on high ground relatively remote from a groundwater discharge area. However, the head differences can be considered as relatively small (i.e. not greatly departing from hydrostatic) given the vertical separation of the piezometers of over 100 m. The change from recharge to discharge conditions occurs over relatively short distances (hundreds of metres) as indicated by the proximity of the flowing exploration holes (TL11155 and TL13320) nearby to TL13117.

4.3 Groundwater Quality Data

Groundwater sampling was completed on six occasions during 2013 by Treasury Metals from the 2013 groundwater quality wells. The wells are screened predominantly to the basal sand and/or shallow bedrock (Table 4). The results of the sampling of these monitoring wells for the time period is summarised in Appendix E. In general it was found that the groundwater comprised typical calcium-magnesium-bicarbonate type water. The dissolved metal concentrations from field filtered samples have been taken and compared to the Provincial Water Quality Objectives (PWQO).

The following dissolved metal concentrations were noted to exceed or meet the Ontario Provincial Water Quality Objectives (PWQO) for the Protection of Aquatic Life at one or more of the eight monitoring wells that were sampled on one or more sampling occasion: aluminum (three sites), chromium (two sites), cobalt (six sites), copper (two sites), iron (six sites), tungsten (one site), vanadium (two sites) and zinc (two sites). It should be noted that groundwater cannot be directly compared to the PWQO, but the objectives can nevertheless be used for description purposes. Groundwater was also found to exceed the Canadian Environmental Quality Guidelines (CEQG) for the protection of aquatic freshwater life for similar metals including: aluminum (three sites), chromium (two sites), copper (three sites), iron (six sites) and zinc (two sites).

4.4 Conceptual Model of Groundwater Flow

The hydrogeology of the proposed Goliath mine has been based on the overburden and rock characteristics and the data obtained from a hydrogeological investigation undertaken primarily during the period 2012 to 2013. This information suggests that the groundwater regime has limited groundwater flow that provides minimal baseflow to creeks in the immediate vicinity of the project site and for much of the project area.

Five hydrostratigraphic units have been identified that are key to explaining: the groundwater – surface water interaction in the watershed within the project area and shallow groundwater flow patterns:

1. Clay – fine-grained glaciolacustrine deposits of dominantly clay composition (clay, silty clay, layered clay and silt) located around the project site and dominating the southern part of the project area. This is an aquitard providing little or no flow to creeks rising on it. The effectiveness of this aquitard is expected increase towards the south-west where the Wabigoon basin deepens;
2. Basal Sand – a relatively thin discontinuous sand layer at the base of the clay that is on average 3-4 m thick, when present. This is a minor aquifer that has limited groundwater flow with a hydraulic conductivity around 1E-06 m/s;
3. Bedrock knolls – bedrock exposure or very thin sand;
4. Sand-Clay/Silt-Sand – generally silty sand overlying a largely continuous clay/silt overlying the basal sand. These occur in the north-western part of the Blackwater Creek Watershed (top of Blackwater Tributary #2). The upper sand provides some baseflow to

Blackwater Creek (Section 3.2) and is expected to have a similar hydraulic conductivity as the basal sand;

5. Sand and Gravel – coarser glacial deposits located mainly on the northern to north-eastern edge of the project area. These are the only reasonable aquifer present within the project area providing baseflow to the unnamed tributaries to Thunder Lake (Section 3.2).

Most of the groundwater flow that occurs around the projects site is expected to follow the topography with greatest flows along the contact between the upper weathered and fractured bedrock and the basal sand. Rates of groundwater flow are expected to be much lower in the deeper bedrock. The following four hydrostratigraphic units have been identified for the bedrock:

1. Shallow Bedrock – this is expected to occur within 10 m of the bedrock surface where the bulk hydraulic conductivity may approach 1E-06 m/s due to near-surface weathering and fracturing. Where shallow bedrock occurs at surface, these have been referred to as bedrock knolls;
2. Intermediate Bedrock – this refers to bedrock from approximately 10 mbgs to a depth of around 400 mbgs (~ 0 masl) where the bulk hydraulic conductivity drops from around 1E-07 m/s to 1E-08 m/s;
3. Deep Bedrock – this refers to bedrock where there are very few fractures (RQD > 90%) and very low hydraulic conductivities are expected (of the order of 1E-09 m/s), which is expected to occur below 400 mbgs (~ 0 masl);
4. Deformation Zone of the Central Unit – this is a steeply inclined zone that occurs in all three of the above units. It is expected to have half to one order of magnitude higher conductivities in the units not affected by near-surface weathering (i.e. intermediate and deep bedrock).

These aspects of the conceptual hydrogeological model have been used to build a numerical model to estimate groundwater inflows to the mine, its zone of influence, baseflow depletion at sensitive creeks and leakage from TMA and WRSA to groundwater and the potential location of discharge of this water as discussed in Section 5.0.

5.0 NUMERICAL GROUNDWATER MODEL OF THE PROJECT AREA

A numerical three-dimensional steady-state groundwater flow model was developed and used to estimate:

- seepage rates into the proposed open pit and underground mine workings at the Goliath mine site;
- ZOI/drawdown created by the mine dewatering; and
- leakage to groundwater from the TMA and WRSA as well as their potential groundwater pathways.

The Modular Finite-Difference Groundwater Flow Model (MODFLOW) originally developed by McDonald and Harbaugh (1988) for the United States Geological Survey (USGS) was used to simulate groundwater flow in the project area. MODFLOW is a groundwater flow simulator that has been accepted by regulatory agencies and used extensively for a variety of applications. It allows the simulation of steady state and transient flow regimes in both two and three dimensions. A detailed description of MODFLOW is provided in the software package manual (McDonald and Harbaugh, 1988).

Steady-state groundwater flow models were developed for the pre-mining (i.e. existing), fully mined and post-closure conditions. The model corresponding to the existing conditions was calibrated to observed groundwater water levels and baseflow contribution to some of the creeks. The calibrated model was then used to predict the seepage into the fully open pit and underground mine workings.

The developed model was used to simulate groundwater flow in both the overburden and bedrock aquifer zones. Although MODFLOW was primarily developed to simulate flow in porous media it is often used for groundwater flow modelling in fractured rocks if they behave as equivalent porous media at the scale of study. This assumption was utilized in the present study.

A fully integrated pre- and post-processor, Visual MODFLOW (Version 4.6) developed by Schlumberger Water Services (SWS, 2011), was used to assemble the input data for the project area groundwater flow model and to present the MODFLOW output results. Simulations were conducted by using the MODFLOW-NWT version of MODFLOW (Niswonger et. al., 2011).

5.1 Model Domain, Numerical Grid and Boundary Conditions

The conceptual model of the project site and overall project area is summarised in Section 4.4. The hydrostratigraphy as described in that section has been applied to the developed numerical groundwater flow model. However, in applying the conceptual model and its hydrostratigraphy a certain number of assumptions and/or simplifications were required in order to construct the model given the inherent limitations and associated uncertainty in subsurface geologic and hydrogeologic data, which are outlined further below.

The following hydrostratigraphic units as identified in Section 4.4 were simulated by the groundwater flow model:

- Clay;
- Basal Sand;
- Sand-Clay/Silt-Sand;
- Sand and Gravel;
- Shallow Bedrock;
- Intermediate Bedrock; and
- Deep Bedrock

It should be noted that in applying these hydrostratigraphic units the model was constructed in the following way:

- Where the surficial Clay is absent it is replaced by Sand and Gravel (Kame and Glaciofluvial Outwash) or bedrock outcrop (bedrock knolls);
- The Sand-Clay/Silt-Sand unit is simulated as two layers. The upper layer represents sand above clay/silt and has a horizontal hydraulic conductivity the same as the Basal Sand unit and a vertical hydraulic conductivity the same as the Clay unit. The lower layer is treated the same as the Basal Sand unit.

The overburden unit contact elevations for the groundwater model have been derived from the geological data available as summarised in Section 3.1.1. The bedrock unit surface elevations are based on data available from the hydrogeological and geomechanical investigations as discussed in Section 4.2 as well as information from the Treasury Metals' 3D resource model.

The deformation zone of the Central Unit, coinciding in the project area with the Main Zone and C subzone (Figure 11) was simulated as a bedrock zone with increased hydraulic conductivity, compared with the surrounding country rock. The deformation zone was assumed to extend north-east and further west, towards Thunder Lake, from the project site, based on the aeromagnetic anomalies mapped by Caracle Creek (2008a) and Beakhouse and Pigeon (2003), as discussed in Section 3.1.3.

The regional-scale Wabigoon fault (Figure 6) was assumed to act as discrete vertical feature with lower hydraulic conductivity reducing groundwater flow in bedrock across the fault.[1]

5.1.1 Model Domain and Numerical Grid

The selected model domain for the groundwater flow model developed for the Goliath Project is shown in Figure 15. All model domain boundaries, with the exception of the south/south-western one, coincide with inferred groundwater divides associated with topographic

[1] The effect on the groundwater inflows and ZOI was assessed with (Base Case) and without the Wabigoon Fault as part of the sensitivity analysis in Section 5.3.1.

watersheds. The south/south-western boundary is established through the middle of Wabigoon Lake.

Outside of the Thunder and Wabigoon Lake areas the top of the model domain was set as the ground surface, interpreted from the available LiDAR (close to the mine site) and Ontario Base Mapping data. Within the Thunder and Wabigoon Lake areas the model top was set at the lakes' bottom obtained from bathymetry data for the Thunder and Wabigoon Lakes published by the MNR.

The total number of model layers is 37. Model layer 1 corresponds to the Clay, Sand and Gravel, the upper layer of the Sand-Clay/Silt Sand unit or bedrock knoll, depending on the surficial geology. Model layer 2 corresponds to the Basal Sand unit in the areas where it is expected to be thicker than 0.3 m.

Model layer 3 corresponds to the weathered Shallow Bedrock unit. This zone was assumed to have a uniform thickness of 7 m. Model layers 4 to 22 correspond to the Intermediate Bedrock. Model layers 23 to 37 correspond to the Deep Bedrock. A significant number of model layers in the bedrock was required to simulate the dipping Central Unit deformation zone, the proposed open pit and underground mine workings.

Figure 16 shows a representative model south-north cross section drawn through the area of the proposed open pit. It also shows the Central Unit deformation zone striking east-west and dipping to the south-south-east at about 70-80°. The deformation zone was the only permeable geologic structure directly simulated in the Base Case of the groundwater flow model.

The model horizontal grid spacing varies from 15 m close to the mine, to about 100 m, close to the model domain boundary.

5.1.2 Boundary Conditions

Thunder Lake and Wabigoon Lake are represented by the constant head nodes with the elevations of 373.5 m and 369 m, respectively (Section 2.2). Smaller lakes, wetlands (including those of the Lola Lake Provincial Park) and creeks are represented by MODFLOW 'river' and 'drain' nodes. MODFLOW drain nodes were also used to simulate groundwater seepage into the proposed open pit and underground mine workings. The Wabigoon fault was simulated by using a horizontal flow barrier package of MODFLOW.

5.1.3 Model Input Parameters

Input parameters (hydraulic conductivities and recharge rates) assigned to the various overburden and bedrock hydrostratigraphic units for the so-called calibrated or Base Case scenario are summarized in Table 8. Figure 14 shows the model hydraulic conductivity profile with depth for the bedrock units and the deformation zone of the Central Unit. The parameters shown in Table 8 were varied within the framework of the model sensitivity analysis.

5.2 Model Calibration

Calibration of a groundwater flow model refers to a demonstration that the model is capable of reproducing field measured heads and flows – the so-called calibration values (Anderson and Woessner, 1992). Calibration of the model was achieved by adjusting the physical and hydraulic parameters (hydraulic conductivity and recharge in this case) in order to obtain a reasonable match between computed and observed (measured) data.

The Goliath Project groundwater flow model was calibrated to the following pre-mining data:

- groundwater levels observed in the nine 2013 groundwater quality monitoring wells (BH1A, BH2A, BH3A (shallow and deep), BH4A, BH5A, BH6D, BH7A and BH8A) for July 2013;
- Groundwater levels measured in nine exploration holes (TL10104, TL11125, TL11142, TL11154, TL11155, TL11196, TL13320, TL13336 and TL220) for July 2013;
- Groundwater heads measured in two nested vibrating wire piezometers (TL13117 and TL13121) for July 2013; and
- minimum daily flow data for TL1a, HS7 and HS5 gauging stations for 2012 and 2013.

It should be noted that:

- the groundwater levels used for the model calibration represent an 'typical' groundwater level based on measurements taken (Table 4);
- minimum daily flow data, as discussed in Section 3.2, was used as a proxy for groundwater/baseflow contribution to the creeks;
- the model was calibrated to the gauging stations that showed reasonable stage discharge relationships for low flows (Section 3.2). Stream flow data obtained at other surface water gauging stations was not utilized for model calibration as their stage discharge relationships appear less reliable for low flows;
- groundwater levels obtained from the four standpipes in BH14-03, BH14-05, BH14-11 and BH14-21 were not utilized for model calibration since they correspond to a spring freshet monitoring event. However, the water levels, measured in these wells, were compared with the computed ones, obtained by the calibrated model.

The model computed hydraulic heads show relatively good agreement with groundwater levels obtained for the 22 calibration wells/holes (Figure 17). The overall residual mean is 0.29 m, the absolute mean is 2.41 m and the correlation coefficient is 0.82. The ratio of the root mean squared error (2.78 m) to the total head loss (or water table relief) in the area of interest is about 14%.

The differences between computed and observed water levels in BH14-03, BH14-05, BH14-11 and BH14-21 are similar to those reported for the 21 calibration wells/holes, i.e. residual mean and absolute mean errors at the locations of these four boreholes are 0.76 m and 1.54 m, respectively.

Figure 18 shows the computed and inferred groundwater elevation contours for in the Basal Sand/Shallow Bedrock units, corresponding to the current, pre-mining conditions. Despite some local discrepancies between contours shown in this figure, the model replicates properly the inferred potentiometric surface and groundwater flow system in these hydrostratigraphic units.

Figure 19 shows comparison between computed groundwater contribution and minimum daily flow data for TL1A, HS7 and HS5 surface water hydrometric stations. Given significant stream flow data scatter and uncertainty in the derivation of the groundwater discharge from field measurements, the model predicted groundwater flow discharge rates appear to be consistent with the available data.

5.3 Predictive Groundwater Model Simulations

The groundwater flow model described above was used to estimate:

- seepage rates into the proposed fully dewatered open pit and underground mine workings;
- the ZOI/drawdown, in the shallow bedrock unit, associated with the fully dewatered open pit and underground mine workings; and
- potential inputs to the groundwater flow system from proposed TMA under the mine post-closure condition (i.e. flooded mine).

The dewatered open pit and underground mine workings corresponding to the ultimate mine development were simulated using the data provided by Treasury Metals. Figure 2 shows the proposed open pit and underground mine workings in plan view. Groundwater seepage into the fully dewatered open pit and underground mine workings was simulated by using MODFLOW “drain” nodes (McDonald and Harbaugh, 1988). Drain elevations were specified at the elevation of cells’ centroids. The cells located within the interior of the dewatered open pit were modeled as inactive, since seepage is expected to occur at the contact with the surrounding rock mass only. Conductance of the MODFLOW drain nodes, representing seepage faces, was specified as being two orders of magnitude higher than the transmissivity of the corresponding numerical cell(s) since the utilized grid spacing did not exceed the dimensions of the majority of the simulated openings by more than a factor of three (Zaidel et al., 2010).

Simulating the mine post-closure condition, it was assumed that the water level in the open pit and underground mine workings will be maintained at an elevation of 391 masl, controlled by an outflow from the open pit to a reach of the Blackwater Creek. The “general-head” nodes of MODFLOW (McDonald and Harbaugh, 1988) with an elevation of 418 masl were prescribed within the TMA to simulate its water cover for the post-closure condition (i.e. 2m below the design elevation of the dam crest at 420 masl). The hydraulic conductivity of the tailings was set at 1E-07 m/s. The proposed run-off and seepage collection ditches, assumed to be 1 m wide and 1 m deep, surrounding the TMA were simulated by using the MODLOW “drain” nodes.

The water level in the water management pond, located close to the south-west corner of TMA, was specified at the elevation of 397 masl.

Potential interaction between the WRSA and the groundwater flow under the post-closure condition was simulated by applying a relatively high recharge rate of 150 mm/year over the proposed WRSA. The hydraulic conductivity of waste rock was set at 1E-03 m/s.

5.3.1 Predicted Long-term Seepage Rates into the Open Pit and Underground Mine Workings

Long-term seepage rates into the proposed open pit and underground mine workings were simulated using a steady-state groundwater flow model corresponding to the fully developed and dewatered mine. Under the Base Case scenario, the stabilized seepage rates into the proposed fully dewatered mine (i.e. open pit and underground mine workings) were estimated to be about 1,320 m^3/d (Table 9).

In addition to the Base Case input parameters, presented in Table 8, the groundwater flow model was also run with other sets of input data as part of the predictive sensitivity analysis. The main purpose of this analysis was to evaluate the influence of uncertainty in the input parameters on the model predictions. The conducted sensitivity analysis demonstrates that the model predicted seepage rate into the proposed fully dewatered mine is expected to be within a range of about 1,000 m^3/d to 1,900 m^3/d (Table 9).

Results presented in Table 9 show that predicted seepage rates are primarily sensitive to the specified hydraulic conductivities of the intermediate, deformation and shallow bedrock zones. The seepage rate will also be dependent on climatic conditions with lower seepage occurring during dry years and higher seepage during wet years.

5.3.2 Predicted ZOI in the Basal Sand and Shallow Bedrock Units

Figure 20 shows model predicted drawdown in basal sand/shallow bedrock, caused by the dewatering of the fully developed open pit and underground mine workings for the Base Case scenario. Figure 21 shows the model predicted ZOIs for all the simulated scenarios (Table 9), defined by a 1 m drawdown contour in basal sand/shallow bedrock. According to the results presented in this figure, ZOIs are predicted to extend over a distance of about 2.5 km to the west, up to 3.5 km to the south, 2 km to the north and 1.5 km to the east from the proposed Goliath mine. The extent of drawdown is largely due to the confined response caused by the extensive clay, particularly to the south and west. As this unit is expected to behave as an aquitard, it will limit the amount of buffering of the extent of the ZOI by recharge boundaries and/or sources.

Results presented in Figure 21 show that predicted ZOIs are primarily sensitive to the specified hydraulic conductivities of the intermediate bedrock zone, the deformation zone and clay in the low lying areas close to/underneath Thunder and Wabigoon Lakes. Increasing the hydraulic conductivity of the clay has the greatest influence on the extent of the ZOI as shown by variant 7 where the ZOI is reduced due to greater leakage drawn from the lakes.

Note that the developed model does not account for the possibility of additional induced recharge, associated with depressed water table under pumping/dewatering conditions. Therefore, model predicted ZOIs, are expected to be conservative.

5.3.3 Predicted Effects of Mine Dewatering on the Local Privately Owned Water Wells

A total of 77 wells fall within the ZOI as defined by the 1 m drawdown contour (the envelope of all sensitivity runs), following the quality assurance checks undertaken on the well locations as described in Section 2.4. All these wells have some potential to be affected by groundwater drawdown associated with mine dewatering. However, the degree to which these wells may suffer an impact in terms of their ability to supply water at the requisite rate will depend on a number of factors:

- The main hydrogeological unit from which the groundwater is sourced;
- The depth of the well compared to static water level, specific capacity of well and pump intake depth;
- The magnitude of drawdown;
- The local hydrogeological setting of the well, specifically the proximity and connection to recharge boundaries and/or sources.

The risk of impact will vary with many wells having low or very low risk of a deleterious effect on the performance of the well. A preliminary qualitative risk analysis is provided here based on the magnitude of drawdown using the 5 m Base Case drawdown contour (Figure 21). There are 55 wells outside the 5 m drawdown contour, which broadly fall into two groups that are both potentially mitigated due to their proximity to a recharge boundary/source:

1. A western group located by Thunder Creek – Thunder Creek is a significant water course and has the potential to be in direct hydraulic contact with the bedrock and/or basal sand;
2. A southern group around Wabigoon – this is located close to the Kame sand and gravel deposit, which is expected to provide significant recharge to the bedrock.

Within the 5 m contour there are 22 records of wells; five of these are within the property boundary of Treasury Metals. Seventeen are located along the shore of Thunder Lake to the east of Thunder Creek. Of these seventeen, five have depths of greater than 30m and are likely to source groundwater from intermediate bedrock; these have lower potential for impact depending on their specific capacity and pump intake depth.

The remaining twelve wells recorded have depths shallower than 25m. These wells predominantly source groundwater from the basal sand and shallow bedrock and consequently have a moderate to high risk of being impacted by mine dewatering.

5.3.4 Predicted Effects of Mine Dewatering on the Groundwater Discharge into Surface Water Features

Modelling results show that due the Goliath mine dewatering annual average groundwater discharge into the Thunder Lake Tributary #2 and #3 (entire watershed from Thunder Lake) can be potentially reduced by about 150 m^3/d (Base Case). According to DST (2014), the minimum daily flow in this tributary at the flow stations is in the range of 30 – 40 L/s or approximately 2,600 – 3500 m^3/d (see combined results for gauging stations HS4 and HS7 in Table 3). Therefore, the model predicted reduction of the baseflow contribution to these creeks constitutes about 4 – 6% of the gauged minimum flows as reported in Table 3. Note that this flow reduction could be even smaller since the flow in Thunder Lake Tributary #2 and #3 at the confluence with Thunder Lake is expected to be somewhat higher than recorded at the hydrometric stations HS7 and HS4. Reduction of the baseflow contribution to Hughes Creek is predicted to be less than 1%.

All the creeks close to the proposed open pit are runoff dominated creeks with watersheds that sit predominantly on clay. These creeks are a lot less sensitive to mine dewatering. Little Creek and Hoffstrom's Bay Tributary fall into this category and have very little baseflow; any baseflow reduction of these creeks caused by mine dewatering is likely to be well below the detection limits of any hydrological monitoring techniques. Blackwater Creek has more baseflow. Nevertheless under very dry periods (such as 2011) flow ceases in this creek, particularly in the upper reaches. Ignoring any mine discharges, it would be expected that periods of no-flow in Blackwater Creek would occur with greater frequency due to mine dewatering. However, the loss of baseflow would be greatly exceeded by the mine discharges (mine dewatering, TMA) that will occur into this creek.

5.3.5 Predicted Leakage from the TMA and WRSA

The leakage from the TMA and the WRSA has been simulated for two site conditions:

1. Under uncapped conditions for the TMA and WRSA when these are at their maximum capacity;
2. Under post-closure conditions when both the TMA and WRSA have been capped to reduce infiltration.

These two conditions are discussed in the following two subsections. For both conditions pathlines were obtained by using a particle tracking code MODPATH (Pollock, 1994), linked to MODFLOW. MODPATH is used to calculate advective transport directions in groundwater and similar to MODFLOW is widely accepted by regulatory agencies.

Uncapped Conditions

Leakage to groundwater from the uncapped TMA at full capacity has been simulated using two configurations of seepage collection ditches in the Base Case model:

a. ditches surrounding the TMA along all sides; and
b. ditches surrounding the TMA along its downstream sides only (east, west and south).

In both cases there is a tailings water management pond on the south-western side of the TMA.

During mine operation under dewatered conditions it would be expected that most groundwater bypassing the TMA drainage ditches would be captured by the drawdown cone created by dewatering of the open pit and flow towards the pit. On completion of mining and cessation of dewatering, recovery would start to occur with movement of flow paths away from the open pit towards other water features. The predictive simulations for the uncapped TMA at full capacity have been undertaken with the mine workings fully flooded and recovered groundwater levels. The fully flooded simulation minimizes capture by the open pit with more leakage from the TMA or WRSA flowing towards neighbouring water bodies. This is a very conservative condition that is extremely unlikely to occur as complete recovery of the groundwater levels would be expected to take much longer than the completion of the capping of both the TMA and WRSA with the closure of the mine.

Under the Base Case, the majority of the flow (about 70% – 90%) coming of the tailings pond is predicted to occur as near-surface horizontal groundwater flow that is captured by the seepage collection ditches and the tailings water management pond located on the south-western side of the TMA. According to the conducted flow budget analysis about 200 m^3/d to 500 m^3/d is predicted to be leaking out of the base of the TMA with the water cover maintained at a final elevation of 418 masl (Table 10). The remaining 10% to 30%, or about 70 m^3/d to 90 m^3/d, is predicted to bypass the ditches, migrating underneath them (Figure 22).

Figure 22 shows pathlines originating in the TMA under the Base Case scenario that by pass the perimeter ditches, corresponding to the uncapped TMA at full capacity, but assuming flooded mine workings. A small amount of the leakage bypassing the drains is predicted to be captured by the flooded open pit (around 10 m^3/d). Blackwater Creek is predicted to be the main recipient of TMA leakage bypassing the drainage ditches, receiving around 10 to 15% of the water coming of the tailings (around 50 m^3/d). Other receivers of TMA leakage bypassing the drainage ditches are Hoffstrom's Bay Tributary, Thunder Lake Tributary #3 and Thunder Lake/Thunder Creek (Figure 22) with rates of around 10 m^3/d or lower for each of these water bodies.

The WRSA is located to the north of the open pit. Taking into account that this infiltration rate is expected to be in the order of 100 mm/yr to 200 mm/yr, seepage out of the uncapped WRSA is estimated to be within the range of 100 m^3/d to 200 m^3/d. Under the Base Case scenario about 75% of seepage coming out of the uncapped WRSA is expected to end up in the flooded open pit, while the remaining 25% is expected to be captured primarily by Thunder Lake (Figure 23). The flooded open pit is predicted to overflow and discharge to Blackwater Creek via Blackwater Tributary #1.

Closure Conditions with Cap

Closure conditions at the proposed Goliath Mine have been simulated with the groundwater flow model where the TMA and WRSA have a cap installed over both facilities to reduce infiltration. In addition, the TMA was simulated without seepage collection drainage ditches and associated tailings water management pond. The cap of the TMA and WRSA was assumed to have the following 5 layers all having 1% slope (from top to bottom):

1. top soil/organics (0.15m)
2. protective layer of soil (1.2m);
3. drainage layer (0.3m);
4. clay layer (0.5m); and
5. foundation layer (0.3m).

The cap layers described above were not simulated directly by the regional-scale groundwater flow model. However, they were used to estimate the corresponding groundwater recharge rate associated with the infiltration rate through the proposed cap. Assuming the hydraulic conductivity of the clay layer is 1E-09 m/s and unit hydraulic gradient across the clay, results in an infiltration rate of about 30 mm per annum. A similar infiltration rate through the barrier was obtained by using the US EPA HELP model (US EPA, 1995a,b) when the drainage layer was simulated as being constructed with gravel having a saturated hydraulic conductivity of 1E-03 m/s.

Figure 24 shows pathlines originating in the TMA under the Base Case scenario, corresponding to the capped conditions of the TMA and fully flooded mine workings. For this scenario around 50 m^3/d is predicted to be leaking out of the base of the TMA of which around 60% (about 30 m^3/d) is predicted to discharge to Blackwater Creek. Around 20% (about 10 m^3/d) is predicted to discharge in the flooded open pit and to Hoffstrom's Bay Creek, with the remainder discharging at much lower rates to Thunder Lake Tributary #3 and Thunder Lake.

Figure 25 shows pathlines originating in the WRSA under the Base Case scenario, corresponding to the capped conditions of the WRSA and fully flooded mine workings. For this scenario around 30 m^3/d is predicted to leak out of the base of the WRSA with approximately two thirds discharging to the flooded open pit and the remainder discharging to Thunder Lake. Similar to previous scenarios, the flooded open pit is predicted to overflow and discharge to Blackwater Creek via Blackwater Tributary #1.

6.0 SUMMARY OF ANTICIPATED GROUNDWATER EFFECTS

A program of hydrogeological investigation has been undertaken by AMEC from mid 2012 to early 2014 on behalf Treasury Metals. This has comprised design of field programs and provision of guidance to Treasury Metals for carrying out fieldwork. The data collected has been used to construct a calibrated numerical groundwater flow model of the project area, which model has been used to predict groundwater effects related to mine dewatering and management and surface management of waste rock and tailings. The predicted effects are summarised below.

Predicted Effects on Dewatering of Wells

In total 77 wells as recorded on the MOE WWIS are located within the ZOI as defined by the predicted 1 m drawdown contour. A preliminary qualitative risk assessment has been undertaken for these 77 wells with the following results:

- twelve wells within the 5 m Base Case drawdown contour located on the Thunder Lake shore to the east of Thunder lake have moderate to high risk of dewatering. These are relatively shallow wells (< 25 m) that likely source most of their water from the basal sand and shallow bedrock;
- five wells within the 5 m Base Case drawdown contour also located on Thunder Lake shore have low risk of dewatering. These are deeper wells (> 30 m) that likely source the majority of their water from deeper bedrock;
- 55 wells outside of the 5 m Base Case drawdown contour are assessed to have low risk of dewatering due to their proximity and likely good hydraulic connection with a recharge boundary and/or recharge source.

The five remaining wells within the 1 m ZOI are within the property boundaries of Treasury Metals.

Predicted Effects on Groundwater Discharge to Surface Water

Little Creek and Hoffstrom's Bay Tributary are located on clay overburden and have very limited baseflow. These creeks will not be affected by mine dewatering. Blackwater Creek is also predominantly on clay overburden and similarly has limited baseflow. This creek will be the recipient of discharges from the mine and TMA perimeter ditches, which will be far greater than any losses in baseflow.

Thunder Lake Tributary #2 and #3 and Hughes Creek are the water courses closest to the project site with significant baseflow from groundwater discharge. These creeks are predicted to have baseflow reductions of around 5% and below 1% respectively.

Predicted Effects on Groundwater TMA and WRSA Leakage

During operation the majority of leakage from the uncapped TMA to groundwater is predicted to be shallow horizontal flow that will be intercepted by perimeter drainage ditches. The remaining 10% to 30%, or about 70 m^3/d to 90 m^3/d for the TMA at full capacity, is predicted to bypass the ditches, migrating underneath them, and eventually discharging either into the flooded open pit, nearby creeks (Hoffstrom's Bay Tributary, Thunder Lake Tributary #3 and Blackwater Creek) or Thunder Lake/Thunder Creek. Following capping the leakage from the TMA is predicted to reduce to about 50 m^3/d for the Base Case scenario with Blackwater Creek receiving around 60% of this water, around 20% discharging in the flooded open pit, 20% discharging to Hoffstrom's Bay Creek with the remainder discharging at much lower rates to Thunder Lake Tributary #3 and Thunder Lake.

Seepage out of the uncapped WRSA is estimated to be within the range of 100 m^3/d to 200 m^3/d largely discharging to the open pit. Following capping the seepage out of the base of the WRSA is predicted to reduce under the Base Case scenario to around 30 m^3/d with approximately two thirds discharging to the flooded open pit and the remainder discharging to Thunder Lake. The flooded open pit is predicted to overflow and discharge to Blackwater Creek via Blackwater Tributary #1.

7.0 QUALIFICATIONS OF AUTHORS AND REVIEWERS

This document was prepared by Dr Martin Shepley, and was reviewed by Simon Gautrey.

Dr. Shepley has 20 years' experience as a regulator and consultant in hydrogeology. He is a registered Professional Geoscientist in Ontario (Registration #1878). His key experience is in quantitative hydrogeology and groundwater modeling from the watershed to site-scale investigations, focusing on well interference and impacts of groundwater taking on the surface water environment.

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8.0 CLOSURE

If you should have any questions regarding this submission, please contact the undersigned at 905-312-0700.

Respectfully submitted,
AMEC Environment & Infrastructure,
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Table 1 Summary of Structural Geology (from Caracle Creek, 2008b)

Event	Structure	Description	Veins	Description
D_0	S_0	Compositional layering of meta-volcanic and meta-sedimentary rocks; argillic alteration zones	V_0	Greyish, highly deformed, S_1 foliation parallel qtz-sulphide ribbons and silicification surrounded by qtz-ser schist
D_1	F_1 S_1	Isoclinal folding F_1 axial planar and layer parallel foliation/schistosity	V_1	White deformed, locally cross-cutting qtz+/-tourmaline+/-sulphide veins
D_2	F_2	Closed (60^o) folds; axial planes ~045/90; discrete, 5-40 m spaced, axial planes	V_2	Weakly deformed white qtz+/-sulphide veins along F_2 axial planes & at 45^o to F_2 axial planes.
D_3	NW Fault	Brittle faults/fractures dip moderately NNE	V_3	Un-deformed white, non-planar qtz veins dip moderately NNE and follow foliation locally

Table 2 Summary of Creek Spot Flow Gauging within the Project Area

Date (DD/MM/YY)	Discharge (m^3/s)(2)								Discharge (m^3/s)(3)		
	HS1/TL1 (Blackwater Creek)	TL1a* (Blackwater Creek)	TL2 (Blackwater Creek)	JCTa* (Blackwater Creek)	HS3/TL3*(4) (Blackwater Creek)	SW1 (Hughes Creek)	HS6/SW2* (Little Creek)	SW3 (McHugh Creek)	HS4* (Thunder Lake Trib. #3)	HS5* (Hoffstrom's Bay Trib.)	HS7* (Thunder Lake Trib. #2)
Easting(1)	529332	528757	527790	528477	527527	531401	525997	534010	527273	527234	527162
Northing(1)	5511656	5511520	5511622	5510999	5509985	5510038	5512219	5504501	5513943	5512922	5514103
Watershed Area (km^2)	4	6.71	0.4	8.35	11.12	36.8	1.03	36.2	10.39	2.24	9.62
16/12/10			0.002			0.176		0.155			
17/01/11	Trace**		Trace**	0	0	0.167	0	0.138			
22/02/11	0		0	0	0	0.192	0	0.137			
25/03/11	0		0	0	0	0.123	0	0.071			
20/04/11	0.165		0.047	0.471	0.077	1.577	0	0.867			
04/05/11	0.202	0.255	0.053	0.603	0.283	1.367	0.011	1.934			
22/06/11	0		0.002	0.011	0.025	0.279	0	0.598			
18/07/11	0		0	0	0	0.062	0	0.078			
22/08/11	0		0	0	0	0	0	0			
22/09/11	0		0	0	0	0.796	0	0			
04/11/11	0		0	0	0	0	0	0			
30/11/11	0		0	0	0	0.493	0	0.197			
11/07/12									0.004	0.004	
24/07/12		0.01			0.001		0.022		0.005		0.034
15/08/12										-0.002***	
06/11/12	0.029	0.035			0.030		0.001				

Date (DD/MM/YY)	Discharge (m^3/s)(2)								Discharge (m^3/s)(3)		
	HS1/TL1 (Blackwater Creek)	TL1a* (Blackwater Creek)	TL2 (Blackwater Creek)	JCTa* (Blackwater Creek)	HS3/TL3*(4) (Blackwater Creek)	SW1 (Hughes Creek)	HS6/SW2* (Little Creek)	SW3 (McHugh Creek)	HS4* (Thunder Lake Trib. #3)	HS5* (Hoffstrom's Bay Trib.)	HS7* (Thunder Lake Trib. #2)
Easting(1)	529332	528757	527790	528477	527527	531401	525997	534010	527273	527234	527162
Northing(1)	5511656	5511520	5511622	5510999	5509985	5510038	5512219	5504501	5513943	5512922	5514103
Watershed Area (km^2)	4	6.71	0.4	8.35	11.12	36.8	1.03	36.2	10.39	2.24	9.62
07/11/12									0.032	0.002	0.046
07/05/13							0.030				
08/05/13	0.312	0.51		0.270	0.069				0.190	0.006	0.460
06/06/13	0.051	0.092			0.062		0.002				
07/06/13				0.099					0.020	0.002	0.110
24/06/13	0.015	0.022		0.079			0.003		0.033		0.053
25/06/13					0.000					0.003	
17/07/13		0.019		0.035	0.026		0.002		0.037	0.001	0.026
20/08/13		0.0026		0.004	-0.0045***		0.001		0.026	0.001	0.016
03/10/13		0.022		0.048	0.021		0.001		0.042	0.003	0.025
07/11/13							0.004		0.028		
13/11/13		0.037		0.034	0.003					0.002	1.000

Notes:

1. Coordinates in NAD 83, UTM Zone 15N;
2. Klohn Crippen Berger (2012) data in shaded in grey, otherwise data from DST (2014);
3. Gauging sites established by Treasury Metals under direction from DST;
4. Site noted to be affected on 25/06/2013 by beaver dams and subsequently moved (DST, 2014);

* Stations equipped with an automatic level logger and flows derived from stage discharge relationships as reported in DST (2014);

** Insufficient flow for accurate measurement; and

*** Negative values indicative of back water flow conditions (DST, 2014).

Table 3 Creek Minimum Gauged Daily Flows for 2012 and 2013 as Determined from Stage-Discharge Relationships

	TL1a (Blackwater Creek)	JCTa (Blackwater Creek)	HS3 (Blackwater Creek)	HS6[(2)] (Little Creek)	HS4 (Thunder Lake Trib. #3)	HS5 (Hoffstrom's Bay Trib.)	HS7 (Thunder Lake Trib. #2)
Easting[(1)]	528757	528477	527527	525997	527273	527234	527162
Northing[(1)]	5511520	5510999	5509985	5512219	5513943	5512922	5514103
Watershed Area (km^2)	6.71	8.35	11.12	1.03	10.39	2.24	9.62
Min 2012 (m^3/s)[(3)]	0.0001		0.0027	*0.0092*	0.0131	0.0004	0.0197
Min 2013 (m^3/s)[(3)]	0.0096	0.0016	0.0020	0.0001	0.0265	0.0000	0.0152
Min 2012 (mm/year)[)(4)]	0.5		7.7	*281.7*	39.8	5.6	64.6
Min 2013 (mm/year)[(4)]	45.1	6.1	5.6	3.1	80.4	0.0	49.8

Notes:

1. Coordinates in NAD 83, UTM Zone 15N;
2. For HS6 2012 minimum flows are not considered accurate as stage discharge relationship determined mainly from 2013 data does not appear accurate for 2012 data;
3. Minimum 2012 and 2013 flows from DST (2014); and
4. Derived from minimum 2012 and 2013 flows by dividing by gauge watershed area.

Table 4 Groundwater Level Measurements for the Project Area

2013 Groundwater Quality Monitoring Wells								Groundwater Levels[2][3]														
	Easting [1]	Northing [1]	Screened Units			Surface Elevation	Stick Up						10-11/06/13	09/07/13	14/08/13	16/10/13	27/11/13	28/11/13	19/12/13	30/01/14	03/02/14	01/05/14
						masl	m						masl	masl	masl	masl	masl	masl	masl	masl	masl	masl
BH1A	528705	5513251	Basal Sand/Bedrock			404.20	0.92						404.06	403.33	403.27	403.89			403.61		403.14	
BH2A	529978	5512931	Clay/Basal Sand/Bedrock			403.91	0.99						403.79	403.57	403.00		403.77		403.57			
BH3A - S	529283	5512359	Sand (top Sand-Clay/Silt-Sand)			396.77	0.78						395.51	395.12	395.15	395.31		395.01	395.12	395.11		
BH3A - D	529281	5512360	Clay/Sand (bottom Sand-Clay/Silt-Sand)			397.00	0.86						396.26	396.11	395.95	396.23		395.73	395.09	395.80		
BH4A	527699	5512263	Clay/Bedrock			396.38	1.02						396.22	395.42	395.03	395.94		396.27	395.99	394.53		
BH5A	527800	5511717	Clay			389.07	0.87						388.31	387.98	387.87				387.97	387.07		
BH6D	526905	5511901	Clay/Basal Sand			394.25	0.88						393.93	393.24	393.14	393.20		392.95	392.81	392.34		
BH7A	526307	5511546	Clay/Basal Sand			390.28	0.64						389.64	388.99	388.73	389.02		388.38	389.01	388.85		
BH8A	528560	5511072	Basal Sand/Bedrock			388.63	0.85						384.73	384.03	383.91	383.94	383.63		383.33		382.81	
2014 Geotechnical Holes – Shallow Standpipes																						
BH14-03	529660	5513406	Silty Sand (top Sand-Clay/Silt-Sand)			411.87	0.17															411.57
BH14-05	528946	5513426	Silty Sand (top Sand-Clay/Silt-Sand)			406.64	0.31															406.41
BH14-11	529025	5512091	Clay			392.35																*392.35*
BH14-21	528280	5512927	Clay			397.65																*397.65*
Exploration Boreholes (all in bedrock)																						
	Easting [1]	Northing [1]	BH Length	BH Dip	Azimuth			21/03/12	25/03/13	12/04/13	06/05/13	27/05/13	17/06/13	05/07/13								
			m	Degrees[4]	Degrees[5]			masl	masl	masl	masl	masl	masl	masl								
TL10104	527173	5511648	321	-70	360	396.00	0.2		395.63	395.65	395.72	394.98	394.74	393.62								
TL11125	528124	5511753	411	-64	309	394.74	0.5		390.75	390.81	392.41	392.16	392.02	391.52								
TL11142	528352	5511909	447	-69	360	394.87	1.0	392.93	392.26	392.30	393.52	393.38	393.38	393.06								
TL11154	528389	5512010	249	-64	360	396.32	1.1	394.62	392.87	392.96	394.52	394.48	394.49	393.11								
TL11155	528342	5511720	585	-67	311	393.00	1.1		*394.13*	393.76	*394.13*	*394.13*	*394.13*	*394.13*								
TL11196	527396	5511608	429	-65	350	395.89	0.2		391.86	392.10	394.37	394.71	394.58	393.83								
TL13320	527521	5511892	123	-44	360	390.90	1.4		391.87	391.78	*392.27*	*392.27*	*392.27*	*392.27*								
TL13336	527910	5512018	105	-44	360	396.10	1.1		393.54	393.70		395.51	395.53	394.86								
TL220	528302	5512035	66	-45	360	396.09	0.8		393.77	393.59	394.63	394.71	394.58	394.21								

Notes:
1. Coordinates in NAD 83, UTM Zone 15N;
2. Groundwater levels shaded in grey used for groundwater model calibration;
3. Groundwater levels italicized when water is at surface/hole is flowing;
4. Measured from ground surface; and
5. Measured from north.

Table 5 Summary RQD Statistics for 297 Treasury Metal Boreholes According to Depth Intervals

Down Borehole Depth Interval	Mean RQD (%)	Standard Deviation RQD (%)
< 50 m	83	17
50 – 100 m	87	15
100 – 200 m	89	12
200 – 400 m	90	11
> 400 m	91	11

Table 6 Summary Details of Packer Tested Boreholes

Type[1]	Borehole	Easting	Northing	Plunge	Azimuth	Total Depth	Geologic Unit Penetration Sequence
		(UTM NAD83, Zone 16N)		Degrees from ground surface	degrees from N	(mbgs)	
EEB	TL0855	527587	5511517	-58	360	424	Hanging-wall – Central
	TL10111	526655	5511625	-49	360	182	Hanging-wall – Central
	TL11195	528185	5511605	-58	348	537	Hanging-wall – Central (intercepts NW Fault at 130m downhole)
NHB	TL13115	528087	5512143	-62	190	265	Foot-wall – Central
	TL13117	528371	5512022	-78	045	314	Hanging-wall – Central
	TL13121	526818	5511759	-82	354	297	Hanging-wall – Central – Foot-wall

Notes:

1. EEB = Existing Exploration Borehole, packer moved progressively upward with packer interval increasing; NHB = New Hydrogeology Borehole, packer set above end hole as hole is progressively advanced and packer interval remaining fixed at approximately 41m (7×3m drill rods).

Table 7 Summary Details of Vibrating Wire Piezometer Installations

Borehole	Easting[1]	Northing[1]	Piezo	Depth (mbgl)	Max Head May 2013 (masl)	Min Head January 2014 (masl)	Geologic Unit
TL13117	528371	5512022	Shallow	62	393.3	391.9	Hanging-wall
			Deep	170	390.5	388.9	Central
TL13121	526818	5511759	Shallow	64	391.7	390.4	Central
			Deep	223	390.7	389.1	Foot-wall

Notes:

1. Coordinates in NAD 83, UTM Zone 15N.

Table 8 Goliath Mine Site Groundwater Flow Model Calibrated Input Parameters

Hydrostratigraphic Unit	Hydraulic Conductivity (m/s)	Expected Range[1] (m/s)	Comment
Clay – north-eastern part of project area	1E-8	1E-7 – 1E-9	Elevated areas more proximal to the Hartman Moraine where a higher component of silt is be expected in Lake Agassiz glaciolacustrine deposits
Clay – south-western part of project area	1E-9	≤1E-9	In low lying area under Wabigoon Lake where deposition of finer grained rhythmites (e.g. varved clays) are expected during Lake Agassiz glaciolacustrine deposition in the deeper parts of the Wabigoon Basin
Basal Sand	5E-6	1E-6 – 1E-5	Underlying clay
Sand – Clay/Silt Horz.	5E-6	1E-6 – 1E-5	Simulated as anisotropic layer with horizontal and vertical hydraulic conductivity same as Basal Sand and Clay respectively
Vert.	1E-8	1E-7 – 1E-9	
Sand and Gravel	5E-5	1E-5 – 1E-4	Kames and Glaciofluvial Outwash
Shallow Bedrock	1E-6	1E-7 – 1E-5	7 m thick unit
Intermediate Bedrock	1E-7 to 1E-8	1E-8 – 1E-7	1E-7 zone extends 100m below bedrock surface
Deep Bedrock	1E-9	<1E-8	Below a depth of about 400m
Deformation Zone	1E-7, 3E-8 and 3E-9	Assumed to be more permeable than surrounding bedrock	Above 250m, between 250m and 400m and below 400m depth, respectively.
Surficial Material	**Recharge Rate (mm/yr)**		
Clay	5	<10	
Bedrock Outcrops and Sand – clay/silt - Sand	10	<30	
Sand/Gravel	80	50-100	Kames and outwash planes
Peat/Wetlands	0		Assumed to be primarily discharge zones

Notes:

1. Derived primarily from Goliath Project site specific. Parametersation of overburden hydraulic conductivity relies partly on literature and data from the Rainy River Gold Project (AMEC, 2013).

Table 9 Predicted Groundwater Inflow into Fully Dewatered Goliath Mine

Simulated Variant	Description/ Parameter Varied	Seepage into Proposed Open Pit and Underground Mine Workings(2) (m^3/d)
1	Base Case(1)	1,320
2a	Hydraulic Conductivity of Basal Sand Increased by a Factor of 2	1,320
2b	Hydraulic Conductivity of Basal Sand Decreased by a Factor of 2	1,310
3a	Hydraulic conductivity of Shallow Bedrock Increased by a Factor of 2	1,470
3b	Hydraulic Conductivity of Shallow Bedrock Decreased by a Factor of 2	1,220
4a	Hydraulic Conductivity of Deformation Zone Increased by a Factor of 2	1,630
4b	Hydraulic Conductivity Deformation Zone Decreased by a Factor of 2(3)	950
5a	Hydraulic Conductivity of Intermediate Bedrock Increased by a Factor of 2(4)	1,870
5b	Hydraulic Conductivity of Intermediate Bedrock Decreased by a Factor of 2	1,020
6a	Hydraulic Conductivity of Deep Bedrock Increased by a Factor of 2	1,370
6b	Hydraulic Conductivity of Deep Bedrock Decreased by a Factor of 2	1,280
7	Hydraulic Conductivity of Clay is 1E-8 m/s Everywhere	1,320
8	Neglecting Hydrogeological Impact of Wabigoon fault	1,320
9	Accounting for NW Fault(5)	1,330

Notes:

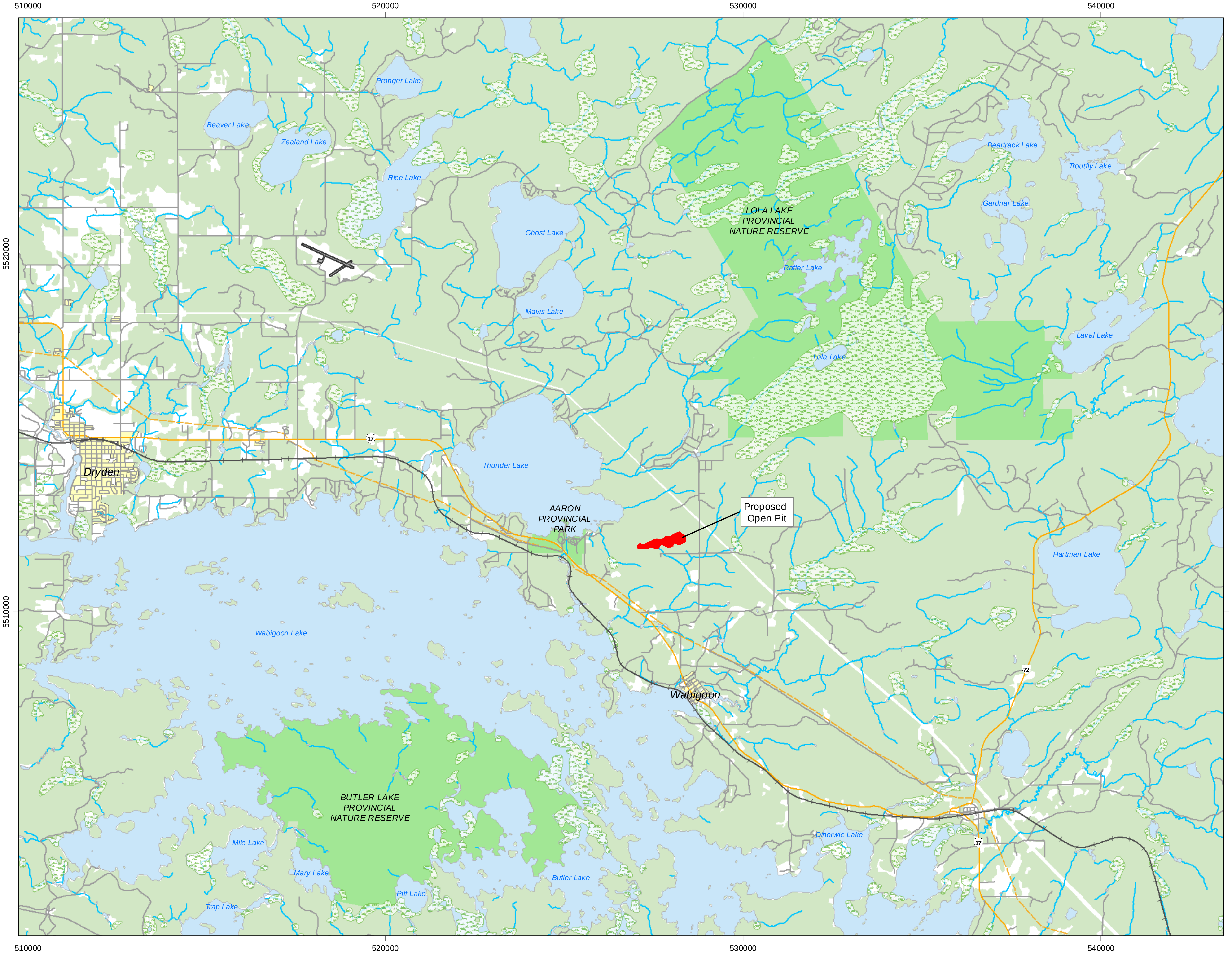
1. Input parameters shown in Table 8;
2. Rounded to the nearest 10 m^3/d;
3. Including intermediate bedrock down to a depth of 100m;
4. Including deformation zone down to a depth of 100m; and
5. Assigned the same hydraulic conductivity values and depth profile the deformation zone (Table 8).

Table 10 Model Predicted Flow Rates (m^3/d) out of Uncapped TMA and Flooded Mine Workings

Simulated Variant	Ditches	Base Case[1]		Hydraulic Conductivity of Surficial Sand 10^{-5} m/s[4]	Hydraulic Conductivity of Surficial Sand 10^{-6} m/s[5]
		1[2]	2[3]	3[2]	4[2]
Total Flow Out of TMA	a	337	509	415	238
	b	320	443	392	230
Intercepted by Seepage Collection Ditches and Pond	a	254	442	328	157
	b	233	370	301	148
Discharged into Flooded Open Pit	a	8	9	7	10
	b	8	8	7	10
Bypassing Ditches and Pond	a	75	59	80	71
	b	79	65	84	72

Notes:

1. Input parameters shown in Table 8. Base Case is run with two configurations: (a) drainage ditches on all sides of the TMA; (b) drainage ditches on downstream sides (west, east and south) of the TMA;
2. Conductance of drain nodes simulating seepage collection ditches and WMP is based on the geometric mean of horizontal and vertical hydraulic conductivities of surficial sand-clay/silt layer;
3. Conductance of drain nodes simulating seepage collection ditches and WMP is based on the horizontal conductivity of surficial sand;
4. Horizontal K-value increased by a factor of 2 compared with Base Case; and
5. Horizontal K-value decreased by a factor of 5 compared with Base Case.



HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

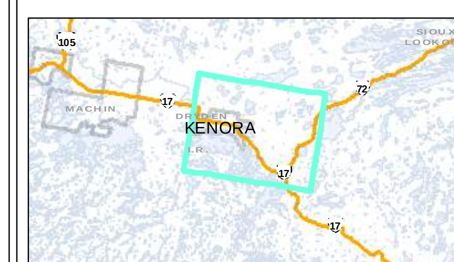
Goliath Project

Figure 1

Project Site Location

Legend

- Proposed Open Pit
- Airport
- Built Up Area
- Provincial Park
- Vegetation
- Wetlands/ Saturated Soil
- Waterbody
- Watercourse
- Railway
- Pipeline



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TB124004
Date: June, 2014
Client: Ontario Infrastructure & Lands

Drawn by: DF
Checked by: MS
Revision No.: 1

UTM NAD 83
Zone 15N
1:100,000

Kilometers 0 1 2 3

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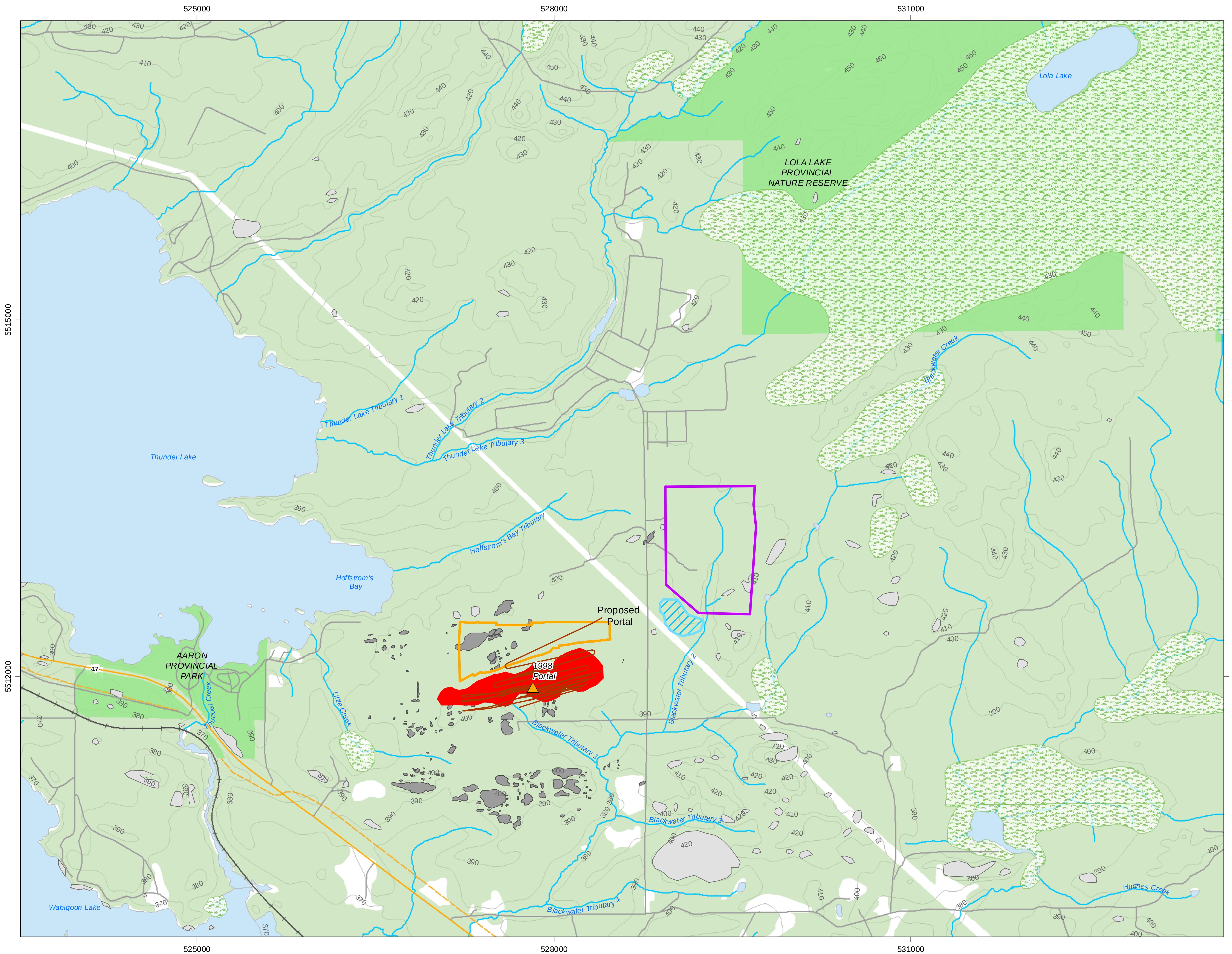

HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 2

Detailed Location Map

Legend

- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Provincial Park
- Vegetation
- Wetlands/ Saturated Soil
- Waterbody
- Watercourse
- Railway
- Pipeline
- Ramps and Drifts - Underground Mine
- Elevation Contour (masl, 10 m intervals)

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals

Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TB124004
Date: July, 2014
Client: Ontario Infrastructure & Lands

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Revision No.: 2

UTM NAD 83
Zone 15N
1:30,000

Kilometers
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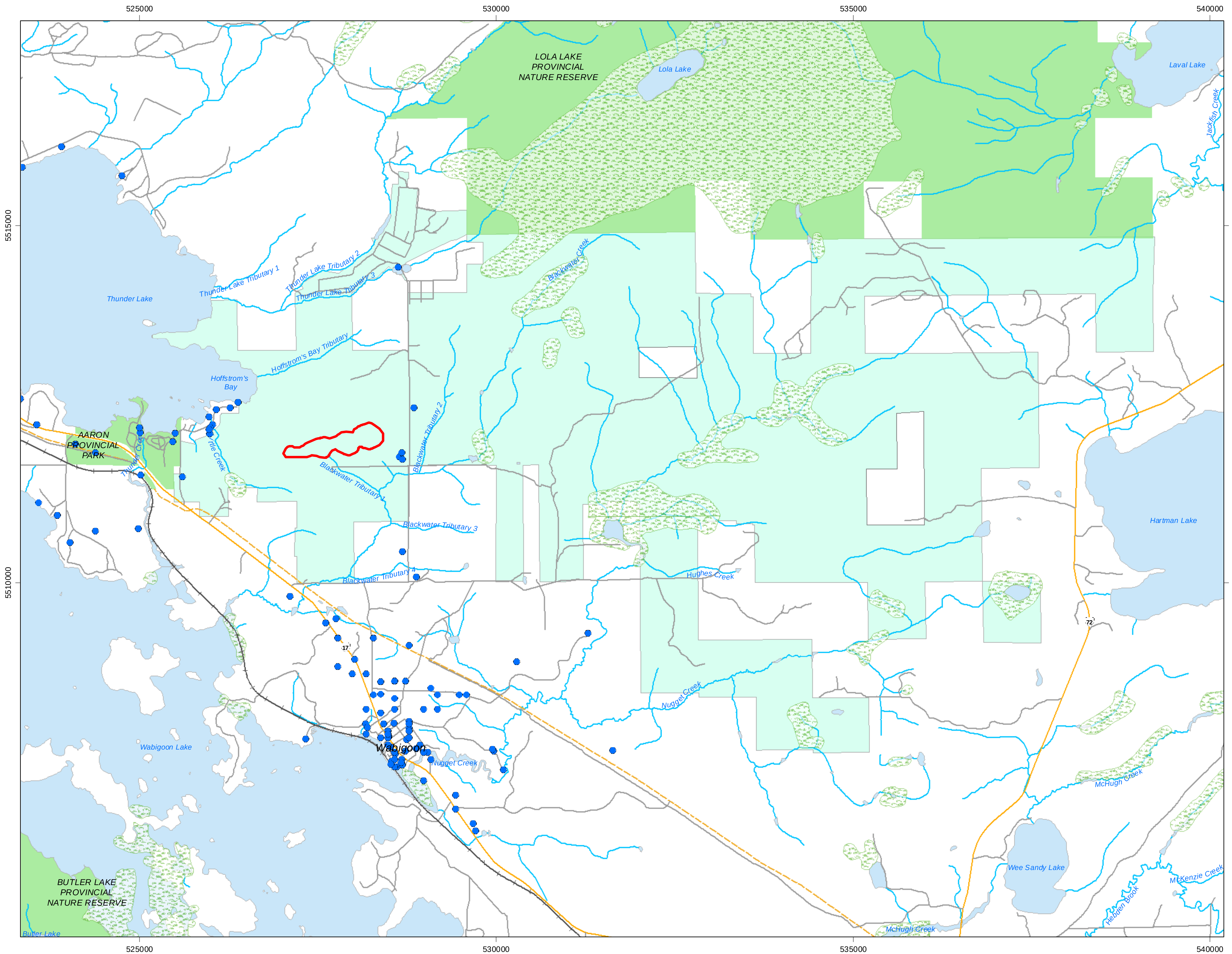


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

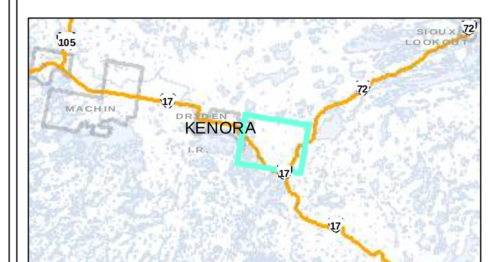
Goliath Project

Figure 3

Private Water Wells and
Surface Water Features

Legend

- Private MOE Water Well
- Proposed Open Pit
- Property Boundary
- Provincial Park
- Wetlands/ Saturated Soil
- Waterbody
- Watercourse
- Railway
- Pipeline



Source: National Topographic Database, 052F09, 052F10,
052F15, and 052F16, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

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Date: June, 2014
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UTM NAD 83
Zone 15N
1:50,000

Kilometers: 0, 0.5, 1, 1.5

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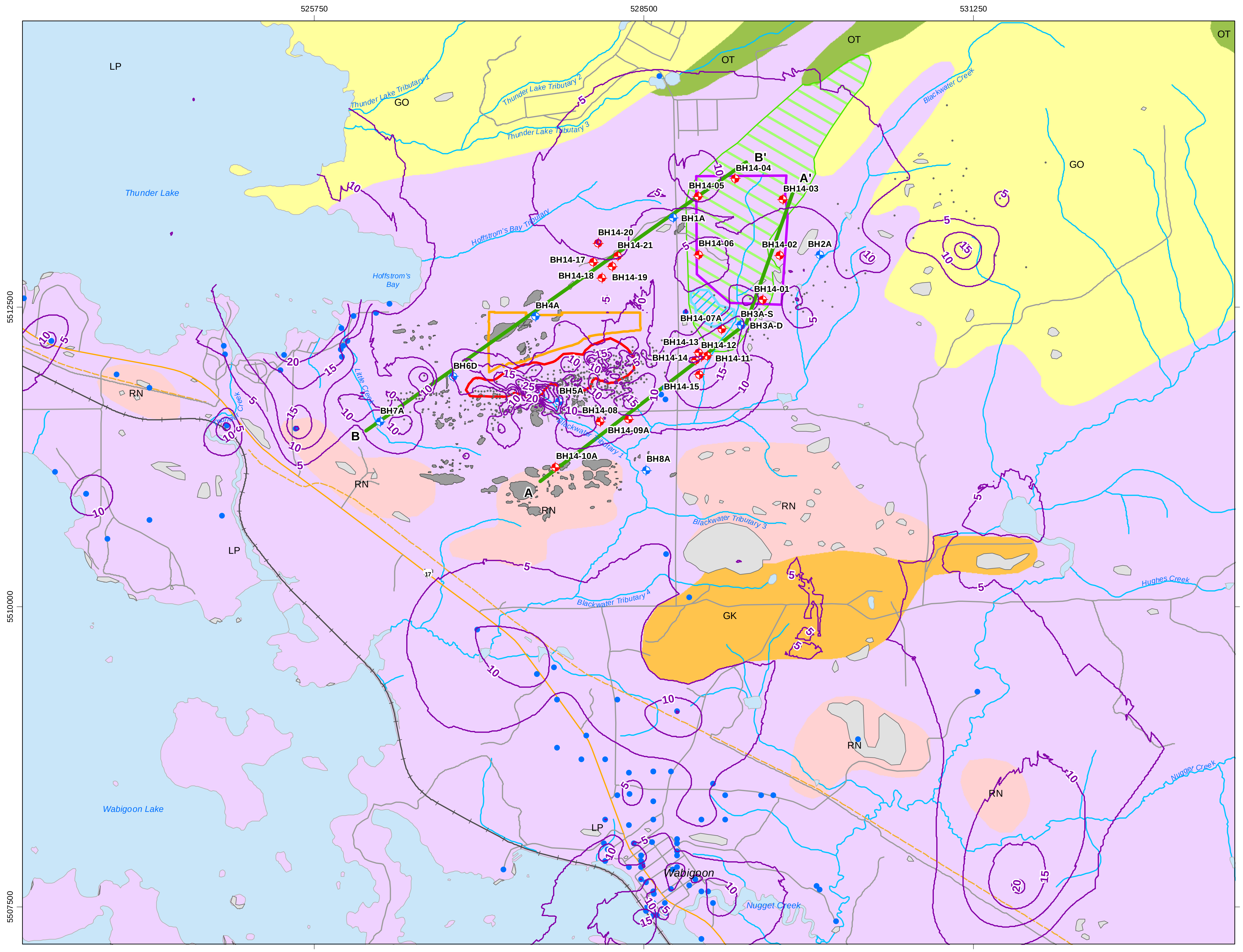


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 4

Project Site Overburden Geology

Legend

- Overburden Thickness (meters below ground surface)
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Cross Section Location
- Railway
- Pipeline

Surficial Geology

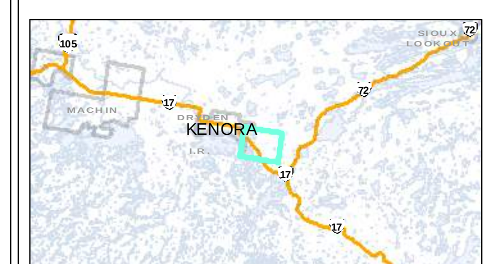
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

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Date: July, 2014
Client: Ontario Infrastructure & Lands

Drawn by: DF
Checked by: MS
Revision No.: 2

UTM NAD 83
Zone 15N
1:30,000

Meters: 0, 200, 400, 600, 800, 1,000

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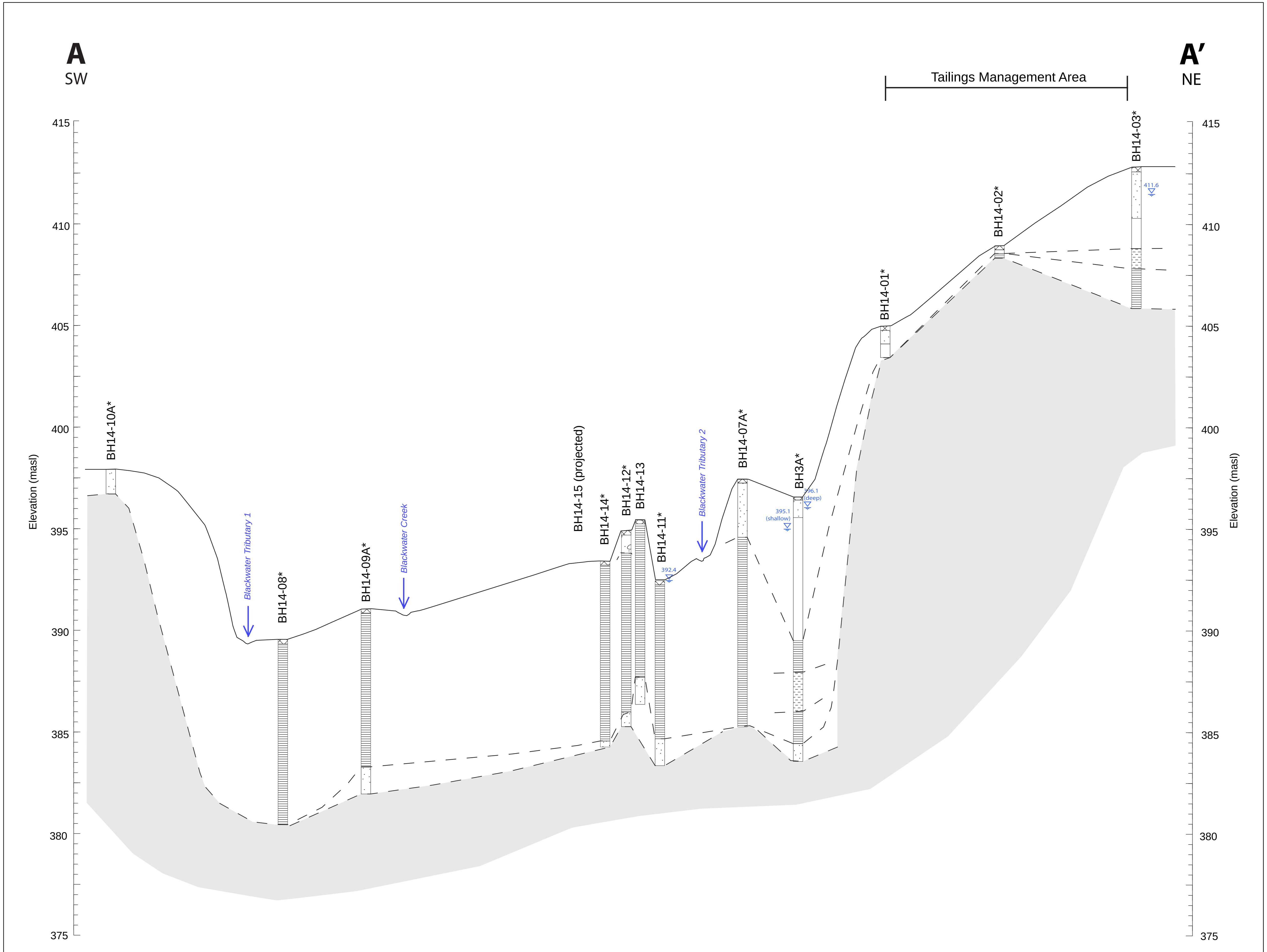


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 5a

South-west to North-east Cross-section through Overburden (a) South-east of Proposed Open Pit

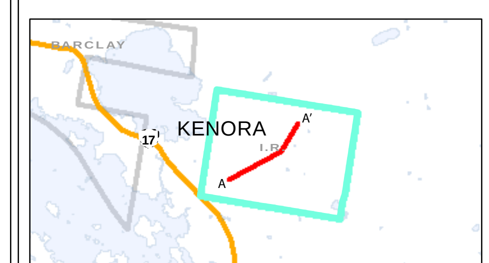
Legend

- Organics
- Sand
- Silty Sand
- Silt
- Clay
- Bedrock
- 400.0 Waterlevel (masl)

Notes: "Clay" indicates lithology of predominantly clay but also includes silty clay and layered clay and silt.

Borehole with * indicates auger refusal (assumed bedrock).

BH14 water levels from May 2014, BH 2013 (BH1A - BH8A) water levels from July 2013.



Source: Treasury Metals Borehole Logs

Conditions encountered in the field may be different from the interpreted information presented on this figure.

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0 100 200 300 400 500 Meters

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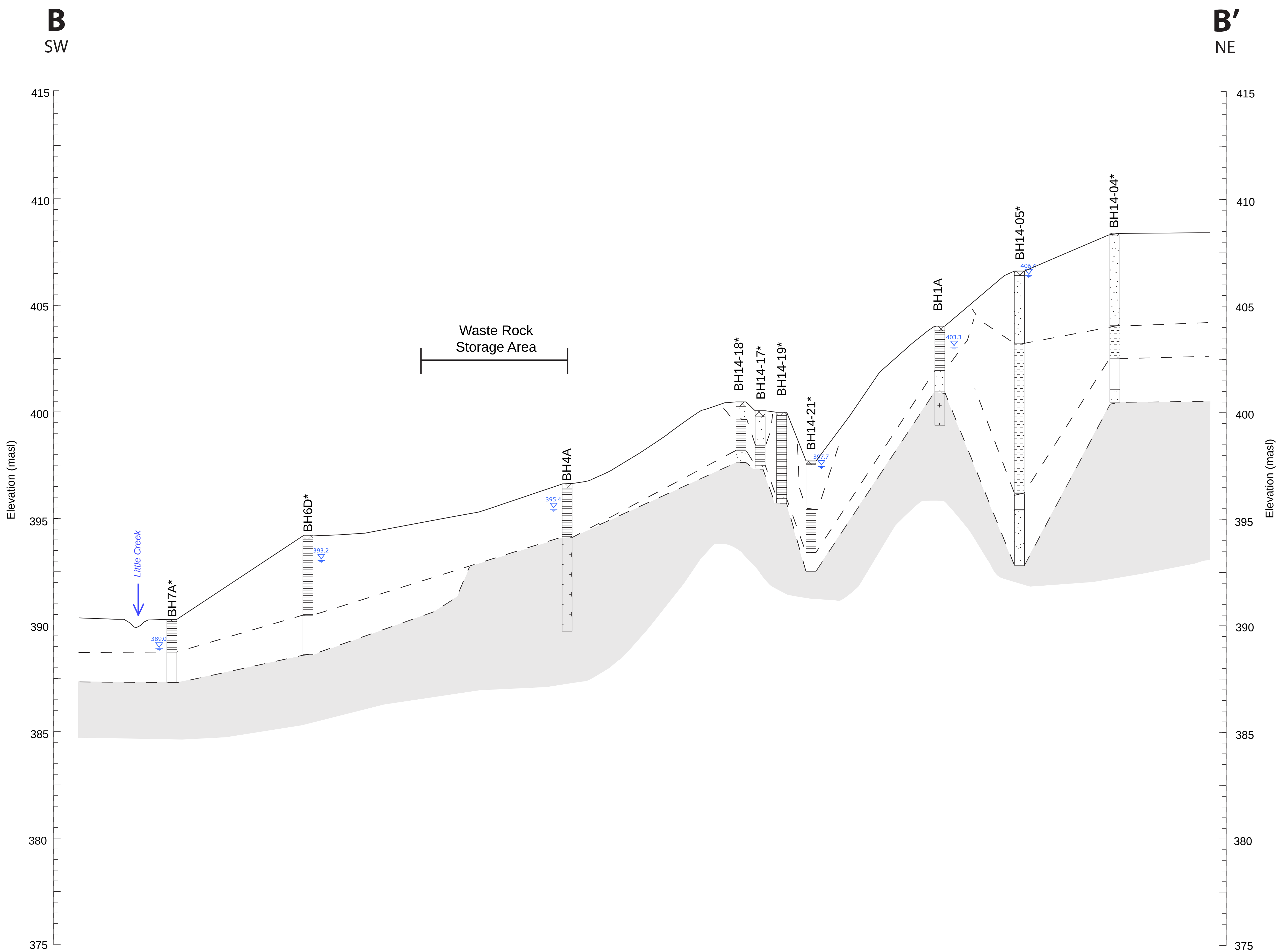

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Goliath Project

Figure 5b

South-west to North-east Cross-section through Overburden (b) North-west of Proposed Open Pit

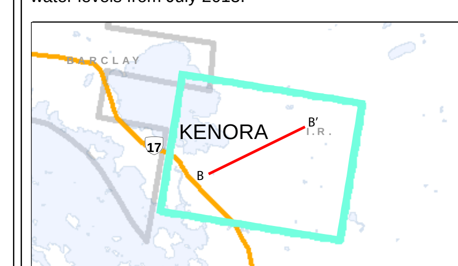
Legend

- Organics
- Sand
- Silty Sand
- Silt
- Clay
- Bedrock
- 400.0 Waterlevel (masl)

Notes: "Clay" indicates lithology of predominantly clay but also includes silty clay and layered clay and silt.

Borehole with * indicates auger refusal (assumed bedrock).

BH14 water levels from May 2014, BH 2013 (BH1A - BH8A) water levels from July 2013.



Source: Treasury Metals Borehole Logs

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0 100 200 300 400 500 Meters

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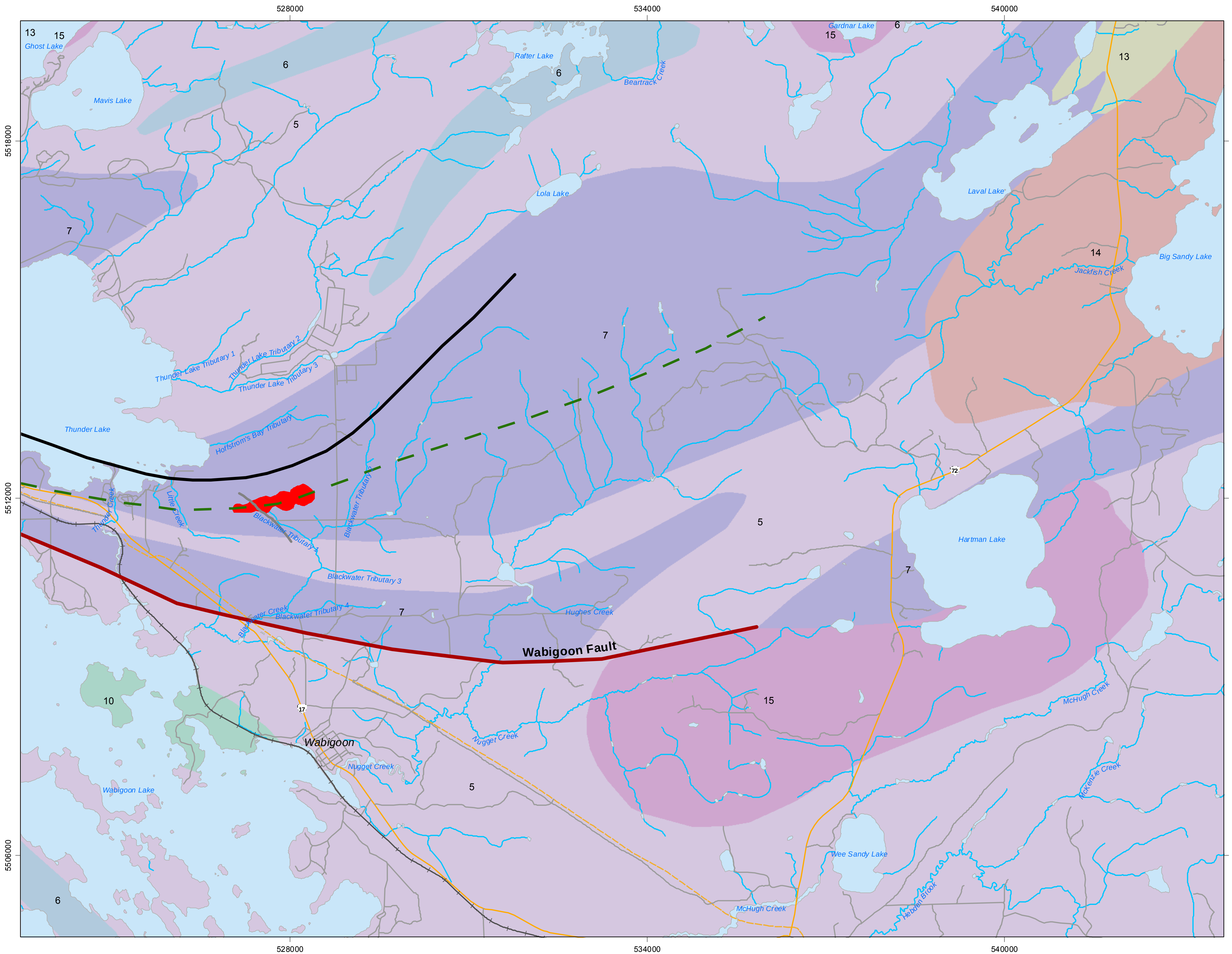


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 6

Project Area Bedrock Geology

Legend

- Proposed Open Pit
- Deformation Zone (Trend inferred from magnetic data)
- Wabigoon Fault
- Northwest Fault
- Iron Formation
- Railway
- Pipeline

Bedrock Geology

Metavolcanic Rocks

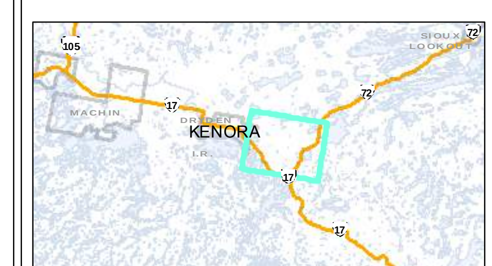
- 6: Felsic to intermediate metavolcanic rocks
- 5: Mafic to intermediate metavolcanic rocks

Sedimentary Rocks

- 7: Metasedimentary rocks

Intrusive Rocks

- 10: Mafic and ultramafic rocks
- 15: Massive granodiorite to granite
- 14: Diorite-monzodiorite-granodiorite suite
- 13: Muscovite-bearing granitic rocks



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale. Ontario Geological Survey 2011. 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release–Data 126 - Revision 1.

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Zone 15N
1:60,000

Kilometers 0 0.5 1 1.5 2

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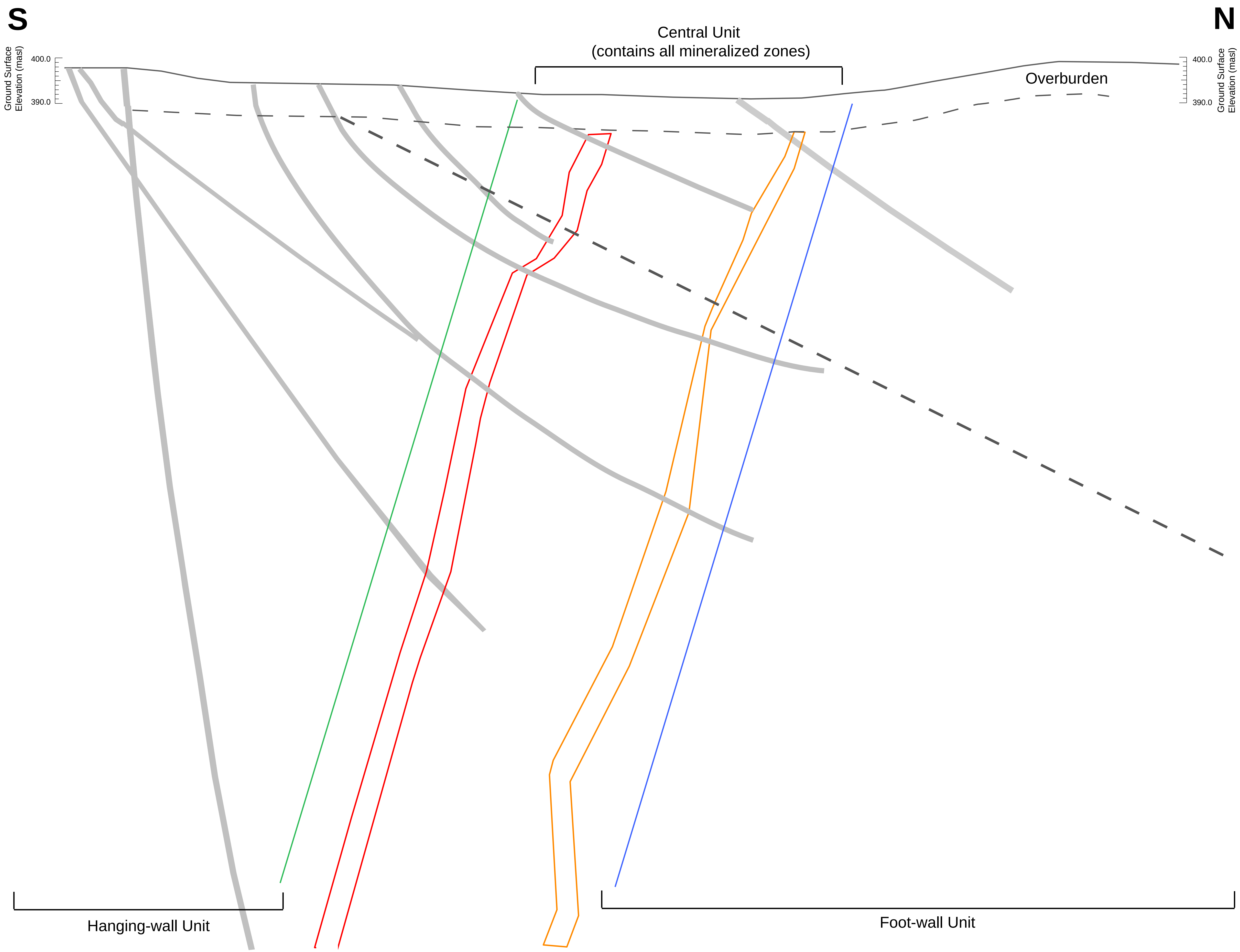

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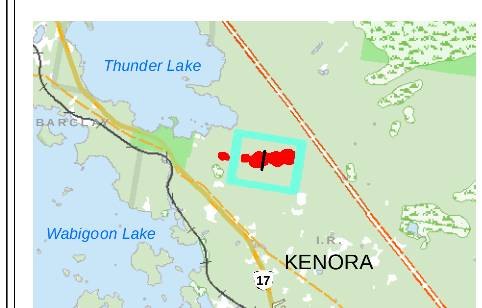
Goliath Project

Figure 7

Schematic Site Cross Section

Legend

- Main Zone
- C Subzone
- Boreholes
- Northwest Fault



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.

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Zone 15N

Scale approximate

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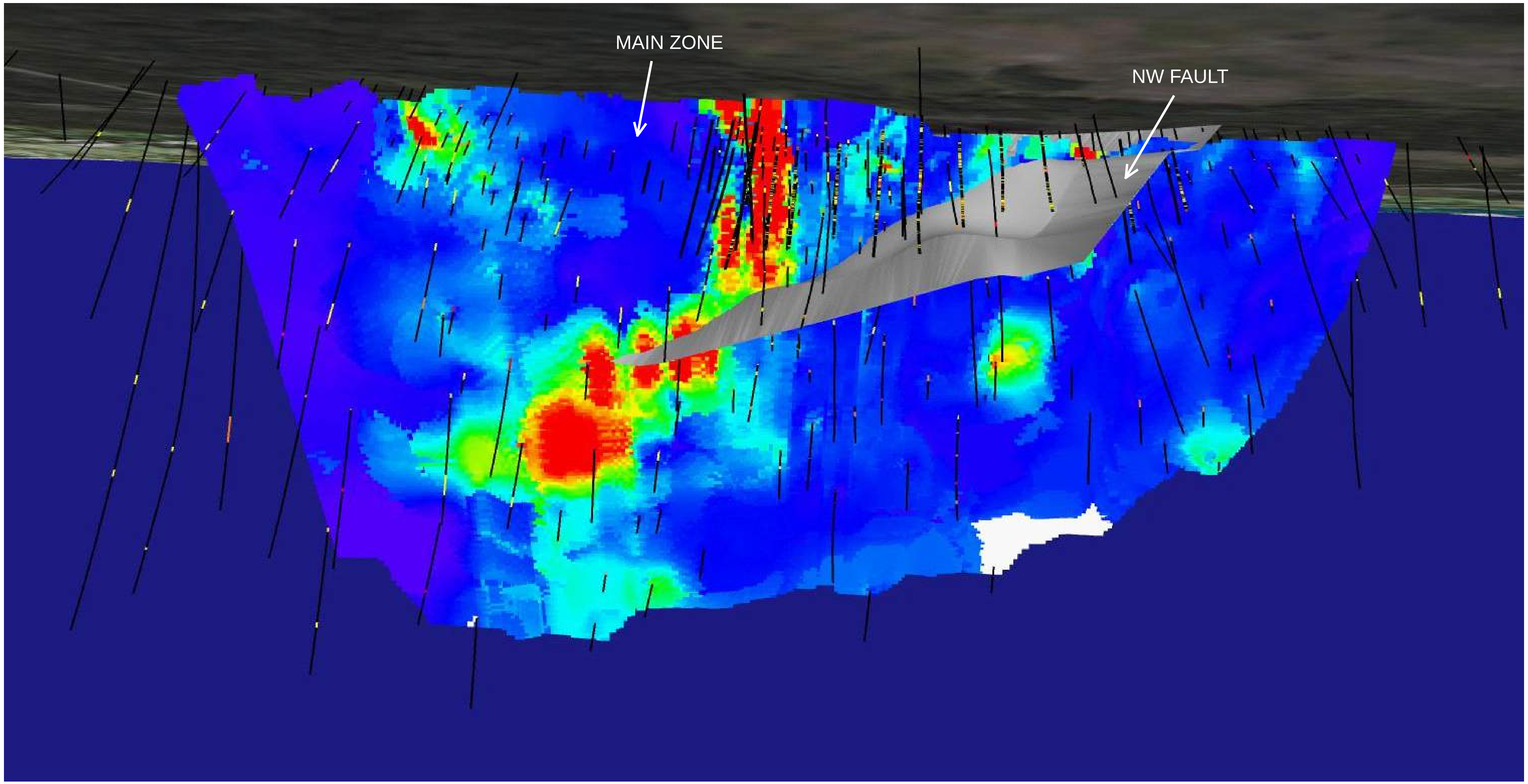
East West



View of Main Zone looking South. The Main Zone dips steeply to the South. The NW Fault is shown in grey, intersecting the Main Zone and dipping shallowly to the Northeast.

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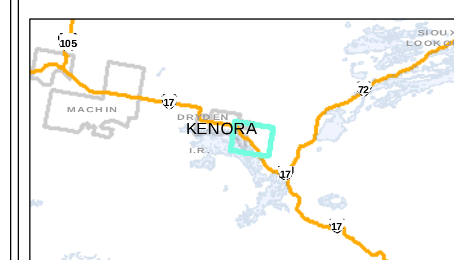
Figure 8

Long-Section of Main Zone and Northwest Fault



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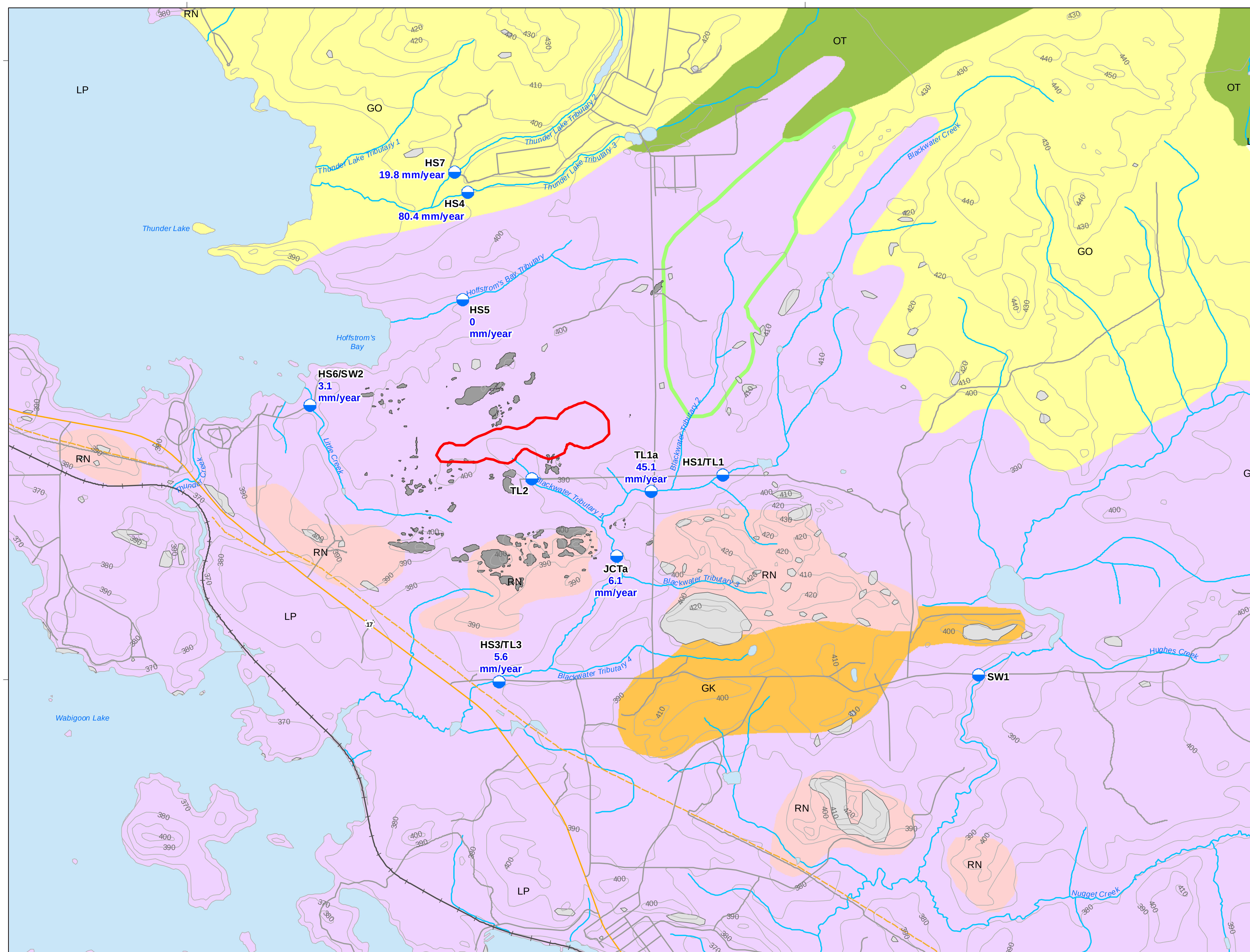

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Figure 9

Creek Gauging Locations in Project Area

Legend

- Creek Gauging Station (labelled with minimum gauge flow 2013, where data available)
- Proposed Open Pit
- Railway
- Pipeline
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals

Note: minimum gauge flow (mm/year) derived dividing by gauge watershed area

Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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Zone 15N
1:30,000

Kilometers
0 0.3 0.6 0.9

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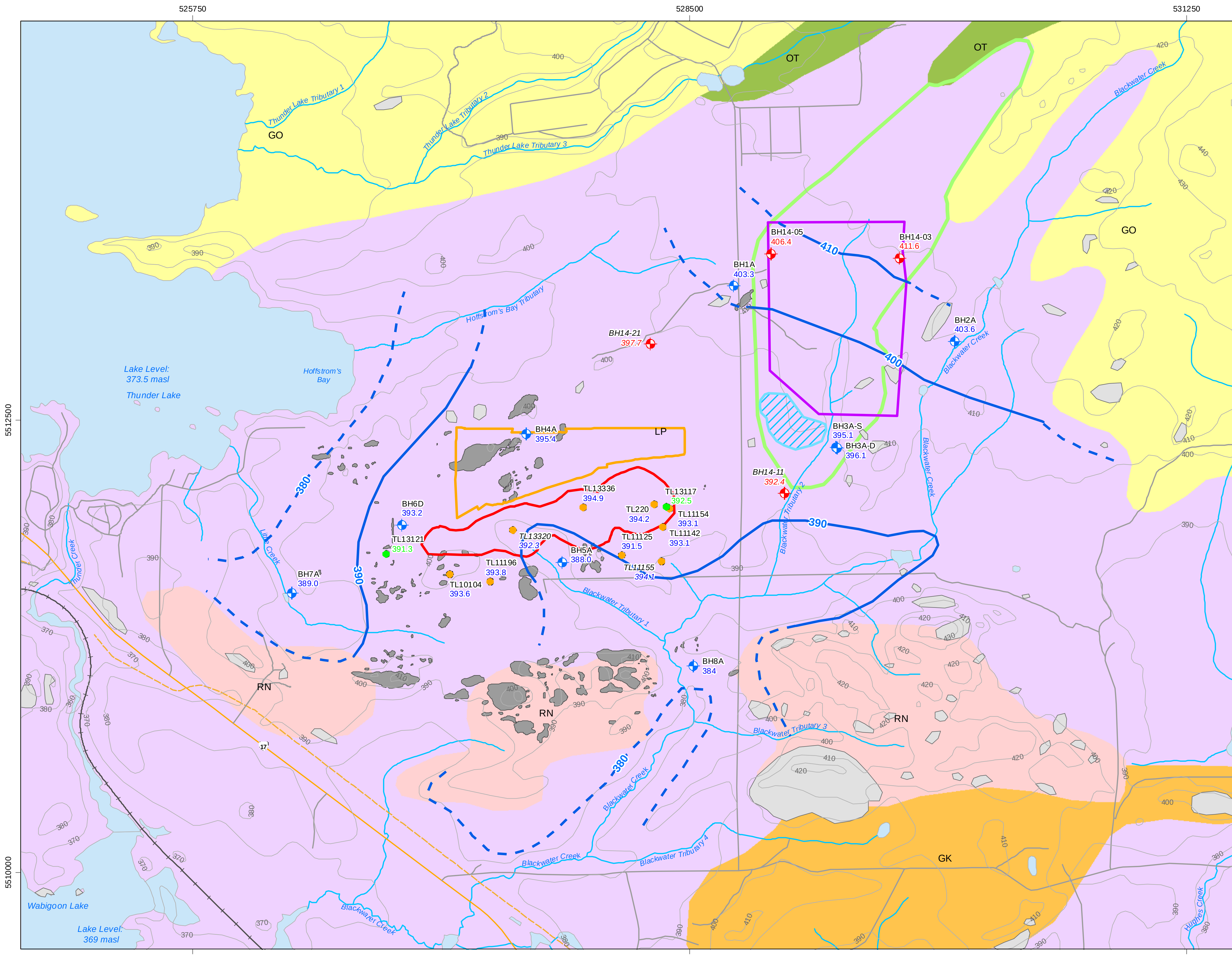

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Figure 10

Groundwater Level Contours Representing Groundwater Conditions at the Overburden/Bedrock Contact

Legend

- 2013 Monitoring Well (July 2013 water level labelled in blue)
- 2014 Geotechnical Hole (May 2014 water level labelled in red)
- 2013 Shallow Vibrating Wire Pezometer (July 2013 water level labelled in green)
- Exploration Borehole (July 2013 water level labelled in blue)
- Water Level Contour (masl)
- Inferred Water Level Contour (masl)
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

- Sand - Clay / Silt - Sand Boundary

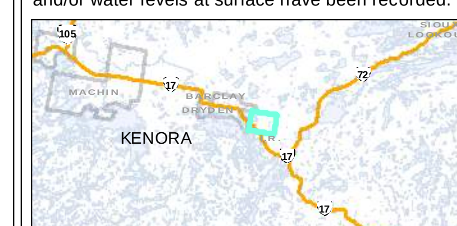
Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals

Note: holes in italics are where flowing conditions and/or water levels at surface have been recorded.



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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UTM NAD 83
Zone 15N
1:20,000

Meters 0 100 200 300 400 500

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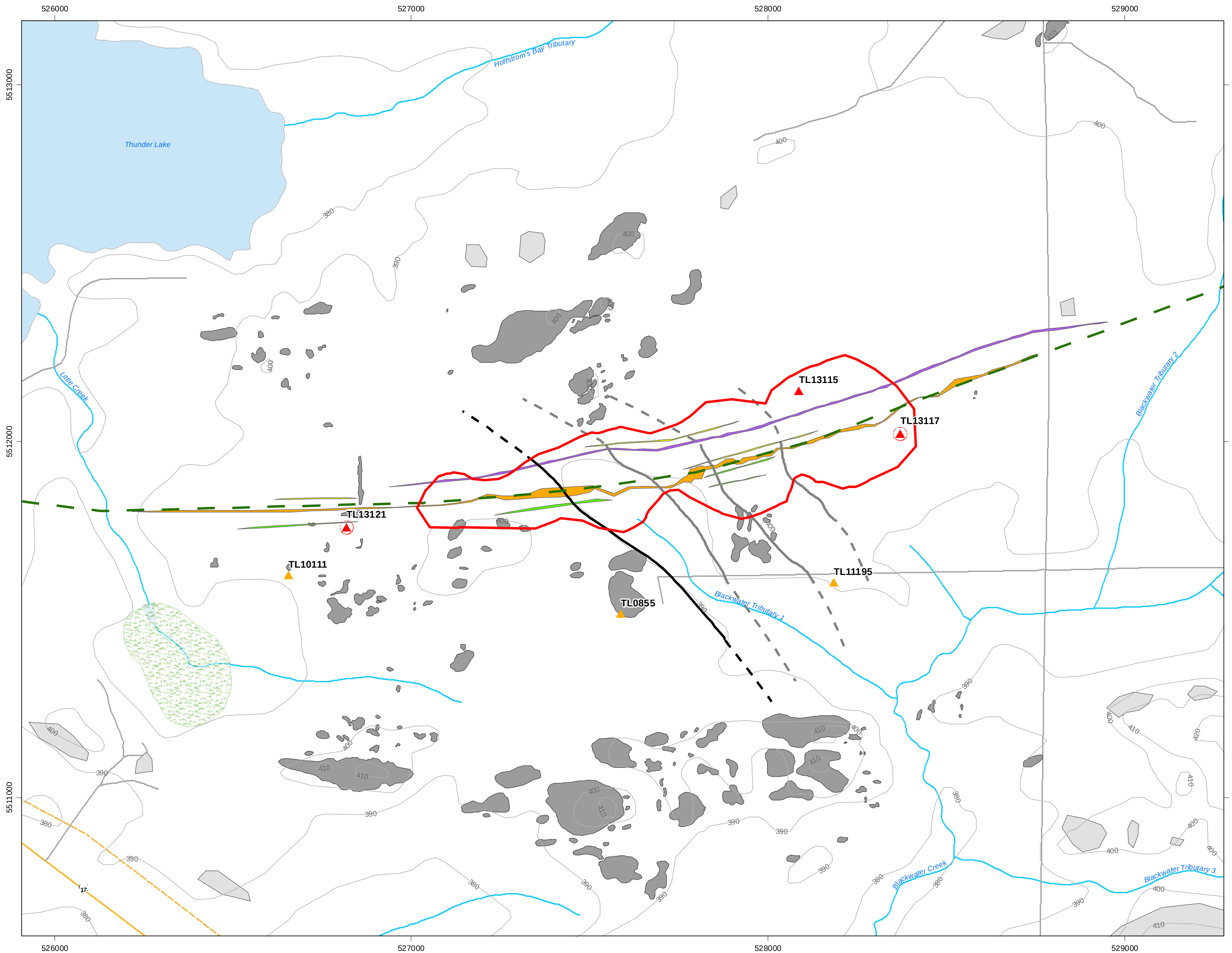

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Figure 11
Mineralized Zones and
Bedrock Borehole Locations

Legend

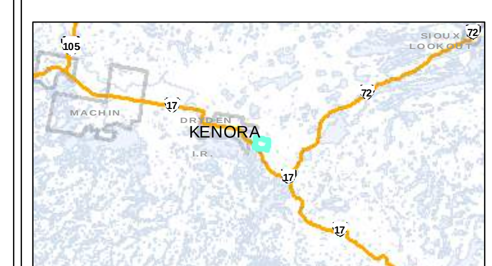
- Proposed Open Pit
- Packer Tested Hydrogeological Borehole
- Packer Tested Exploration Borehole
- Vibrating Wire Piezometer Installed
- Northwest Fault
- Northwest Fault Bedrock Surface
- Deformation Zone (Trend inferred from magnetic data)
- Railway
- Pipeline
- Elevation Contour (masl, 10 m intervals)

Mineralized Zones Projected to Surface

- Main Zone
- Subzone C
- Mineralized Zone B & D
- Mineralized Zone H

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16

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Zone 15N
1:10,000
Meters
0 100 200 300

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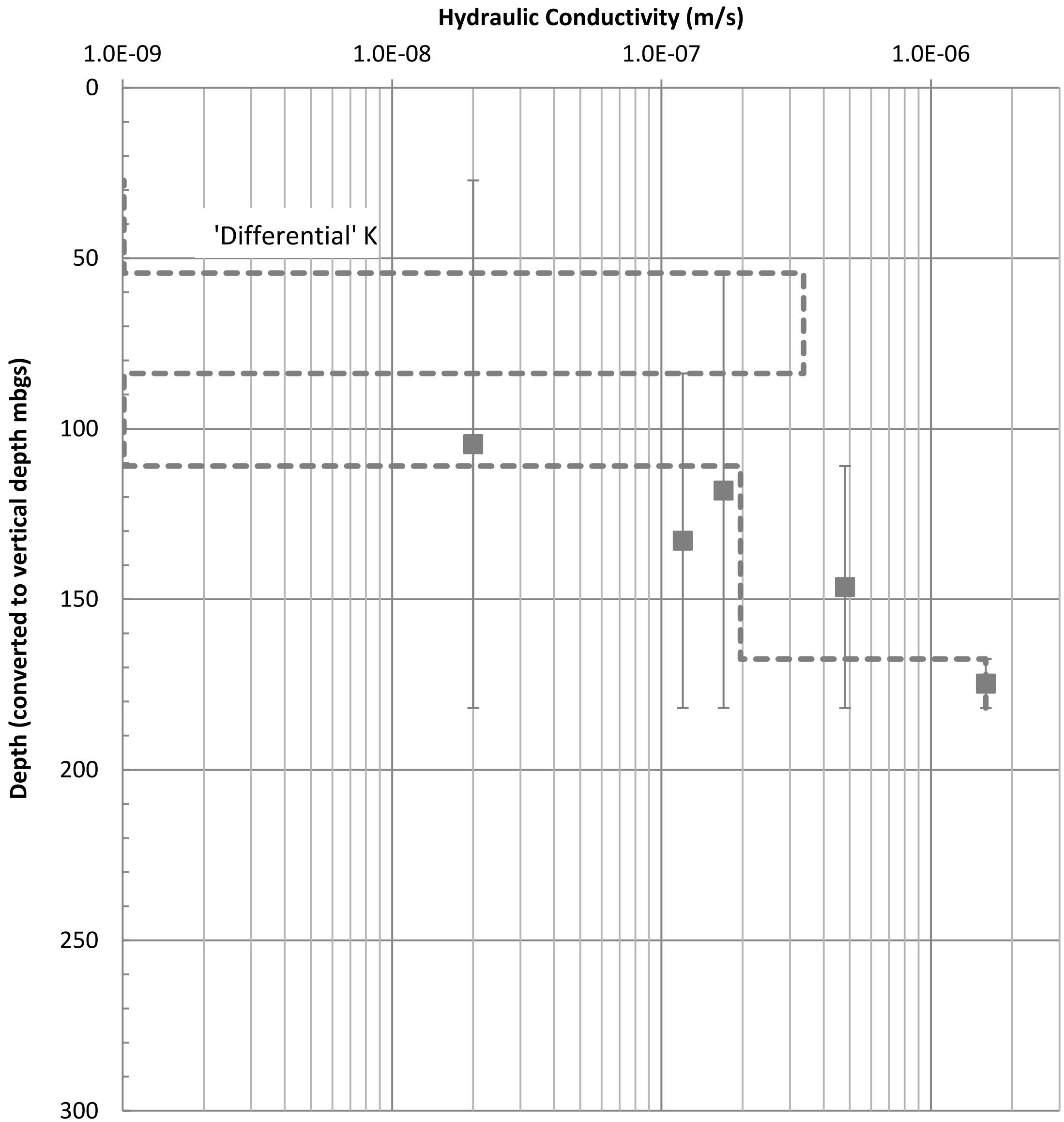
Figure 12a Packer Test Results for Existing Exploration Boreholes from West to East - TL10111



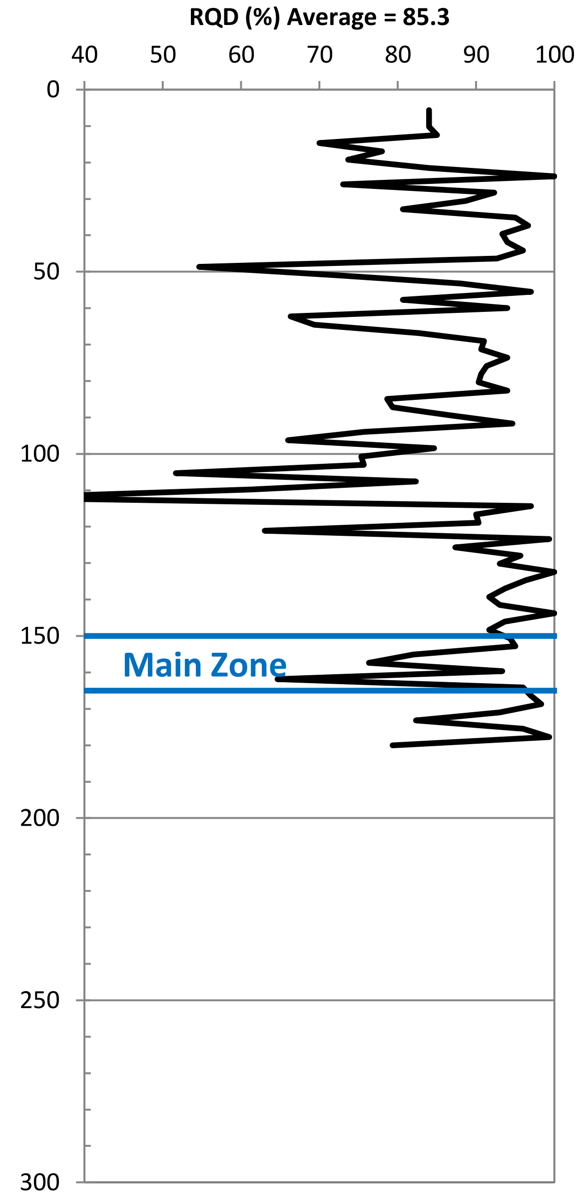
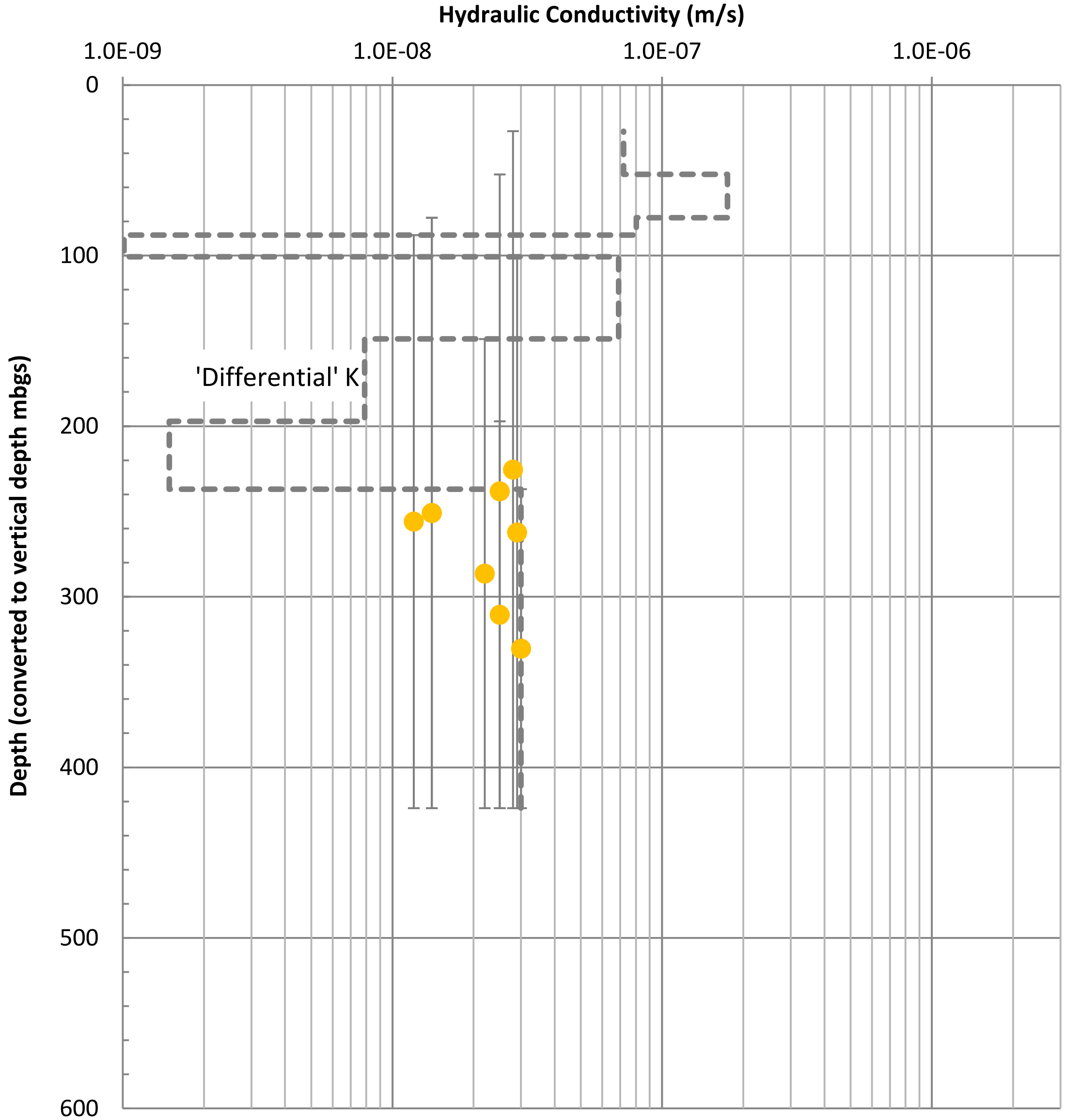


Figure 12b Packer Test Results for Existing Exploration Boreholes from West to East - TL0855



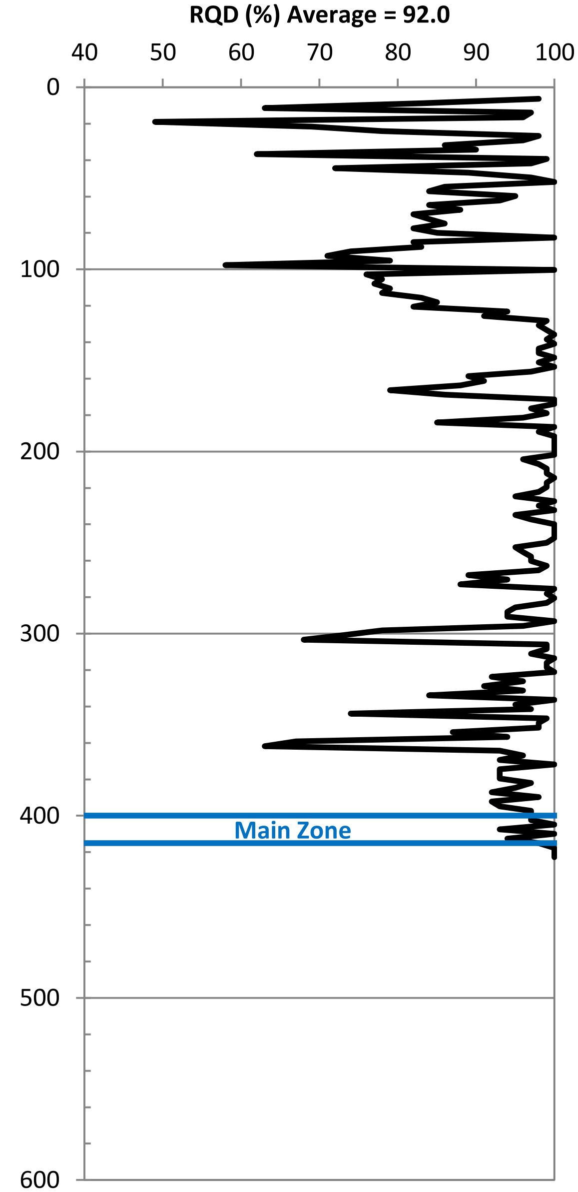
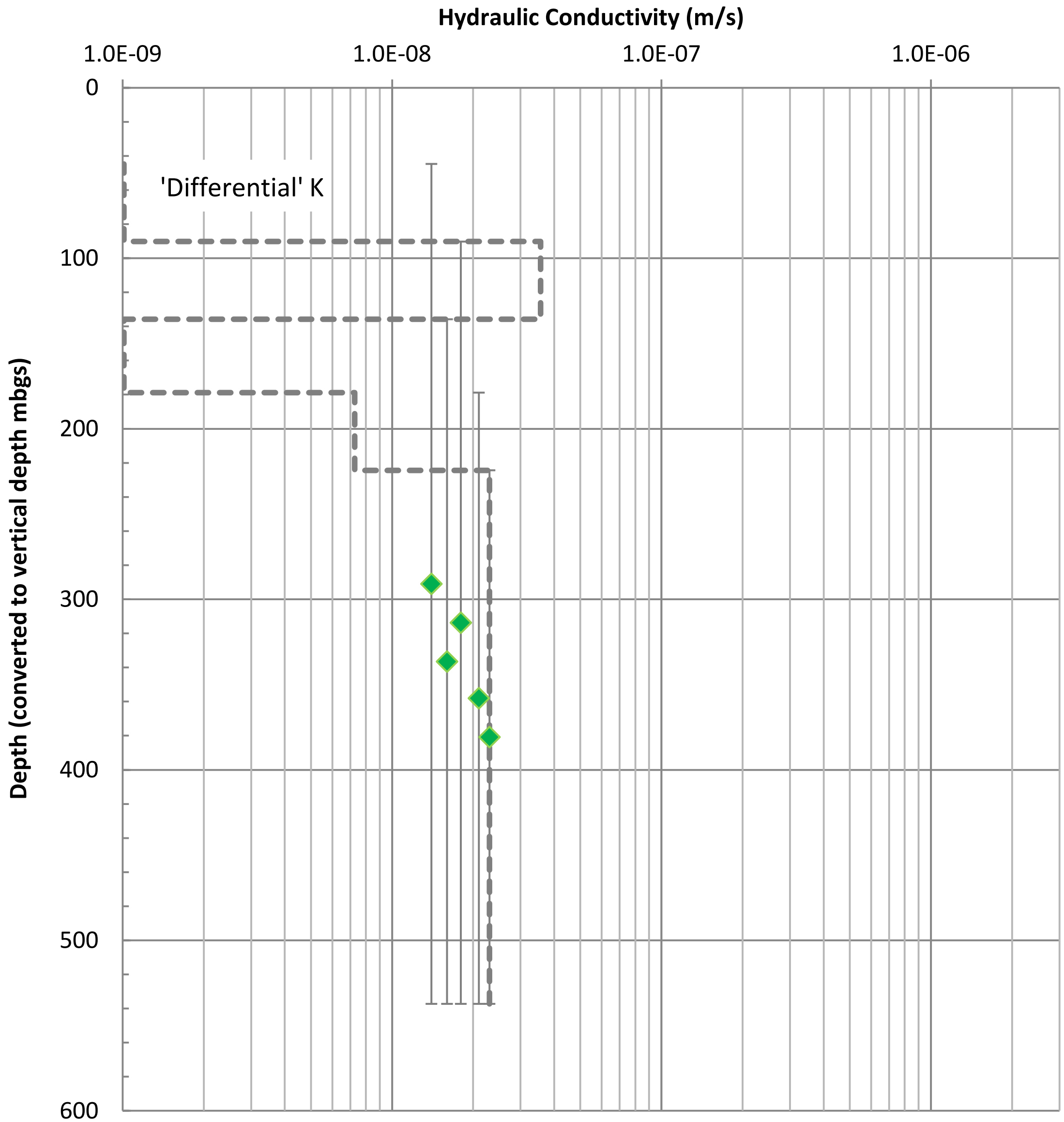


Figure 12c Packer Test Results for Existing Exploration Boreholes from West to East - TL11195



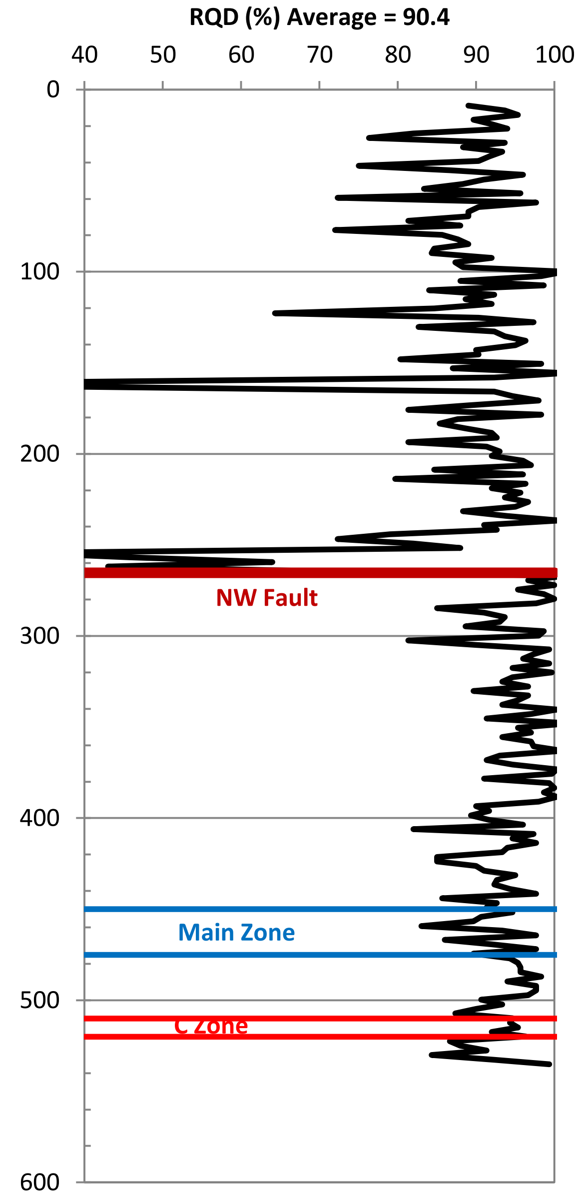
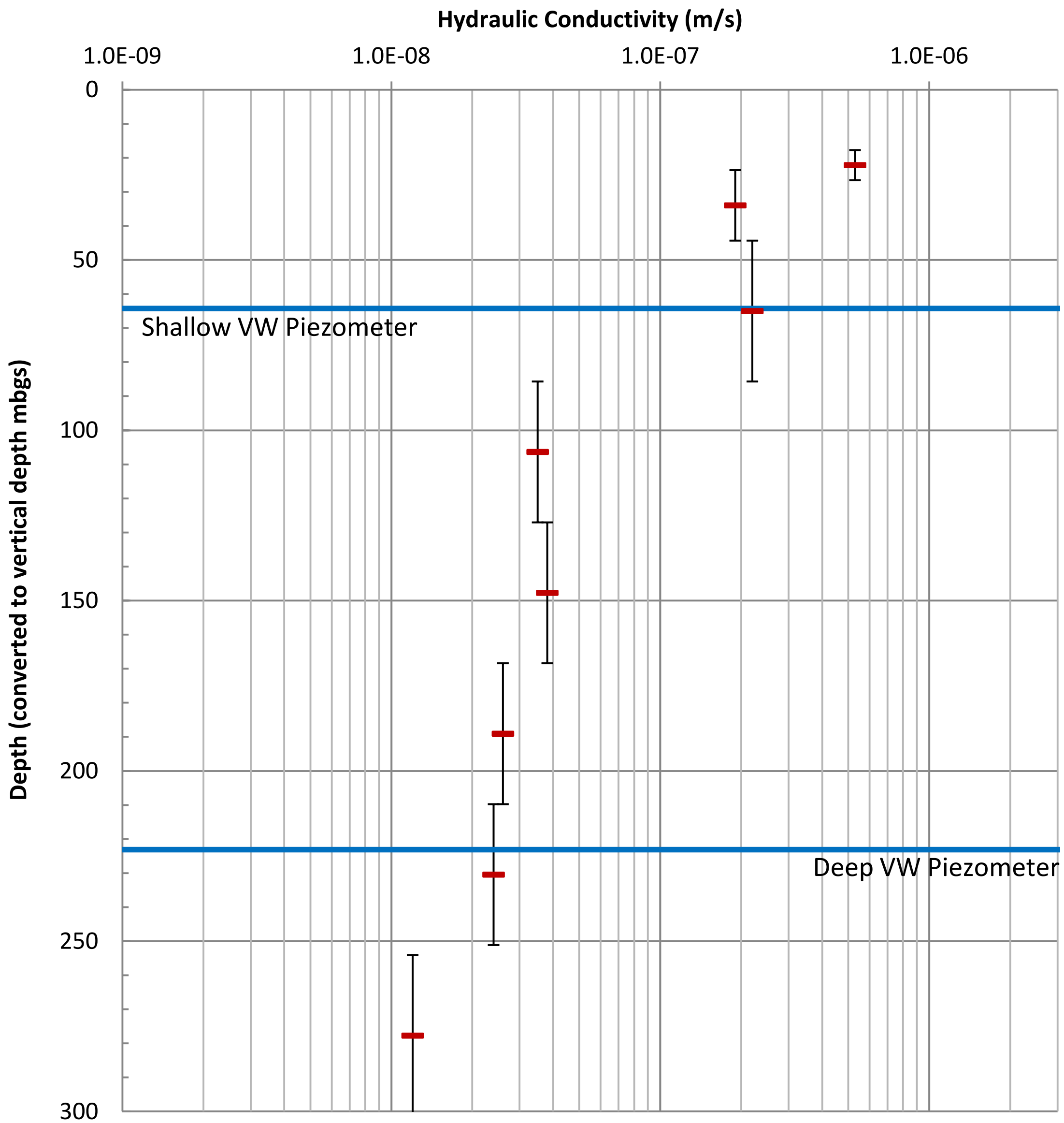


Figure 13a Packer Test Results for Hydrogeology Boreholes from West to East - TL13321



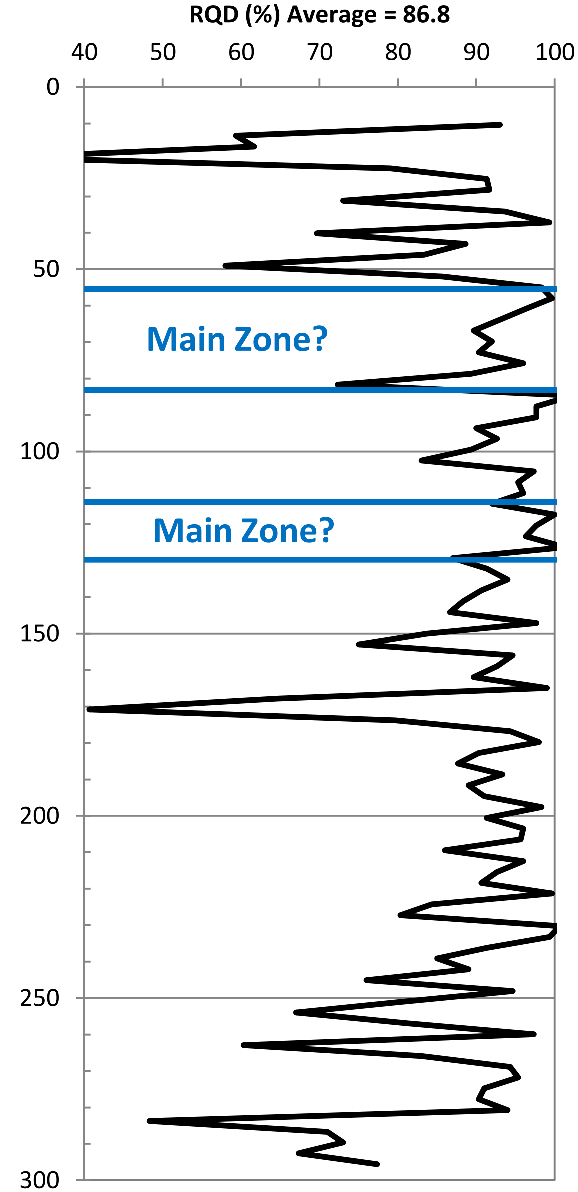


Figure 13b Packer Test Results for Hydrogeology Boreholes from West to East - TL13315

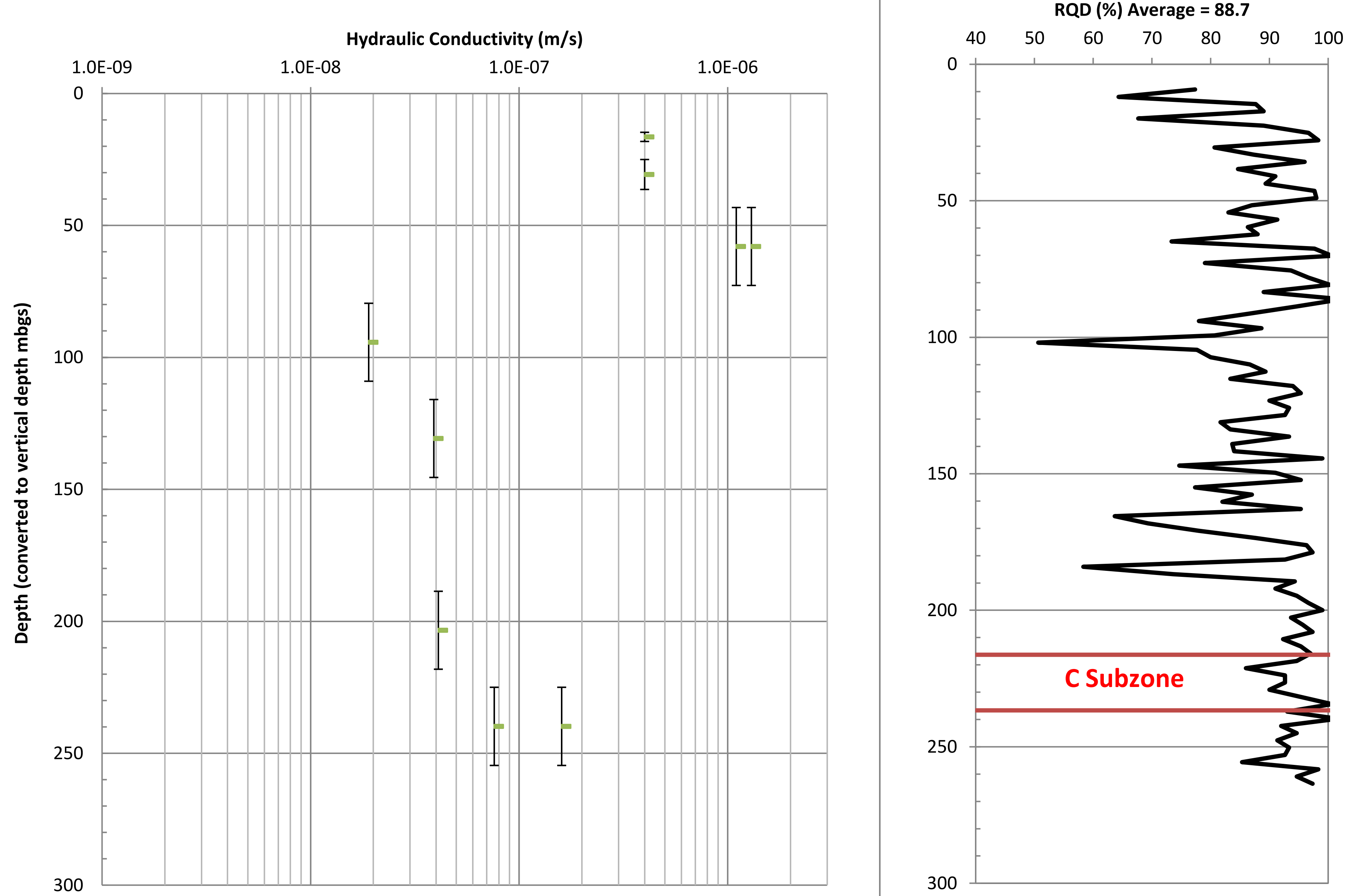


Figure 13c Packer Test Results for Hydrogeology Boreholes from West to East - TL13317

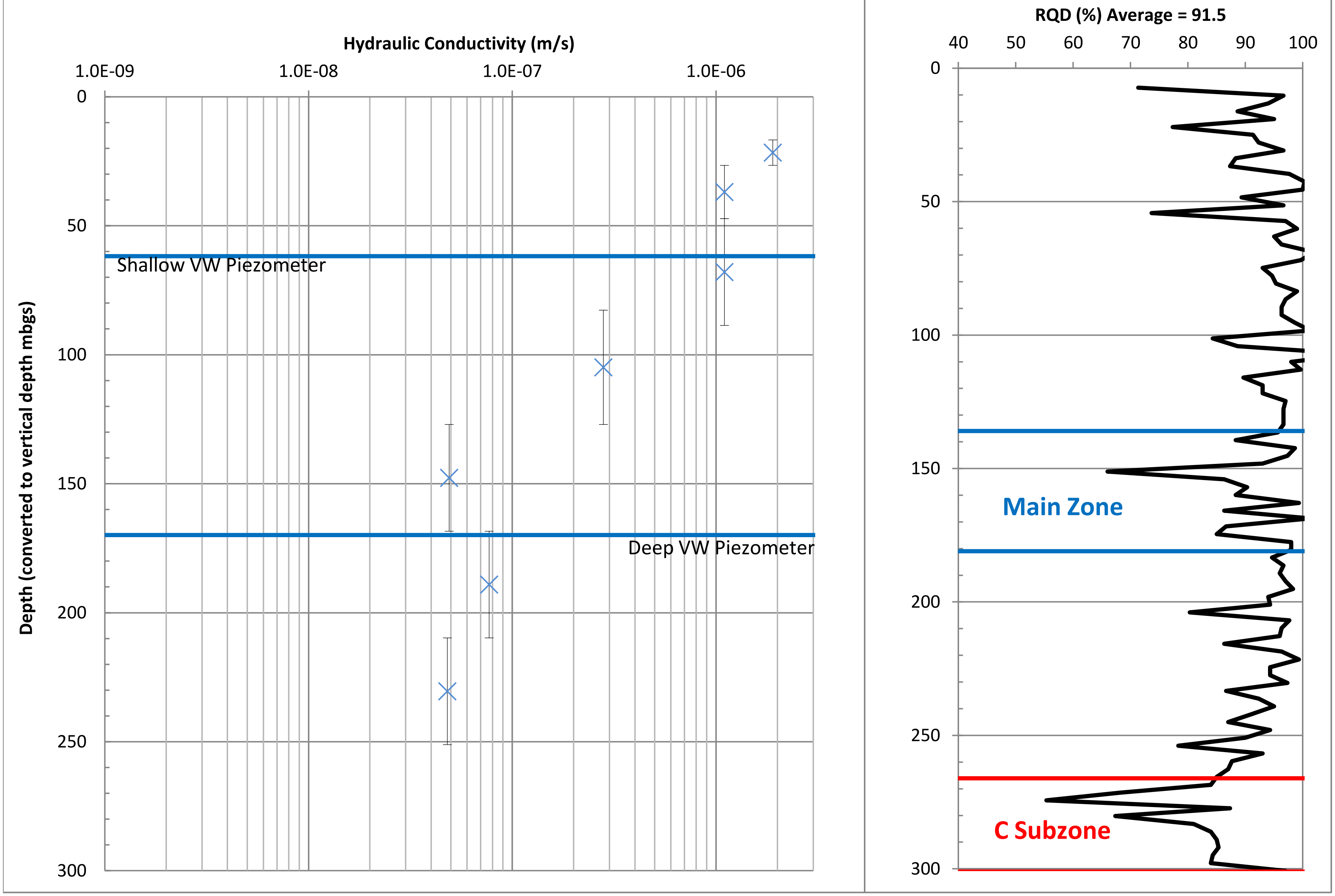


Figure 14 Combined Packer Test Results

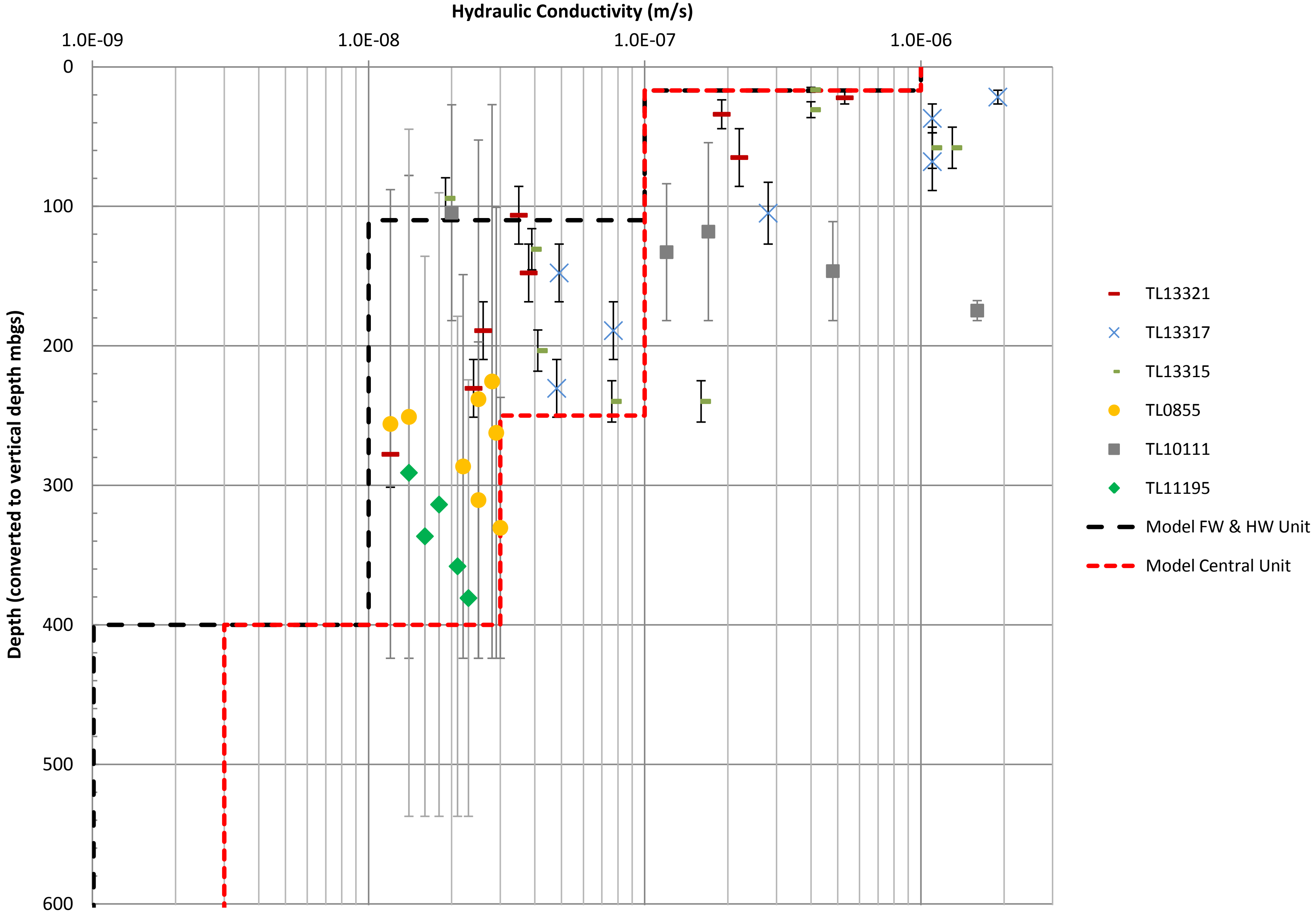


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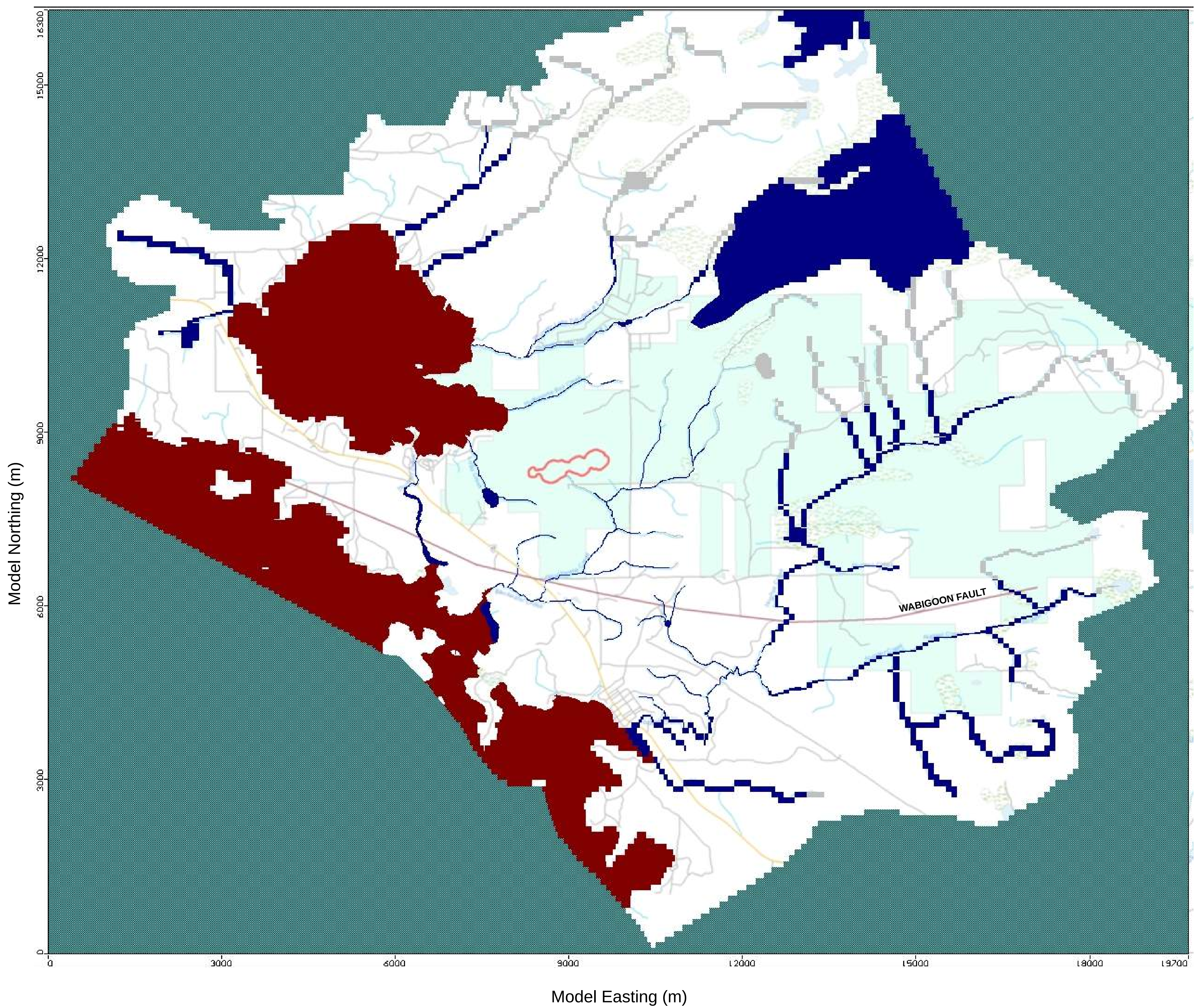
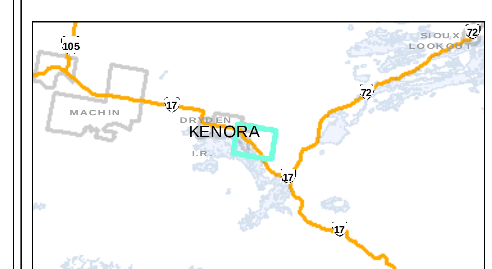
Figure 15

Model Domain and Boundary Conditions



Legend

- Constant Head Nodes
- River Nodes
- Drain Nodes



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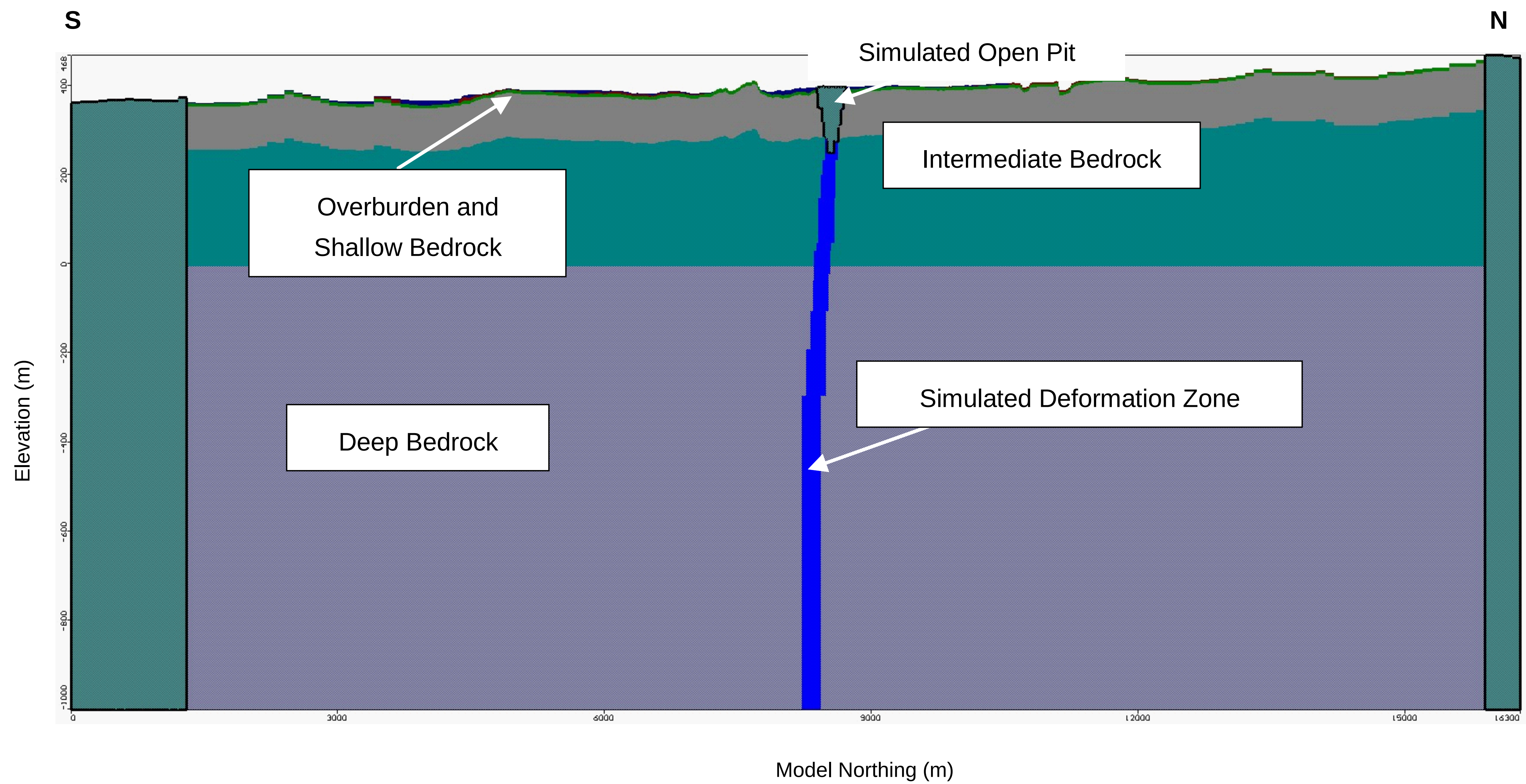

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Figure 16

Representative Groundwater Flow Model Cross Section

Legend

- Overburden and Shallow Bedrock
- Intermediate Bedrock
- Deep Bedrock

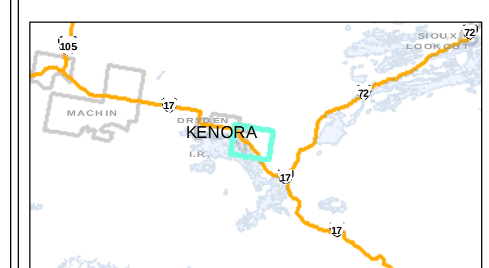

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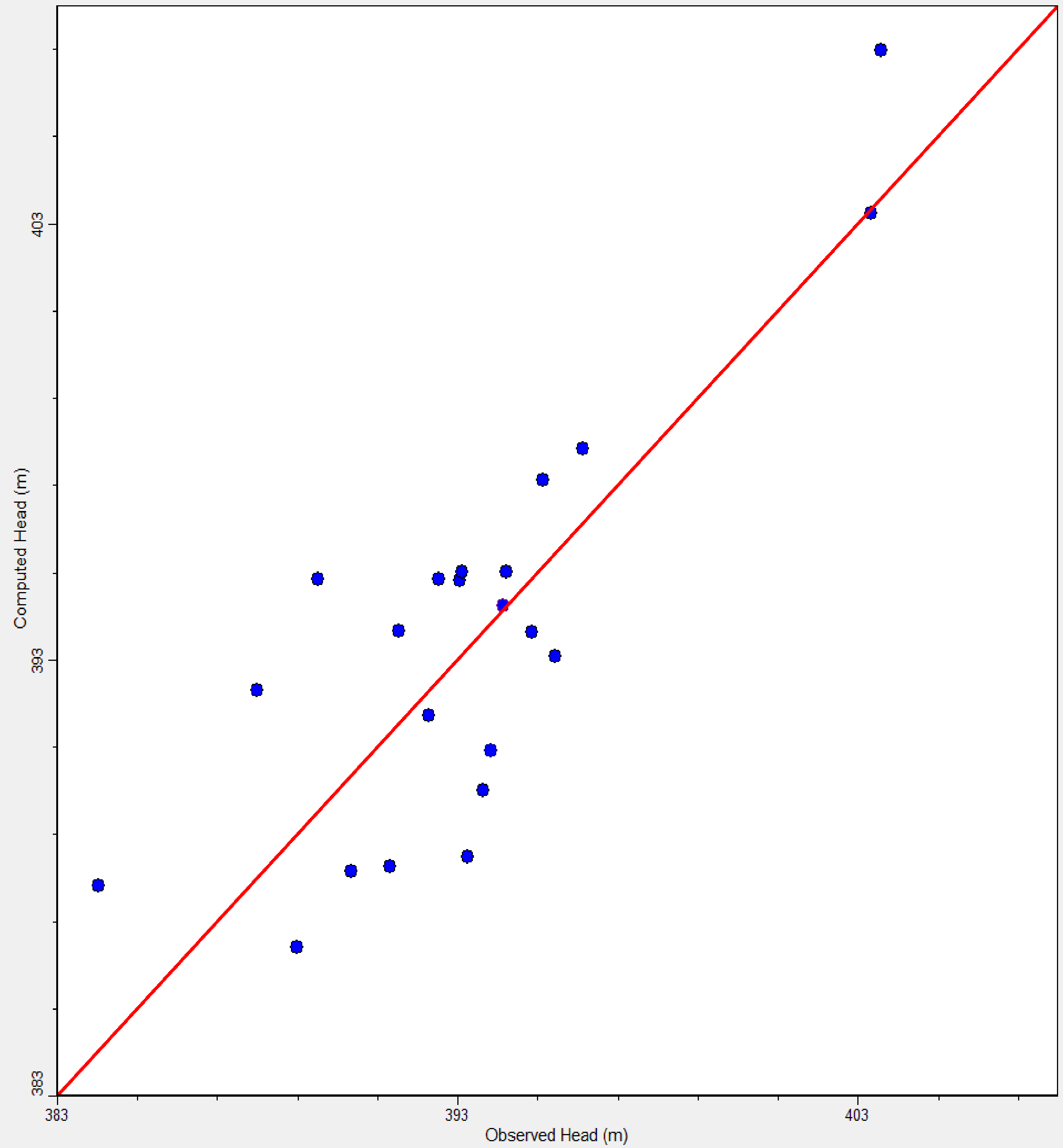
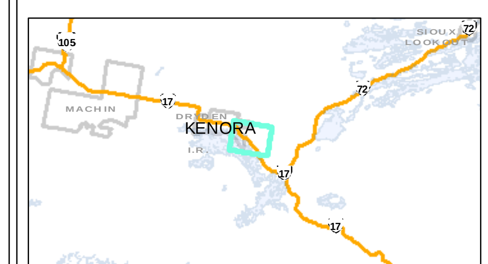
Figure 17

Computed vs. Observed Water Levels



Max. Residual: 5.34 (m) at TL13117/D
Min. Residual: -0.1 (m) at BH-1A/4.6
Residual Mean : 0.29 (m)
Abs. Residual Mean : 2.41 (m)

Num. of Data Points : 22
Standard Error of the Estimate : 0.6 (m)
Root Mean Squared : 2.78 (m)
Normalized RMS : 14.23 (%)
Correlation Coefficient : 0.82



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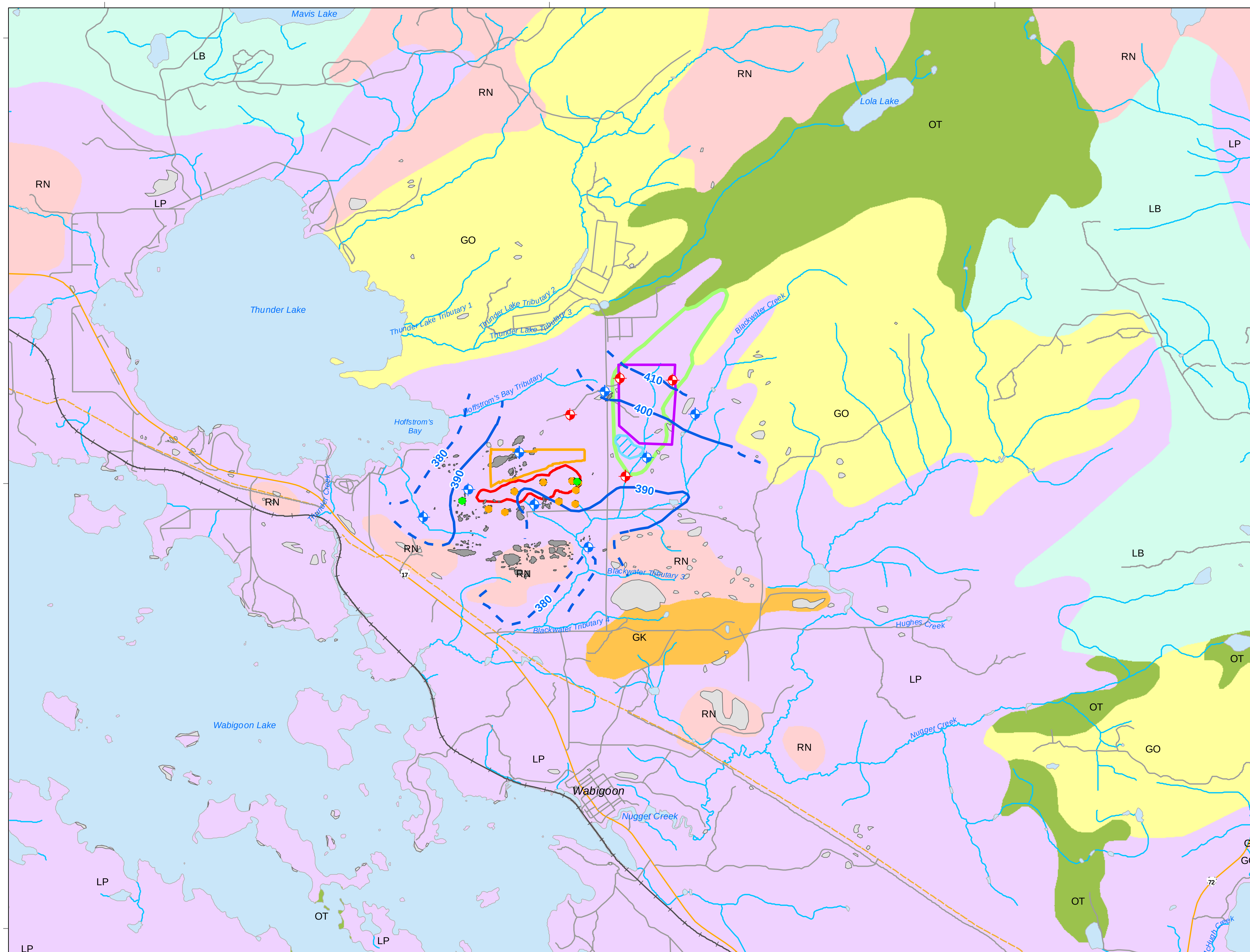

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Figure 18

Computed and Inferred Groundwater Elevation Contours in the Basal Sand/Shallow Bedrock

Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- 2013 Shallow Vibrating Wire Pezometer
- Exploration Borehole
- Computed Pre-Ming Groundwater Elevation Contours (masl, 5 m intervals)
- Water Level Contour (masl)
- Inferred Water Level Contour (masl)
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Railway
- Pipeline

Surficial Geology

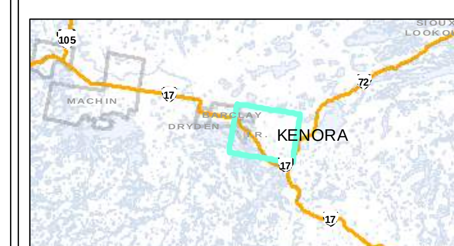
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LB: Raised Beach
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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N / S / E / W

Kilometers: 0 0.3 0.6 0.9 1.2 1.5

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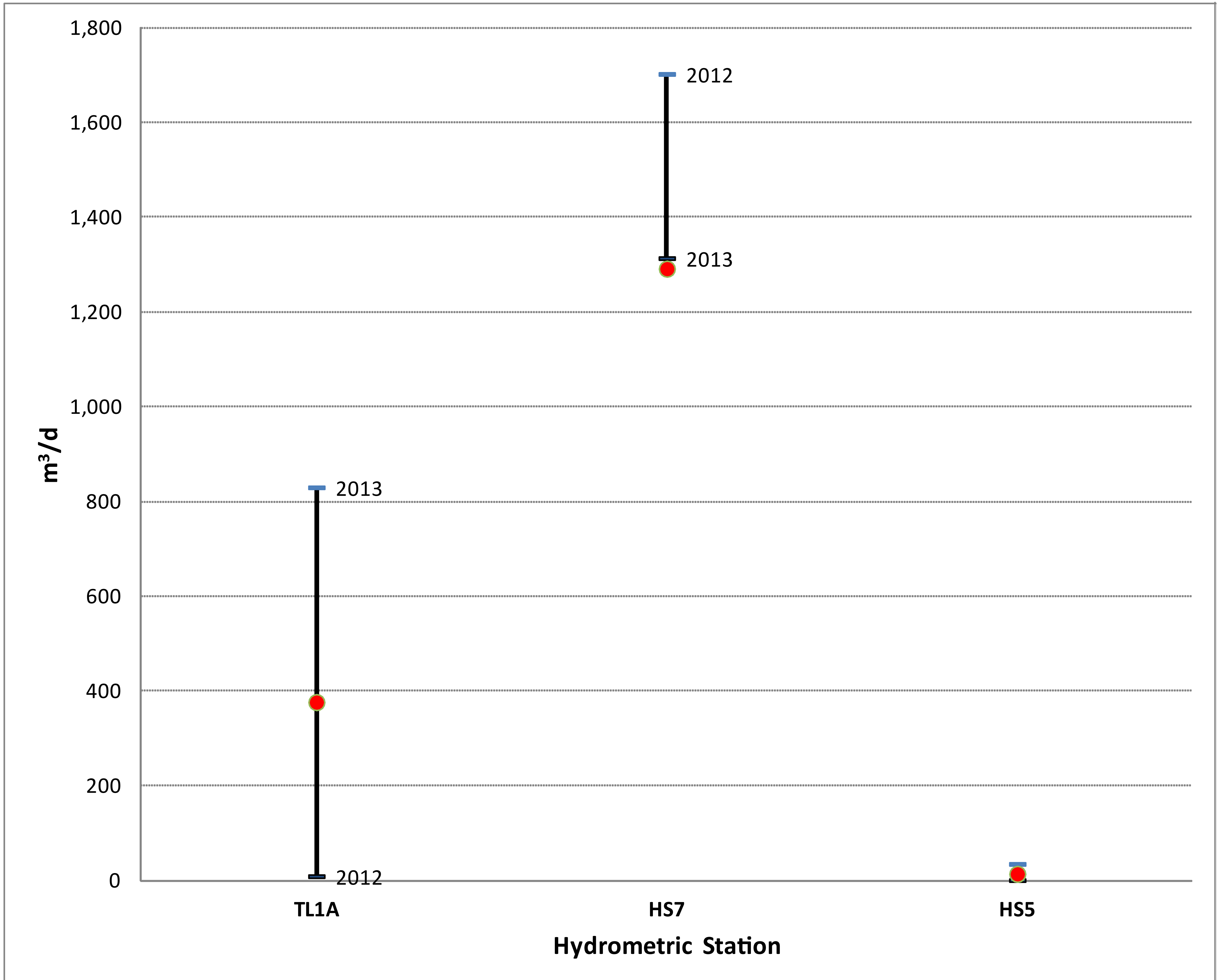

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Figure 19

Computed Baseflow Contribution and Gauged Minimum Daily Flow Rates

Minumum Gauged Daily Flow Rates for 2012 & 2013

Computed Baseflow

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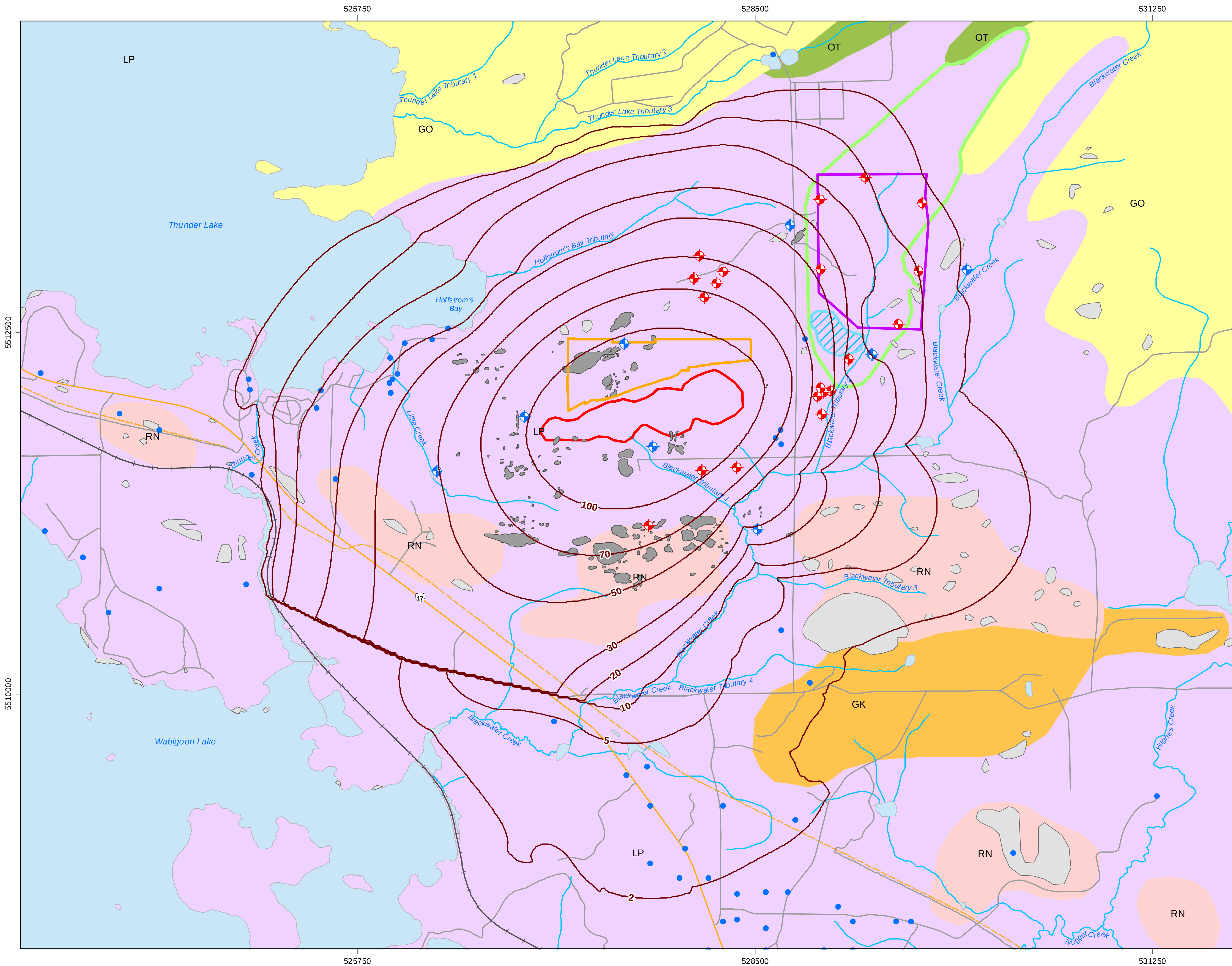
Figure 20

Model Predicted Drawdown in Basal Sand/Shallow Bedrock for the Fully Developed and Dewatered Goliath Mine (Base Case)



Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well
- Base Case Drawdown (m)
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond

Surficial Geology

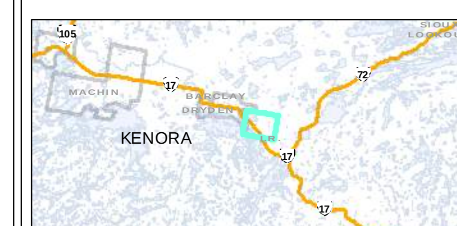
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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Meters: 0 130 260 390 520 650

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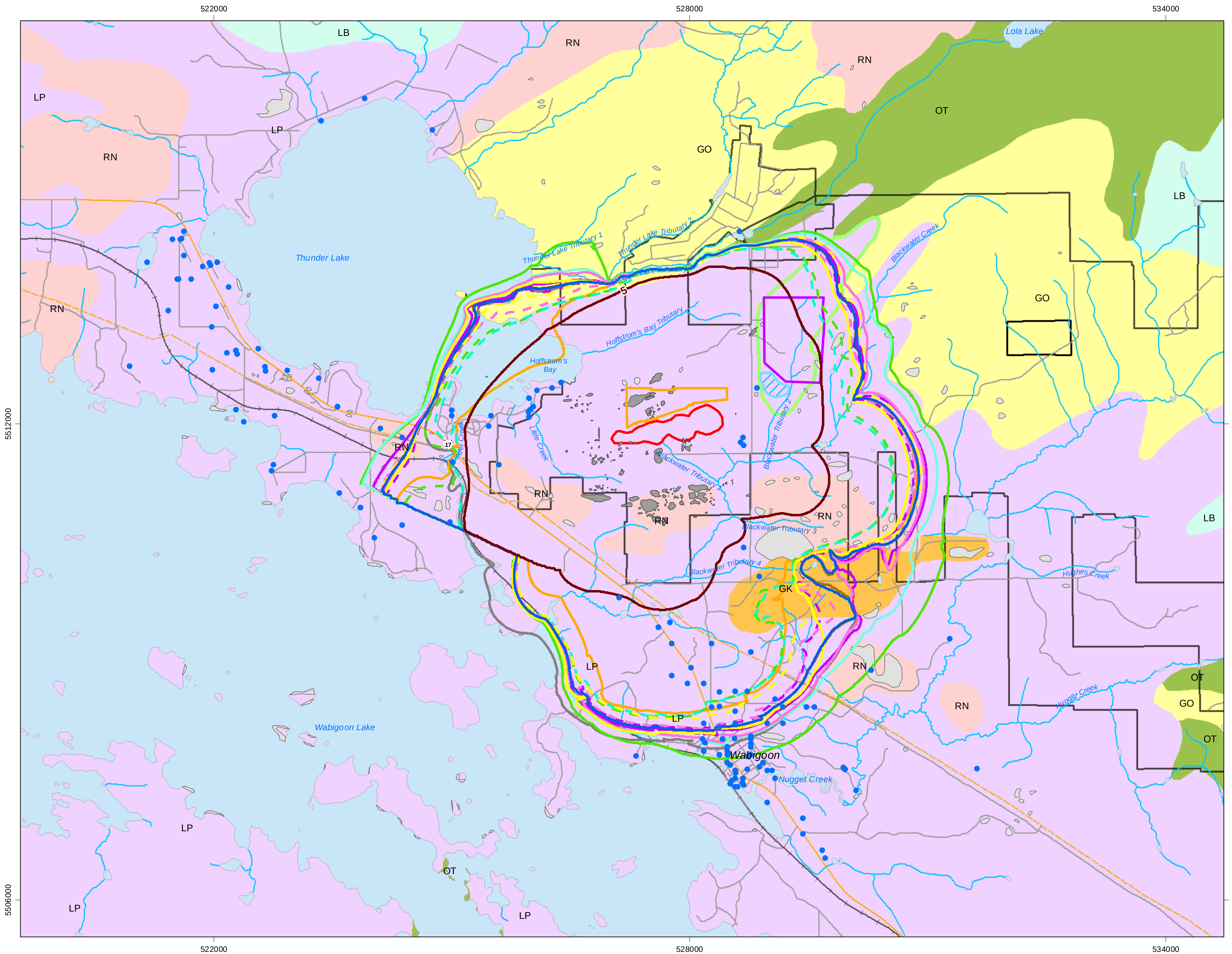


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 21

Model predicted ZOIs (1m drawdown) in Basal Sand/Shallow Bedrock Units

Legend

- Private MOE Water Well
- Base Case 5 m Drawdown

Zones of Influence

- Base Case
- 2a - HC of Basal Sand X 2
- 2b - HC of Basal Sand / 2
- 3a - HC of Shallow Bedrock X 2
- 3b - HC of Shallow Bedrock / 2
- 4a - HC of Deformation Zone X 2
- 4b - HC of Deformation Zone / 2
- 5a - HC of Intermediate Bedrock X 2
- 5b - HC of Intermediate Bedrock / 2
- 6a - HC of Deep Bedrock X 2
- 6b - HC of Deep Bedrock / 2
- 7 - HC of Clay is 1E-8 m/s Everywhere
- 8 - Neglecting Hydrogeological Impact of Wabigoon fault
- 9 - NW Fault
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Treasury Metals Property Boundary

Surficial Geology

- Sand - Clay / Silt - Sand Boundary

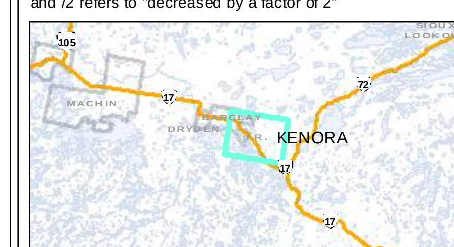
Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LB: Raised Beach
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals

HC refers to "Hydraulic Conductivity"
X2 refers "increased by a factor of 2"
and /2 refers to "decreased by a factor of 2"



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

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Date: July, 2014
Client: Ontario Infrastructure & Lands

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Checked by: MS
Revision No.: 2

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Kilometers 0 0.3 0.6 0.9 1.2 1.5

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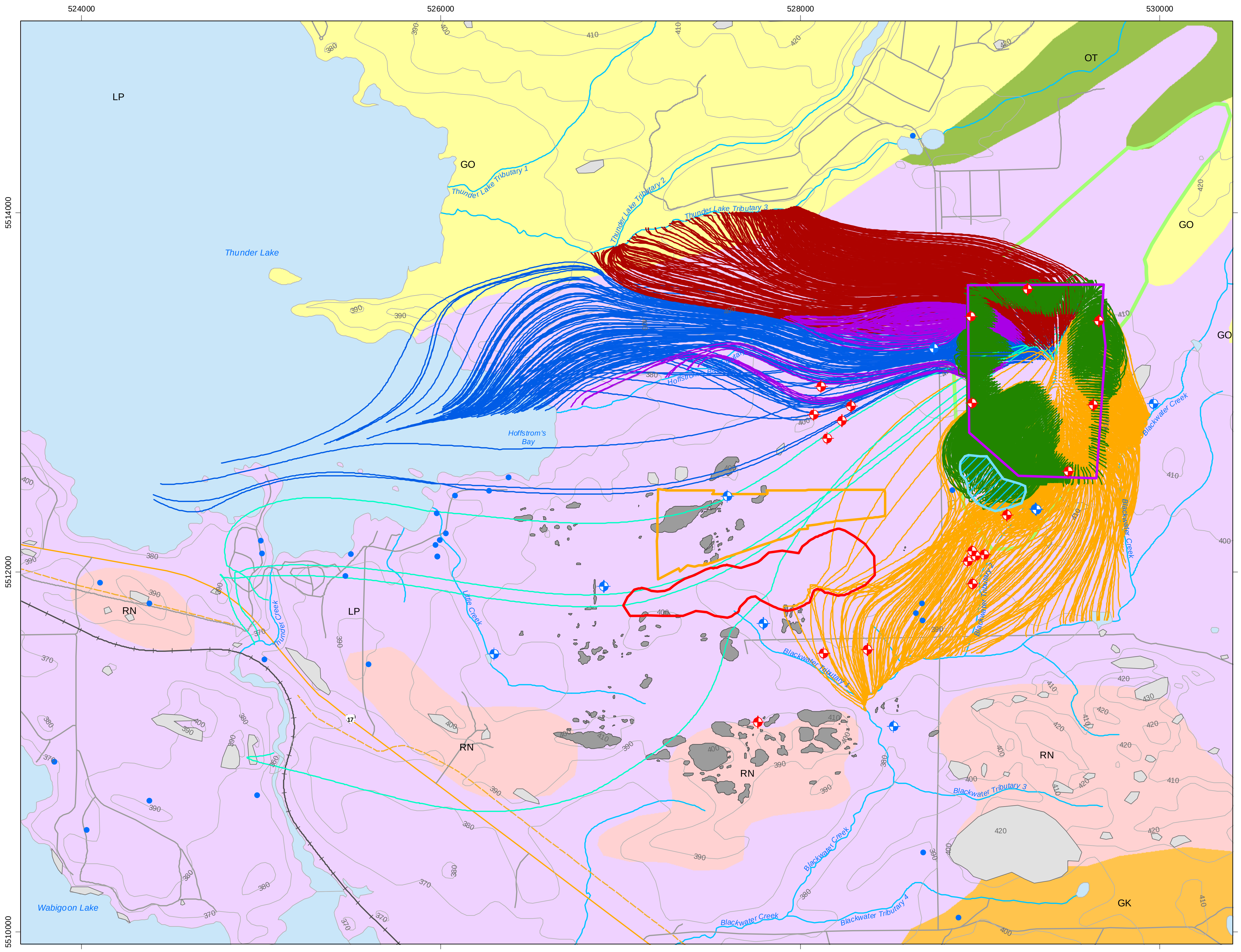
Figure 22

Particle-Tracking Results for Uncapped TMA and Flooded Mine Workings (Base Case)



Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well

Pathlines Discharging to:

- Perimeter Ditch and TMA Pond
- Hoffstrom's Bay Tributary
- Thunder Lake Tributary 3
- Thunder Creek
- Blackwater Creek
- Thunder Lake
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

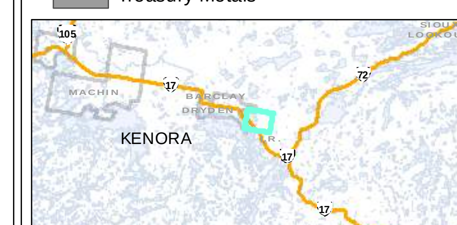
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

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Client: Ontario Infrastructure & Lands

Drawn by: DF
Checked by: MS
Revision No.: 2

UTM NAD 83
Zone 15N
1:20,000

Meters 0 100 200 300 400 500

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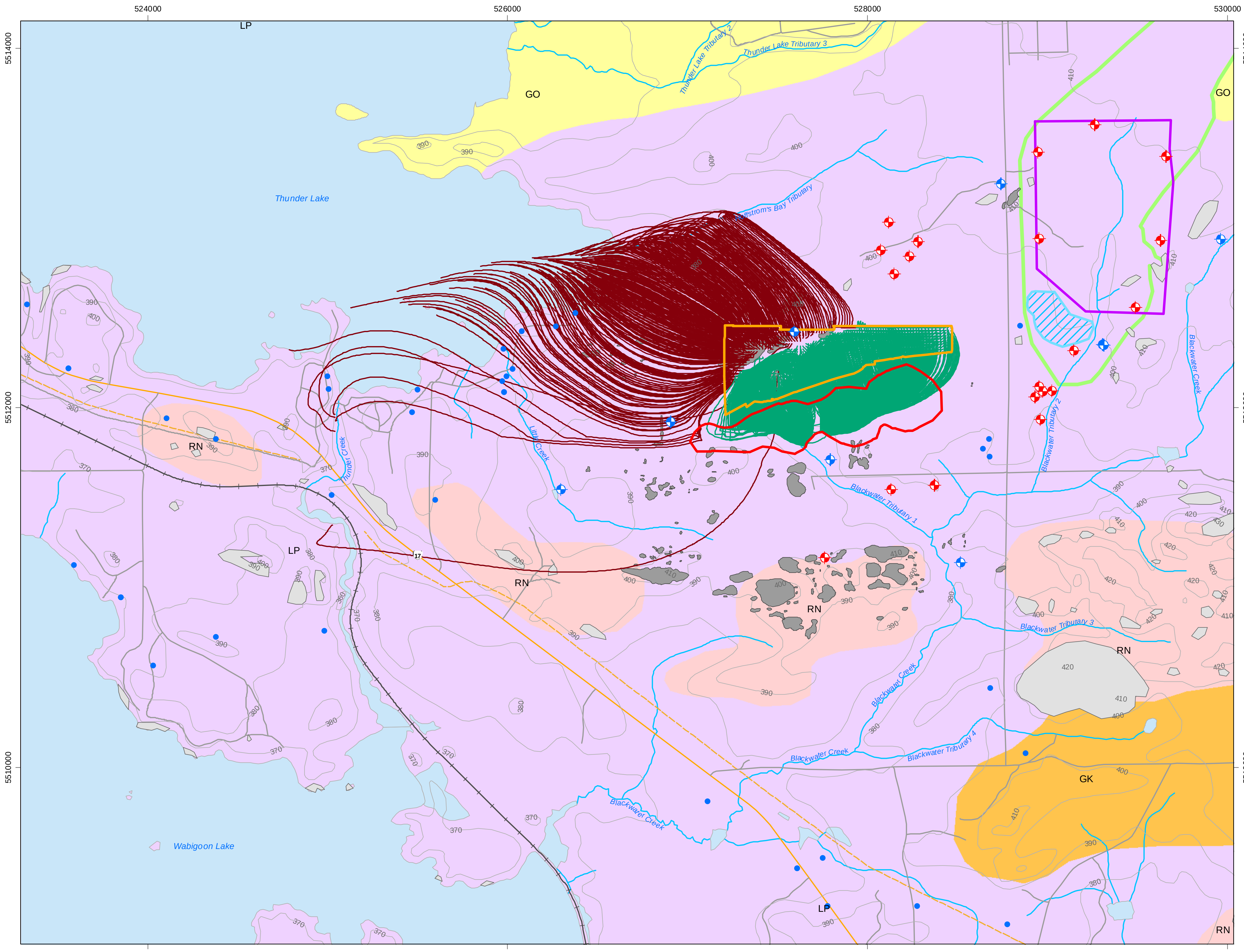
HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 23

Particle-Tracking Results for Uncapped WRSA and Flooded Mine Workings (Base Case)



Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well

Pathlines Discharging to:

- Pit
- Thunder Lake
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

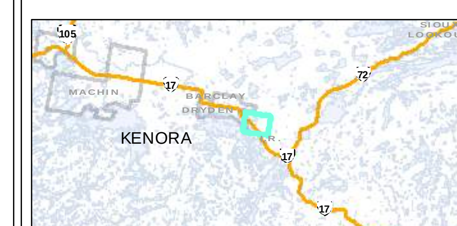
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

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Client: Ontario Infrastructure & Lands	Revision No.: 2

Meters 0 100 200 300 400 500

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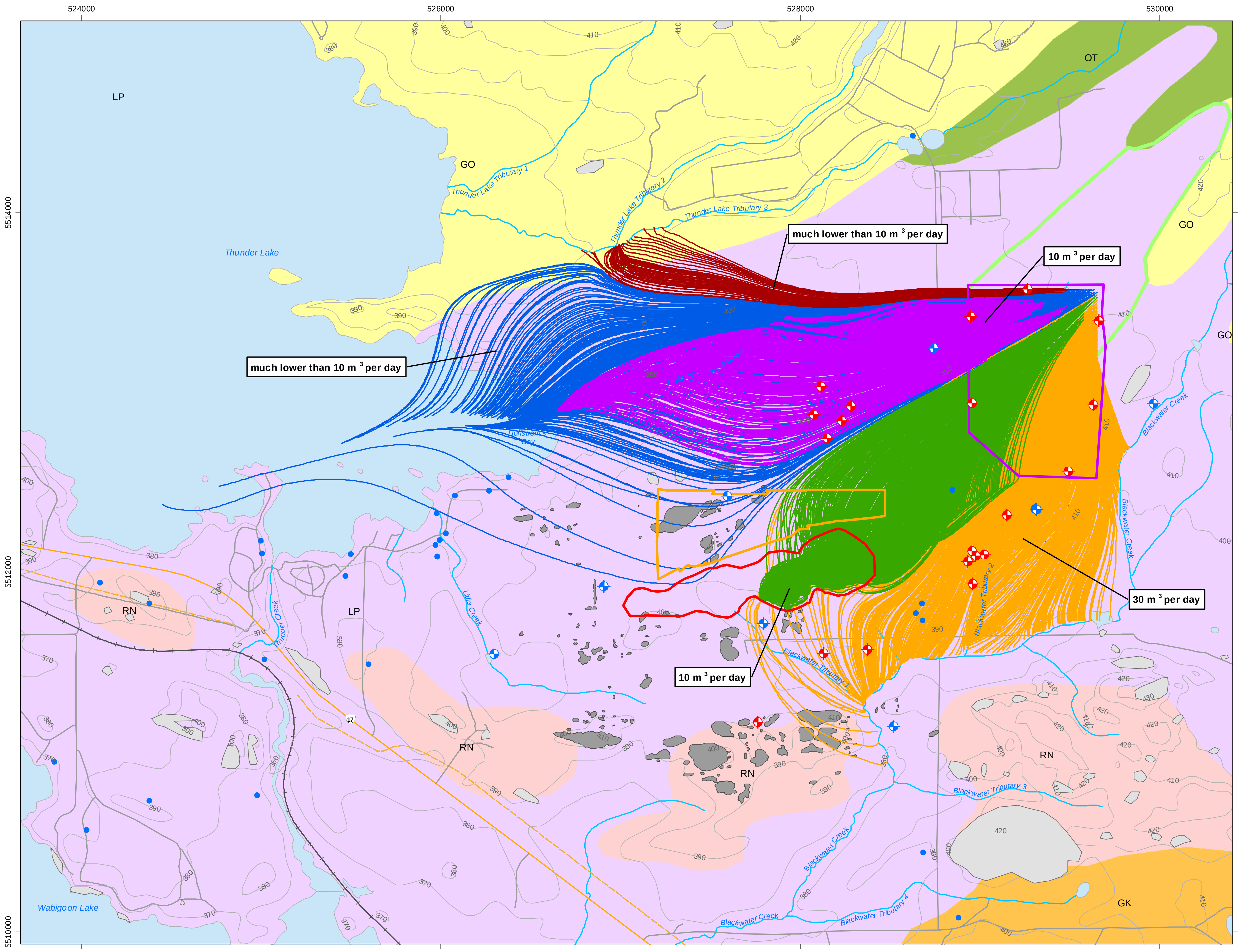
HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 24

Particle-Tracking Results for Capped TMA and Flooded Mine Workings (Base Case)



Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well

Pathlines Discharging to:

- Flooded Pit
- Hoffstrom's Bay Creek
- Thunder Lake Tributary 3
- Blackwater Creek
- Thunder Lake
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals

Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TB124004
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Meters 0 100 200 300 400 500

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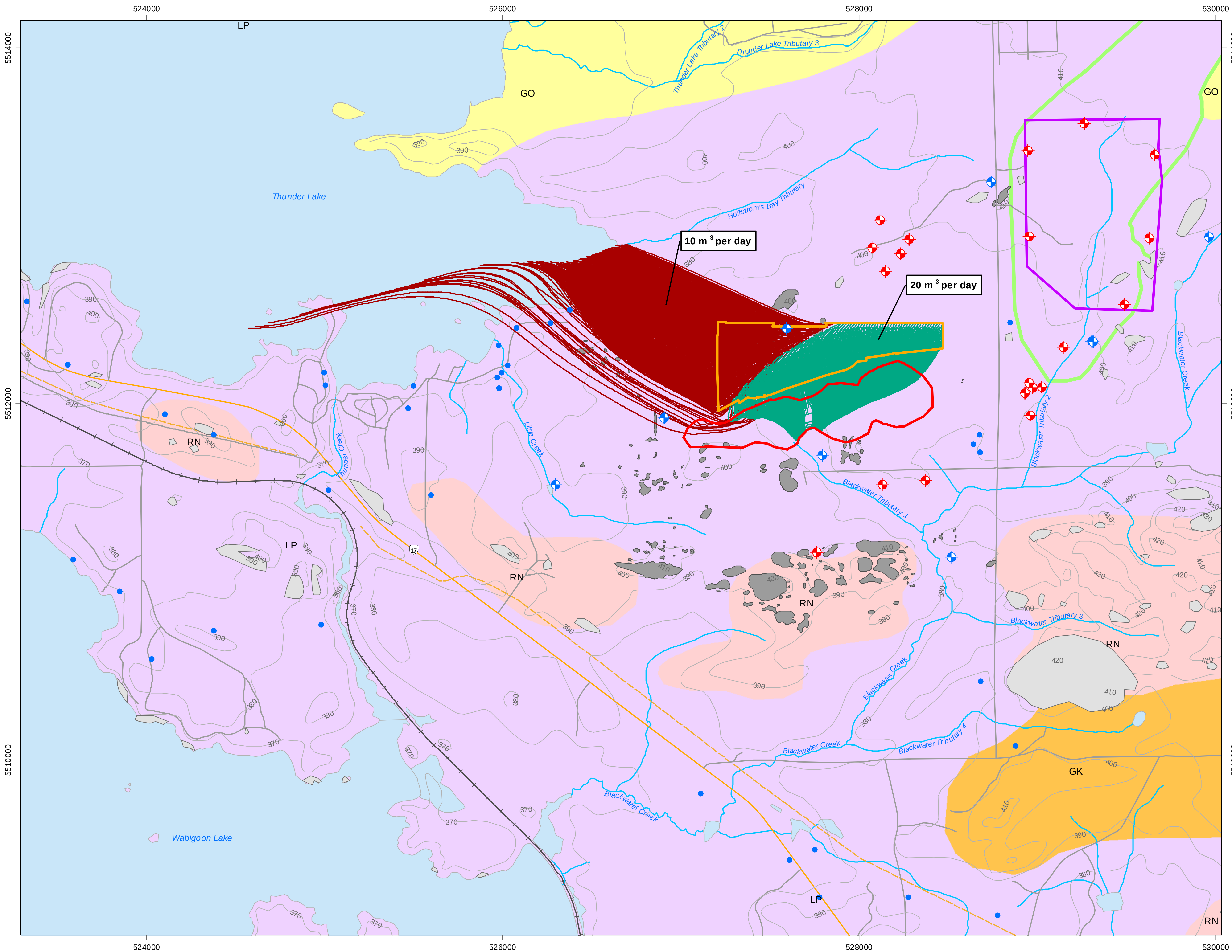
Figure 25

Particle-Tracking Results for Capped WRSA and Flooded Mine Workings (Base Case)



Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole
- MOE Private Water Well

Pathlines Discharging to:

- Pit
- Thunder Lake
- Proposed Open Pit
- Waste Rock Storage Area
- Tailings Management Area
- Elevation Contour (masl, 10 m intervals)

Surficial Geology

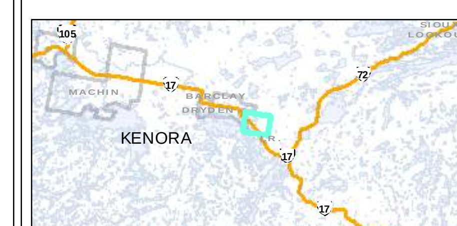
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TB124004
Date: August, 2014
Client: Ontario Infrastructure & Lands

Drawn by: DF
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Revision No.: 2

UTM NAD 83
Zone 15N
1:20,000

Meters 0 100 200 300 400 500

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APPENDIX A

2013 GROUNDWATER QUALITY WELL BOREHOLE LOGS

LOG OF BOREHOLE 1

PROJECT:	**Well Installation**	EQUIPMENT:	**HS Auger**
LOCATION:	**Treasury Metals** **Dryden, Ontario**	DIAMETER:	**250 mm**
CLIENT:	**Treasury Metals**	DATE:	**2013/5/13**
SURFACE ELEV.:	**metres**	TBT REF. No.:	**13-082**

DEPTH	ELEV.	SOIL PROFILE – DESCRIPTION	SAMPLES – TYPE	REMARKS
		TOPSOIL - 150 mm		Water level @ 0.4 m on completion.
		CLAY - Silty, grey	AS	
1			SS	
2			SS	
		- grey/brown	SS	
		SILT - Sandy, grey		
3		SAND - Silty, trace gravel, occasional cobbles, brown	SS	
		- occasional cobbles		
		BEDROCK		
4			RC	
		End of Borehole @ 4.6 m.		Monitoring Well installed to 4.6 m.
5				
6				
7				
8				
9				

Column headings: STRAT PLOT; % RECOVERY; TYPE; "N" VALUES; GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT 0 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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Web: www.tbte.ca

SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Peat Sampler

NOTES:

✖[3] ★[3]: Numbers refer to Sensitivity

ENCLOSURE 1

01A BOREHOLE 13-082 DRYDEN.GPJ TBT.GDT 13/5/27

LOG OF BOREHOLE 2A

PROJECT: **Well Installation**
LOCATION: **Treasury Metals Dryden, Ontario**
CLIENT: **Treasury Metals**
SURFACE ELEV.: **metres**

EQUIPMENT: **HS Auger**
DIAMETER: **250 mm**
DATE: **2013/5/15**
TBT REF. No.: **13-082**

Depth (m)	Description	Strat plot	Sample type	Remarks
0–0.3	PEAT - 300 mm			Water level @ 0.9 m on May 16, 2013.
0.3	CLAY - Silty, brown		AS	
~1			SS	
~2	- - - - - - grey/brown		SS	
~2.3	SAND & SILT - some gravel, grey/brown		SS	
~2.8	BEDROCK		RC	
4.4	End of Borehole @ 4.4 m.			Monitoring Well installed to 4.4 m.

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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Web: www.tbte.ca

SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Peat Sampler

NOTES:

× 3 ★ 3 : Numbers refer to Sensitivity

ENCLOSURE 2

LOG OF BOREHOLE 3A

TBT REF. No.: **13-082**	SURFACE ELEV.: **metres**
CLIENT: **Treasury Metals**	EQUIPMENT: **HS Auger**
PROJECT: **Well Installation**	DIAMETER: **80mm ID**
LOCATION: **Treasury Metals Dryden,Ontario**	DATE: **2013/5/14**

Depth (m)	Description	Sample Type	Remarks
0	TOPSOIL - 100 mm		Deep Well water level @ 0.6 m on completion. Shallow Well water level @ 1.2 m on completion.
	SAND - brown	AS	
1		SS	
	SAND - Silty, brown		
2		SS	
		SS	
3		SS	
4			
5		SS	
6			Shallow Monitoring Well installed to 6.1 m.
		SS	
7	CLAY - Silty, grey		
8		SS	
9	SILT - Sandy, grey		
		SS	

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, 'N' VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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Web: www.tbte.ca

SAMPLE TYPE LEGEND

- AS Auger Sample
- SS Split Spoon Sample
- TW 70mm Thin Wall Tube
- CC Concrete Core
- RC Rock Core
- PS Ponar Sample
- CB Core Barrel
- HS Hiller Peat Sampler

NOTES:

✖3 ★3: Numbers refer to Sensitivity

ENCLOSURE 3

LOG OF BOREHOLE 3A

TBT REF. No.: **13-082**
CLIENT: **Treasury Metals**
PROJECT: **Well Installation**
LOCATION: **Treasury Metals Dryden,Ontario**

SURFACE ELEV.: **metres**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2013/5/14**

DEPTH	ELEV.	DESCRIPTION (SOIL PROFILE)	SAMPLES: TYPE	REMARKS
		CLAY - Silty, grey		
11			SS	
12		SAND - Silty, grey	SS	
13		End of Borehole @ 12.9 m. Auger Refusal.		Deep Monitoring Well installed to 12.9 m.
14				
15				
16				
17				
18				
19				

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS: GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

01G-2 BOREHOLE 13-082 DRYDEN.GPJ TBT.GDT 13/5/27

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Peat Sampler

NOTES:

✖ 3 ★ 3 : Numbers refer to Sensitivity

ENCLOSURE 4

LOG OF BOREHOLE 4A

PROJECT:	**Well Installation**	EQUIPMENT:	**HS Auger**
LOCATION:	**Treasury Metals**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2013/5/16**
CLIENT:	**Treasury Metals**	TBT REF. No.:	**13-082**
SURFACE ELEV.:	**metres**		

SOIL PROFILE: DEPTH | ELEV | DESCRIPTION | STRAT PLOT — SAMPLES: % RECOVERY | TYPE | "N" VALUES — GROUND WATER CONDITIONS — DEPTH SCALE — CPT (kPa) 300 600 900 1200 1500 (kPa); ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100 — PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60 — REMARKS: GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Depth (m)	Description	Sample Type	Remarks
0	TOPSOIL - 150 mm		Water level @ 0.5 m on completion.
0.15	CLAY - Silty, brown	AS	
1		SS	
2		SS	
2.4	BEDROCK		
3–4		RC	
5–6		RC	
7–8		RC	
8.3	End of Borehole @ 8.3 m.		Monitoring Well installed to 8.3 m.

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9

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Web: www.tbte.ca

SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Peat Sampler

NOTES:

✖ 3 ★ 3 : Numbers refer to Sensitivity

ENCLOSURE 5

LOG OF BOREHOLE 5A

PROJECT: **Well Installation**
LOCATION: **Treasury Metals, Dryden, Ontario**
CLIENT: **Treasury Metals**
SURFACE ELEV.: **metres**

EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2013/5/15**
TBT REF. No.: **13-082**

DEPTH	ELEV.	DESCRIPTION	SAMPLE TYPE	REMARKS
0		TOPSOIL - 150 mm		Water level @ 0.8 m on completion.
		CLAY - Silty, brown	AS	
1		- grey/brown	SS	
2		- brown	SS	
			SS	
3			SS	
5		- grey/brown	SS	
6		- grey	SS	
8			SS	
9			SS	
9.6		End of Borehole @ 9.6 m.		Monitoring Well installed to 9.6 m.

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, 'N' VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS: GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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SAMPLE TYPE LEGEND
- AS Auger Sample
- SS Split Spoon Sample
- TW 70mm Thin Wall Tube
- CC Concrete Core
- RC Rock Core
- PS Ponar Sample
- CB Core Barrel
- HS Hiller Peat Sampler

NOTES:

× 3 ★ 3 : Numbers refer to Sensitivity

ENCLOSURE 6

01A BOREHOLE 13-082 DRYDEN.GPJ TBT.GDT 13/5/27

LOG OF BOREHOLE 6D

PROJECT:	**Well Installation**	EQUIPMENT:	**HS Auger**
LOCATION:	**Treasury Metals**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2013/5/16**
CLIENT:	**Treasury Metals**	TBT REF. No.:	**13-082**
SURFACE ELEV.:	**metres**		

DEPTH	ELEV.	DESCRIPTION (SOIL PROFILE)	SAMPLE TYPE	REMARKS
0		TOPSOIL - 100 mm		
		CLAY - Silty, brown	AS	
		- - - - -		
1		- grey/reddish brown	SS	
		- - - - -		
2		- grey/brown	SS	
			SS	
3			SS	
4.5		SAND - Silty, brown	SS	
6		End of Borehole @ 6.0 m. Auger Refusal.		Monitoring Well installed to 6.0 m.

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE (1–9); CPT (kPa) 300 600 900 1200 1500; ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N); ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS: GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

TBT Engineering Limited 1918 Yonge Street Thunder Bay, Ontario P7C 6T9 PH: (807) 624-5160 FX: (807) 624-5161 Email: tbte@tbte.ca Web: www.tbte.ca	*SAMPLE TYPE LEGEND* AS Auger Sample SS Split Spoon Sample TW 70mm Thin Wall Tube CC Concrete Core RC Rock Core PS Ponar Sample CB Core Barrel HS Hiller Peat Sampler	*NOTES:* ✖[3] ★[3]: Numbers refer to Sensitivity

ENCLOSURE 7

01A BOREHOLE 13-082 DRYDEN.GPJ TBT.GDT 13/5/27

LOG OF BOREHOLE 7A

PROJECT:	Well Installation	EQUIPMENT:	HS Auger
LOCATION:	Treasury Metals Dryden, Ontario	DIAMETER:	80mm ID
		DATE:	2013/5/17
CLIENT:	Treasury Metals	TBT REF. No.:	13-082
SURFACE ELEV.:	metres		

Depth (m)	Soil Profile – Description	Samples – Type	Ground Water Conditions	Remarks
0	TOPSOIL - 100 mm			Water level @ 1.2 m on completion.
	CLAY - Silty, brown	AS		
1		SS	▼ (1.2 m)	
2	- grey/brown	SS		
2.5	- grey/reddish brown	SS		
3	- grey/brown	SS		
5	- grey	SS		
6	SILT & SAND - some gravel, grey	SS		
7	End of Borehole @ 7.0 m. Auger Refusal.			Monitoring Well installed to 7.0 m.

Column headings: DEPTH; ELEV.; DESCRIPTION; STRAT PLOT; % RECOVERY; TYPE; 'N' VALUES; GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N); ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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SAMPLE TYPE LEGEND

- AS Auger Sample
- SS Split Spoon Sample
- TW 70mm Thin Wall Tube
- CC Concrete Core
- RC Rock Core
- PS Ponar Sample
- CB Core Barrel
- HS Hiller Peat Sampler

NOTES:

×3 ★3: Numbers refer to Sensitivity

ENCLOSURE 8

LOG OF BOREHOLE 8A

PROJECT:	**Well Installation**	EQUIPMENT:	**HS Auger**
LOCATION:	**Treasury Metals**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2013/5/17**
CLIENT:	**Treasury Metals**	TBT REF. No.:	**13-082**
SURFACE ELEV.:	**metres**		

DEPTH (m)	DESCRIPTION	SAMPLE TYPE	REMARKS
0 – 0.1	TOPSOIL - 100 mm		Water level @ 2.1 m on completion.
0.1 – 2.2	CLAY - Silty, brown	AS, SS, SS	
2.2 – 3.1	SILT - Sandy, layered, grey/brown	SS	
3.1 – 8.5	BEDROCK	RC, RC, RC, RC	Monitoring Well installed to 8.2 m.
8.5	End of Borehole @ 8.5 m.		

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); ✖ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS – GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Peat Sampler

NOTES:

✖3 ★3 : Numbers refer to Sensitivity

ENCLOSURE 9

APPENDIX B

2014 GEOTECHNICAL BOREHOLE LOGS

LOG OF BOREHOLE 14-01

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512562 E 529491**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 27**

DEPTH	ELEV.	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	% RECOVERY (SAMPLES)	TYPE (SAMPLES)	"N" VALUES (SAMPLES)	GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa) 300 600 900 1200 1500 / × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) / ■ SPT (N) ◆ DCPT / 0 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 20 40 60	REMARKS / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		ORGANICS, black									Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		SAND, trace Silt, brown			AS						
1		SAND, Silty, grey and brown			SS	7		1	■		
		End of Borehole @ 1.5 m. Auger refusal.									
2								2			
3								3			
4								4			
5								5			
6								6			
7								7			
8								8			
9								9			
10								10			
11								11			
12								12			
13								13			
14								14			

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 1

LOG OF BOREHOLE 14-02

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512932 E 529632**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 27**

SOIL PROFILE | SAMPLES | CPT (kPa) 300 600 900 1200 1500 | ✕ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) ■ SPT (N) ◆ DCPT 0 20 40 60 80 100 | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60 | REMARKS — GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH SCALE	REMARKS
		ORGANICS, black							Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		SAND, trace Silt, brown			AS				
		CLAY and SILT, grey			AS				
1		End of Borehole @ 1.05 m. Auger and Split Spoon refusal.						1	
2								2	
3								3	
4								4	
5								5	
6								6	
7								7	
8								8	
9								9	
10								10	
11								11	
12								12	
13								13	
14								14	

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

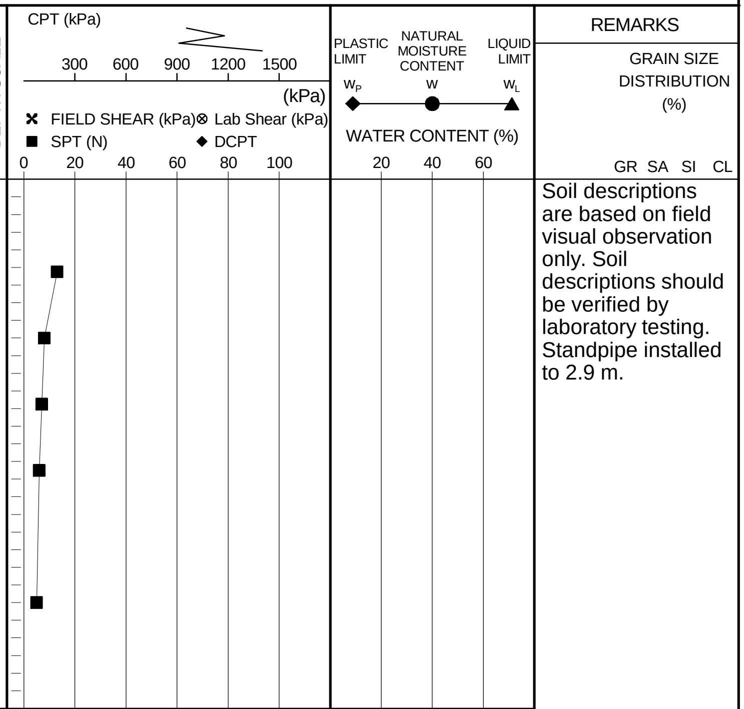
ENCLOSURE 2

LOG OF BOREHOLE 14-03

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road**
Dryden, Ontario

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5513400 E 529660**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 26**

DEPTH (m)	ELEV.	DESCRIPTION	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS
0		ORGANICS, black				Standpipe	Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing. Standpipe installed to 2.9 m.
0.3		SAND, some Silt, brown		AS			
				SS	13		
1.5		SILT and SAND, trace Clay, layered, grey		SS	8		
				SS	7		
3.0		SILT, some Clay and Sand, grey		SS	6		
4.5		SILT and CLAY, grey		SS	5		
6.0		End of Borehole @ 6.0 m. Auger refusal.					



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SAMPLE TYPE LEGEND
AS Auger Sample
SS Split Spoon Sample
TW 70mm Thin Wall Tube
CC Concrete Core
RC Rock Core
PS Ponar Sample
CB Core Barrel
HS Hiller Sample
AC Asphalt Core

NOTES:

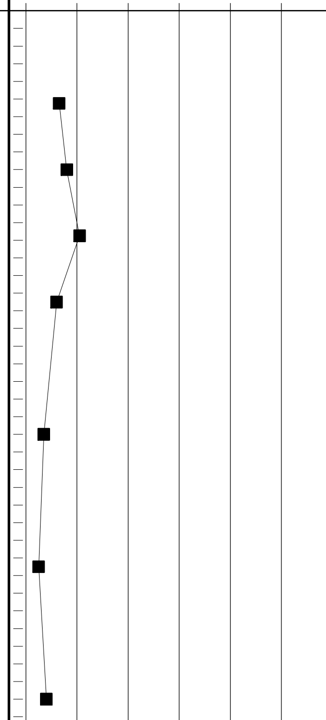
ENCLOSURE 3

LOG OF BOREHOLE 14-04

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road**
Dryden, Ontario

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5513576 E 529264**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 26**

Depth (m)	Elev.	Description (Soil Profile)	Strat Plot	% Recovery	Type	"N" Values	Ground Water Conditions	Remarks
0		ORGANICS, black						Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		SAND, trace Silt, brown			AS			
1		- - - - - - grey			SS	13		
2					SS	16		
2.5					SS	21		
3					SS	12		
4.5		SILT, trace Clay, grey			SS	7		
6		SILT and SAND, trace Clay, grey			SS	5		
7.5		SAND, trace Silt, grey			SS	8		
8.1		End of Borehole @ 8.1 m. Auger refusal.						



PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14

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SAMPLE TYPE LEGEND

Code	Sample Type
AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 4

LOG OF BOREHOLE 14-05

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road**
Dryden, Ontario

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5513425 E 528949**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 25**

SOIL PROFILE – DESCRIPTION	SAMPLE TYPE	"N" VALUES
ORGANCIS, roots, black		
SAND, some Silt, brown	AS	
SAND, Silty, grey	SS	14
	SS	32
	SS	23
	SS	3
SILT, Sandy, grey	SS	10
SILT, trace Sand, grey	SS	4
	SS	6
SILT and CLAY, grey	SS	3
SILT, some Clay, grey	SS	4
	SS	6
	SS	7
	SS	4
	SS	4
SAND, Silty, grey	SS	8
SAND, trace Silt, grey	SS	12
	SS	25
	SS	12
- rock fragments in split spoon	SS	>50
End of Borehole @ 13.75 m. Split spoon refusal.		

Column headings: DEPTH, ELEV., DESCRIPTION, STRAT PLOT, % RECOVERY, TYPE, "N" VALUES, GROUND WATER CONDITIONS, DEPTH SCALE, CPT (kPa) 300 600 900 1200 1500, × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa), ■ SPT (N) ◆ DCPT 0 20 40 60 80 100, PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60, REMARKS, GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

REMARKS: Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.

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SAMPLE TYPE LEGEND
AS Auger Sample
SS Split Spoon Sample
TW 70mm Thin Wall Tube
CC Concrete Core
RC Rock Core
PS Ponar Sample
CB Core Barrel
HS Hiller Sample
AC Asphalt Core

NOTES:

ENCLOSURE 5

LOG OF BOREHOLE 14-06

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512942 E 528957**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road Dryden, Ontario**	DIAMETER:	**80mm ID**
		DATE:	**2014 March 26**

SOIL PROFILE · SAMPLES · GROUND WATER CONDITIONS · DEPTH SCALE · CPT (kPa) 300 600 900 1200 1500 · ✕ FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) ■ SPT (N) ◆ DCPT · 0 20 40 60 80 100 · PLASTIC LIMIT W_P · NATURAL MOISTURE CONTENT W · LIQUID LIMIT W_L · WATER CONTENT (%) 20 40 60 · REMARKS · GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

DEPTH (m)	ELEV.	DESCRIPTION	% RECOVERY	TYPE	"N" VALUES	REMARKS
0		ORGANICS, black				Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		SAND, some Silt, black		AS		
0.75		SAND, trace Silt, brown		SS	11	
				SS	10	
				SS	9	
3.0		SILT and CLAY, trace sand, layered - red clay and grey silt layers		SS	2	
4.5		CLAY and SILT, layered - dark grey clay and light grey silt layers		SS	1	
6.0		CLAY, grey		SS	3	
		(Field shear vane at approx. 7 m)				Remold shear vane test = 4 KPa
7.5		SILT, some Clay and Sand, layered, grey		SS	6	
				SS	14	
9.9		End of Borehole @ 9.9 m. Auger refusal.				

01A-2 STANDARD BH 14-035 TREASURY METALS DRYDEN.GPJ TBT.GDT 14/4/8

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

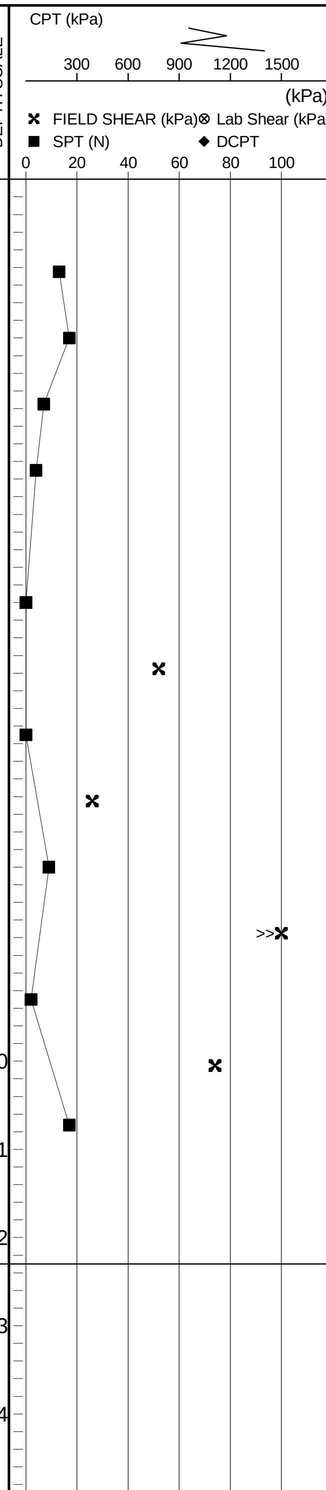
ENCLOSURE 6

LOG OF BOREHOLE 14-07A

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road, Dryden, Ontario**

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5512321 E 529150**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 27**

DEPTH (m)	DESCRIPTION	TYPE	"N" VALUES	REMARKS
0	ORGANICS, black			Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
	SAND, trace Silt, brown	AS		
1	- - - - - - grey	SS	13	
2		SS	17	
		SS	7	
3	SILT and CLAY, trace Sand, grey	SS	4	
4.5	CLAY, Silty, layered, grey	SS	0	
5.5				Remold shear vane test = 4 KPa
6		SS	0	
7				Remold shear vane test = 9 KPa
8		SS	9	
8.5				Remold shear vane test = 37 KPa
9		SS	2	
10				Remold shear vane test = 9 Kpa
10.7		SS	17	
11	Clay, Silty, some gravel and rock fragments, grey	SS		Rock fragments in split spoon sample (SS10B)
12		SS	>50	
12.3	End of Borehole @ 12.3 m. Spoon and auger refusal.			



PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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SAMPLE TYPE LEGEND

- AS Auger Sample
- SS Split Spoon Sample
- TW 70mm Thin Wall Tube
- CC Concrete Core
- RC Rock Core
- PS Ponar Sample
- CB Core Barrel
- HS Hiller Sample
- AC Asphalt Core

NOTES:

ENCLOSURE 7

LOG OF BOREHOLE 14-08

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5511549 E 528132**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 April 2**

SOIL PROFILE				SAMPLES								REMARKS
DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa) 300 600 900 1200 1500 / × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) / ■ SPT (N) ◆ DCPT (0 20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60		GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0		ORGANICS, black										Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		CLAY, brown and grey			AS							
1					SS	4		1	■ 4; >>×			Shear vane attempted, vane refused when pushing
2					SS	5		2	■ 5; >>×			Shear vane attempted, vane refused when pushing
3					SS	6		3	■ 6; >>×			Shear vane attempted, vane refused when pushing
					SS	5			■ 5			
4.5		CLAY and SILT, layered, grey			SS	4		5	■ 4; >>×			Remold shear vane test = 47 KPa
6		Clay, grey						6				
7					SS	3		7	× (~60); ■ 3			Remold shear vane test = 12 KPa
8					SS	2		8	■ 2; >>×			No shear of vane during test.
9		End of Borehole @ 9.0 m. Auger refusal.						9				

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 8

LOG OF BOREHOLE 14-09A

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5511570 E 528374**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road Dryden, Ontario**	DIAMETER:	**80mm ID**
		DATE:	**2014 April 2**

SOIL PROFILE: DEPTH, ELEV., DESCRIPTION, STRAT PLOT. SAMPLES: % RECOVERY, TYPE, "N" VALUES. GROUND WATER CONDITIONS. DEPTH SCALE. CPT (kPa) 300, 600, 900, 1200, 1500 (kPa). × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) ■ SPT (N) ◆ DCPT, 0 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60. REMARKS, GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Depth (m)	Description	Sample Type	"N" Values	Field Shear	Remarks
0	ORGANICS, black				
	CLAY, brown and grey	AS			Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
1		SS	6		
2		SS	6	>>×	Remold shear vane test = 70 KPa
		SS	7		
3	CLAY and SILT, red clay with grey silt seams				
4.5	CLAY and SILT, layered, grey	SS	5		
6		SS	1		
7				>>×	Remold shear vane test = 44 KPa
7.5	SAND, SILT, and CLAY, grey	SS	6		
9	End of Borehole @ 7.5 m. Auger refusal.				

01A-2 STANDARD BH 14-035 TREASURY METALS DRYDEN.GPJ TBT.GDT 14/4/8

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 9

LOG OF BOREHOLE 14-10A

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5511168 E 527763**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 April 3**

DEPTH	ELEV.	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa) 300 600 900 1200 1500; × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100	PLASTIC LIMIT W_P ◆ NATURAL MOISTURE CONTENT W ● LIQUID LIMIT W_L ▲; WATER CONTENT (%) 20 40 60	REMARKS GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		FILL - SAND, some Gravel, occasional cobbles			AS						Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing. Borehole location appears to be on an old access road.
1					AS			1			
		End of Borehole @ 1.35 m. Auger refusal.									
2								2			
3								3			
4								4			
5								5			
6								6			
7								7			
8								8			
9								9			
10								10			
11								11			
12								12			
13								13			
14								14			

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 10

LOG OF BOREHOLE 14-11

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512098 E 529026**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 30**

DEPTH	ELEV.	DESCRIPTION (SOIL PROFILE)	% RECOVERY	TYPE	"N" VALUES	REMARKS
0		ORGANICS, black				Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing. Standpipe installed to 2.9 m.
		SAND, brown		AS		
1		SILT, some Sand and Clay, grey		SS	0	
		CLAY, grey		SS	0	
2.5				SS	0	Remold shear vane test = 3 KPa
3				SS	0	Remold shear vane test = 4 KPa
4						Remold shear vane test = 4 KPa
5				SS	1	
5.5						Remold shear vane test = 4 KPa
6		CLAY, reddish grey		SS	0	
7						Remold shear vane test = 20 KPa
7.5		CLAY, some Silt layers, grey		SS	2	
8.5						Remold shear vane test = 11 KPa
9				SS	3	
10						Remold shear vane test = 44 KPa
10.5		CLAY, SILT, SAND and GRAVEL		SS	10	
11.1		End of Borehole @ 11.1 m. Spoon refusal.				

Chart columns: CPT (kPa) 300 600 900 1200 1500; × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60. GRAIN SIZE DISTRIBUTION (%) GR SA SI CL. GROUND WATER CONDITIONS. DEPTH SCALE.

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

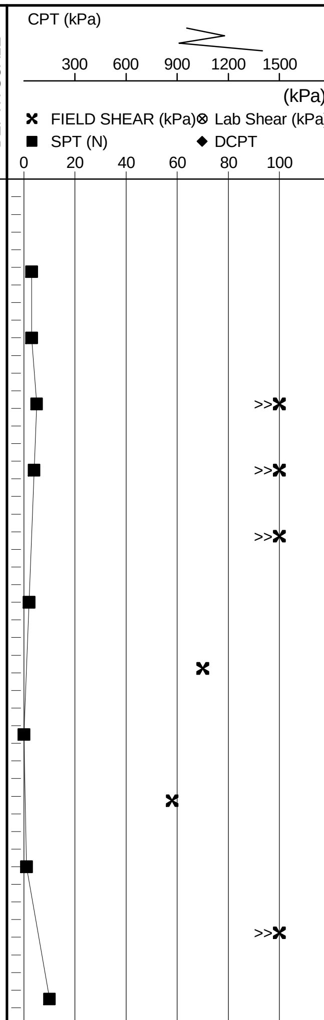
NOTES:

ENCLOSURE 11

LOG OF BOREHOLE 14-12

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512093 E 528978**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 30**

SOIL PROFILE: DEPTH (m)	ELEV.	DESCRIPTION	STRAT PLOT	SAMPLES: % RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS
0.0		ORGANICS, black						Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
0.15		SAND, brown			AS			
0.75		CLAY, some Sand and Silt seams, brown and grey			SS	3		
1.5		CLAY and SILT, layered, grey and brown			SS	3		
					SS	5		Soil did not shear on shear vane test.
					SS	4		Remold shear vane test = 33 KPa
								Remold shear vane test = 58 KPa
4.5		CLAY and SILT, layered, grey			SS	2		
								Remold shear vane test = 14 KPa
					SS	0		
								Remold shear vane test = 23 KPa
					SS	1		
								Vane refused
					SS	10		
9.3		CLAY, SILT, SAND and GRAVEL, grey						
9.6		End of Borehole @ 9.6 m. Spoon refusal.						



PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 20 40 60

GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

DEPTH SCALE: 1–14

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 12

LOG OF BOREHOLE 14-13

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512121 E 528957**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 31**

DEPTH (m)	ELEV.	SOIL PROFILE – DESCRIPTION	SAMPLE TYPE	"N" VALUES	FIELD SHEAR (kPa)	REMARKS
0.0		ORGANICS, black	AS			Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
0.1		CLAY and SILT, layered, brown and grey	SS	1		
			SS	3	>>100	Remold shear vane test = 7 KPa
			SS	2	>>100	Remold shear vane test = 44 KPa
3.0		CLAY, grey	SS	3	>>100	Remold shear vane test = 28 KPa
					>>100	
4.5		CLAY, reddish grey	SS	3		
					~60	Remold shear vane test = 14 KPa
6.0		CLAY and SILT, layered, grey	SS	2		
					~55	Remold shear vane test = 11 KPa
			SS	1		
					>>100	Remold shear vane test = 20 KPa
9.0		SAND, trace Silt, grey	SS	5		
9.6		End of Borehole @ 9.6 m. Refusal not achieved.				Client instructed TBTE to cease drilling this borehole at 9.0m if refusal was not achieved.

Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE; CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; REMARKS – GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

01A-2 STANDARD BH 14-035 TREASURY METALS DRYDEN.GPJ TBT.GDT 14/4/8

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 13

LOG OF BOREHOLE 14-14

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road**
Dryden, Ontario

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5512062 E 528933**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 31**

DEPTH (m)	DESCRIPTION	SAMPLE TYPE	"N" VALUES	FIELD SHEAR (kPa)	REMARKS
0	ORGANICS, black				Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
~0.5		AS			
~1.0	- - - - - - frozen	SS	2		
1.5	CLAY, grey				
~1.8		SS	2		
~2.5		SS	2	>>100	Remold shear vane test = 65 KPa
3.0	CLAY, some Silt seams, grey	SS	3	>>100	Remold shear vane test = 23 KPa
4.5	CLAY, reddish grey	SS	0		
~5.5				~80	
6.0	CLAY, grey	SS	1		
~7.0				~65	Remold shear vane test = 9 KPa
~8.0		SS	1		
~8.5				>>100	Remold shear vane test = 70 KPa
9.0	SILT and SAND, some Clay	SS	>50		
9.15	End of Borehole @ 9.15 m. Spoon refusal.				

CPT (kPa): 300, 600, 900, 1200, 1500
× FIELD SHEAR (kPa) ⊗ Lab Shear (kPa)
■ SPT (N) ◆ DCPT
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 20, 40, 60
GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

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SAMPLE TYPE LEGEND
AS Auger Sample
SS Split Spoon Sample
TW 70mm Thin Wall Tube
CC Concrete Core
RC Rock Core
PS Ponar Sample
CB Core Barrel
HS Hiller Sample
AC Asphalt Core

NOTES:

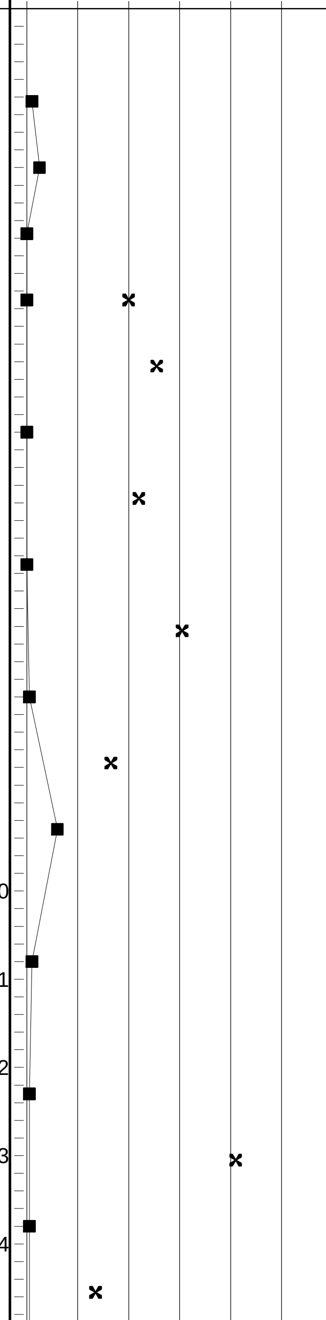
ENCLOSURE 14

LOG OF BOREHOLE 14-15

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5511938 E 528962**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road Dryden, Ontario**	DIAMETER:	**80mm ID**
		DATE:	**2014 March 29**

SOIL PROFILE: DEPTH, ELEV., DESCRIPTION, STRAT PLOT — SAMPLES: % RECOVERY, TYPE, "N" VALUES — GROUND WATER CONDITIONS — DEPTH SCALE — CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa) ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100 — PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60 — REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Depth (m)	Description	Type	"N" Values	Remarks
0	ORGANICS, frozen, black	AS		Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
0.75	SAND, some ORGANICS, trace Silt, grey	SS	2	
		SS	5	
2.25	CLAY, reddish grey, occasional Silt seams	SS	0	
		SS	0	Remold shear vane test = 5 KPa
				Remold shear vane test = 7 KPa
		SS	0	
				Remold shear vane test = 5 KPa
		SS	0	
				Remold shear vane test = 15 KPa
		SS	1	
				Remold shear vane test = 8 KPa
9.0	SILT, grey	SS	12	
10.5	SILT, some Clay seams, grey	SS	2	
12.0	CLAY. grey	SS	1	
				Remold shear vane test = 14 KPa
		SS	1	
				Remold shear vane



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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

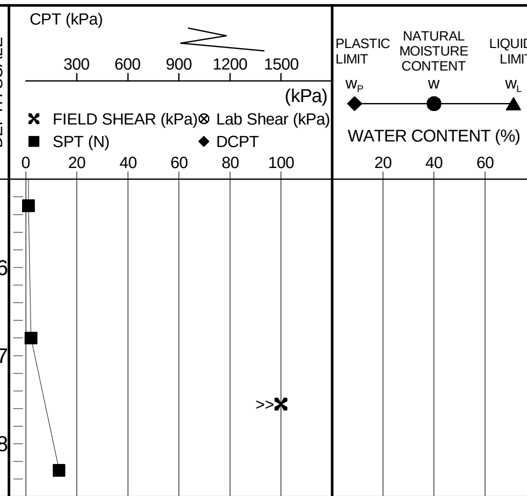
NOTES:

ENCLOSURE 15

LOG OF BOREHOLE 14-15

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5511938 E 528962**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 29**

DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS
		SILT, grey			SS	1		test = 16 KPa
16								
		SILT and CLAY, layered, grey			SS	2		
17								
								No soil shear on vane test.
18					SS	13		
19		End of Borehole @ 18.6 m. Spoon refusal.						



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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 16

LOG OF BOREHOLE 14-17

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512879 E 528077**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 28**

DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa) / FIELD SHEAR / SPT (N)	WATER CONTENT (%)	REMARKS
		ORGANICS, black			AS						Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
1		SAND, trace Silt, brown			SS	9		1			
2		CLAY, some Silt, grey			SS	2		2			
					SS	>50					
3		SAND, some Clay, Silt and Gravel, grey						3			Remold shear vane test = 9 KPa
		End of Borehole @ 2.7 m. Auger refusal.									

Chart legend: CPT (kPa) 300, 600, 900, 1200, 1500; × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0, 20, 40, 60, 80, 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60. GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 17

LOG OF BOREHOLE 14-18

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512748 E 528151**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road Dryden, Ontario**	DIAMETER:	**80mm ID**
		DATE:	**2014 March 28**

DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa) / FIELD SHEAR (kPa) / Lab Shear (kPa) / SPT (N) / DCPT	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	REMARKS / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		ORGANICS, black									Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
		SAND, trace Silt, brown			AS						
1		CLAY and SILT, layered, grey			SS	7		1			
2					SS	8		2			
		SILT, trace Sand and Clay, grey			SS	>50					
3		End of Borehole @ 2.7 m. Auger refusal.						3			

CPT (kPa) scale: 300 600 900 1200 1500
Shear / SPT scale: 0 20 40 60 80 100
Water content scale: 20 40 60

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

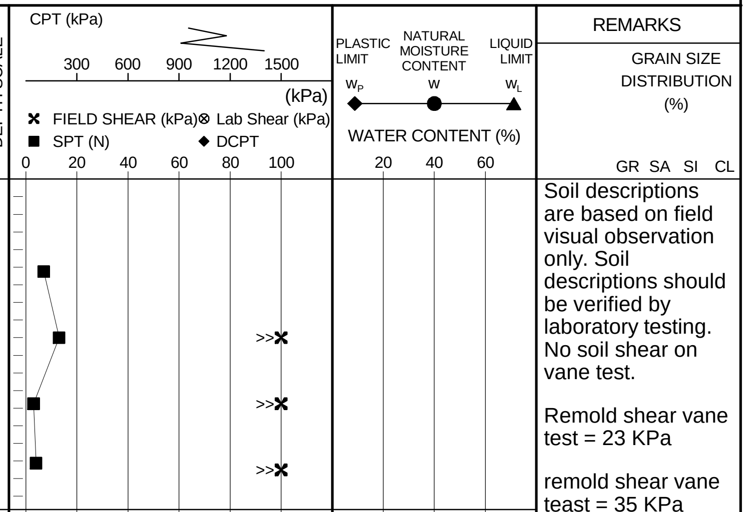
ENCLOSURE 18

LOG OF BOREHOLE 14-19

TBT REF. No.: **14-035**
CLIENT: **Treasury Metals Incorporated**
PROJECT: **Goliath Project**
LOCATION: **Tree Nursery Road**
Dryden, Ontario

SURFACE ELEV.: **metres**
COORDINATES: **UTM 15 N 5512845 E 528233**
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **2014 March 28**

DEPTH (m)	DESCRIPTION	TYPE	"N" VALUES	FIELD SHEAR (kPa)	REMARKS
0	ORGANICS and SAND, brown	AS			Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
0.6	CLAY and SILT, layered, grey	SS	7		
		SS	13	>>✕	No soil shear on vane test.
2.2	CLAY. grey	SS	3	>>✕	Remold shear vane test = 23 KPa
		SS	4	>>✕	remold shear vane teast = 35 KPa
3.45	SILT, some Sand and Clay	SS			
3.75	End of Borehole @ 3.75 m. Auger refusal.				



Column headings: SOIL PROFILE (DEPTH, ELEV., DESCRIPTION, STRAT PLOT); SAMPLES (% RECOVERY, TYPE, "N" VALUES); GROUND WATER CONDITIONS; DEPTH SCALE (1–14 m); REMARKS.

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 19

LOG OF BOREHOLE 14-20

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5513035 E 528118**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road**	DIAMETER:	**80mm ID**
	Dryden, Ontario	DATE:	**2014 March 28**

SOIL PROFILE: DEPTH | ELEV. | DESCRIPTION | STRAT PLOT
SAMPLES: % RECOVERY | TYPE | "N" VALUES
GROUND WATER CONDITIONS | DEPTH SCALE
CPT (kPa): 300, 600, 900, 1200, 1500 (kPa)
× FIELD SHEAR (kPa) ⊗ Lab Shear (kPa)
■ SPT (N) ◆ DCPT
0, 20, 40, 60, 80, 100
PLASTIC LIMIT W_P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L
WATER CONTENT (%): 20, 40, 60
REMARKS: GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Soil Profile (Description)	Sample Type	"N" Value	Remarks
ORGANICS, roots, black	AS		Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.
SAND, trace SIlt, brown	SS	7	
CLAY and SILT, layered, grey and brown	SS	5	
	SS	5	No soil shear in vane test. (Field shear >>)
	SS	3	Remold shear vane test = 28 KPa (Field shear >>)
			Remold shear vane test = 9 KPa
	SS	2	
			Remold shear vane test = 12 KPa
	SS	3	
			Remold shear vane test = 12 KPa
	SS	2	
			Remold shear vane test = 22 KPa
	SS	0	
			Remold shear vane test = 5 KPa
End of Borehole @ 10.5 m. Spoon and auger refusal.			

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 20

LOG OF BOREHOLE 14-21

TBT REF. No.:	**14-035**	SURFACE ELEV.:	**metres**
CLIENT:	**Treasury Metals Incorporated**	COORDINATES:	**UTM 15 N 5512927 E 528282**
PROJECT:	**Goliath Project**	EQUIPMENT:	**HS Auger**
LOCATION:	**Tree Nursery Road Dryden, Ontario**	DIAMETER:	**80mm ID**
		DATE:	**2014 March 28**

DEPTH (m)	ELEV.	DESCRIPTION	% RECOVERY	TYPE	"N" VALUES	SPT (N)
0		ORGANICS, black				
		SAND, trace Silt, brown		AS		
1				SS	19	19
		SAND, some Silt, grey		SS		
		SILT, trace Clay and Sand		SS	10	10
2.3		CLAY and SILT, layered, grey		SS	4	4
				SS	2	2
4.5		SILT, trace Sand, grey		SS	5	5
5.1		End of Borehole @ 5.1 m. Auger refusal.				

Chart headings: CPT (kPa) 300 600 900 1200 1500 (kPa); × FIELD SHEAR (kPa) ⊗ Lab Shear (kPa); ■ SPT (N) ◆ DCPT; 0 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60. GROUND WATER CONDITIONS. DEPTH SCALE 1–14.

REMARKS — GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Soil descriptions are based on field visual observation only. Soil descriptions should be verified by laboratory testing.

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SAMPLE TYPE LEGEND

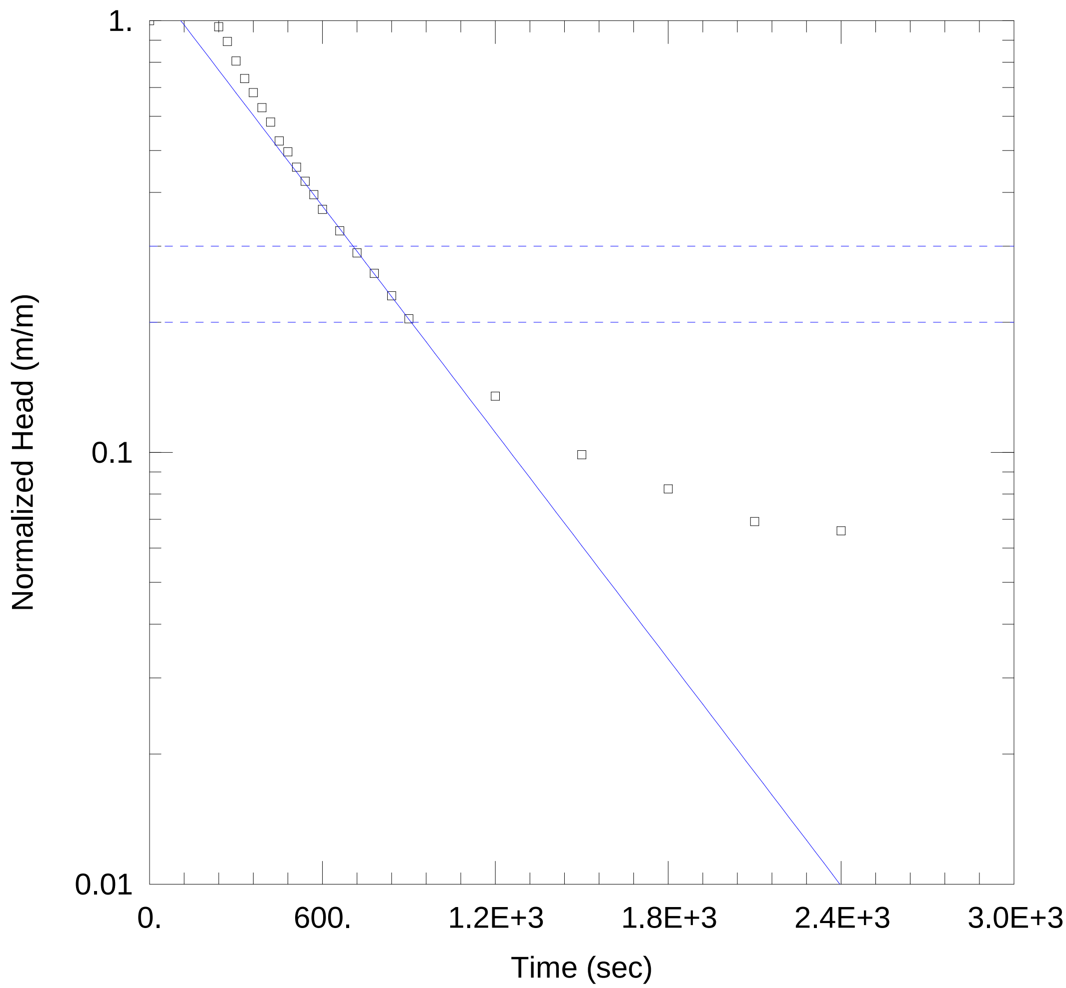
AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
HS	Hiller Sample
AC	Asphalt Core

NOTES:

ENCLOSURE 21

APPENDIX C

SLUG TEST ANALYSIS



WELL TEST ANALYSIS

Data Set: \...\1A (B&R).aqt
Date: 05/20/14 Time: 14:09:03

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc.
Project: TB124004
Location: Dryden
Test Well: 1A
Test Date: February 10, 2014

AQUIFER DATA

Saturated Thickness: 1.58 m Anisotropy Ratio (Kz/Kr): 0.1

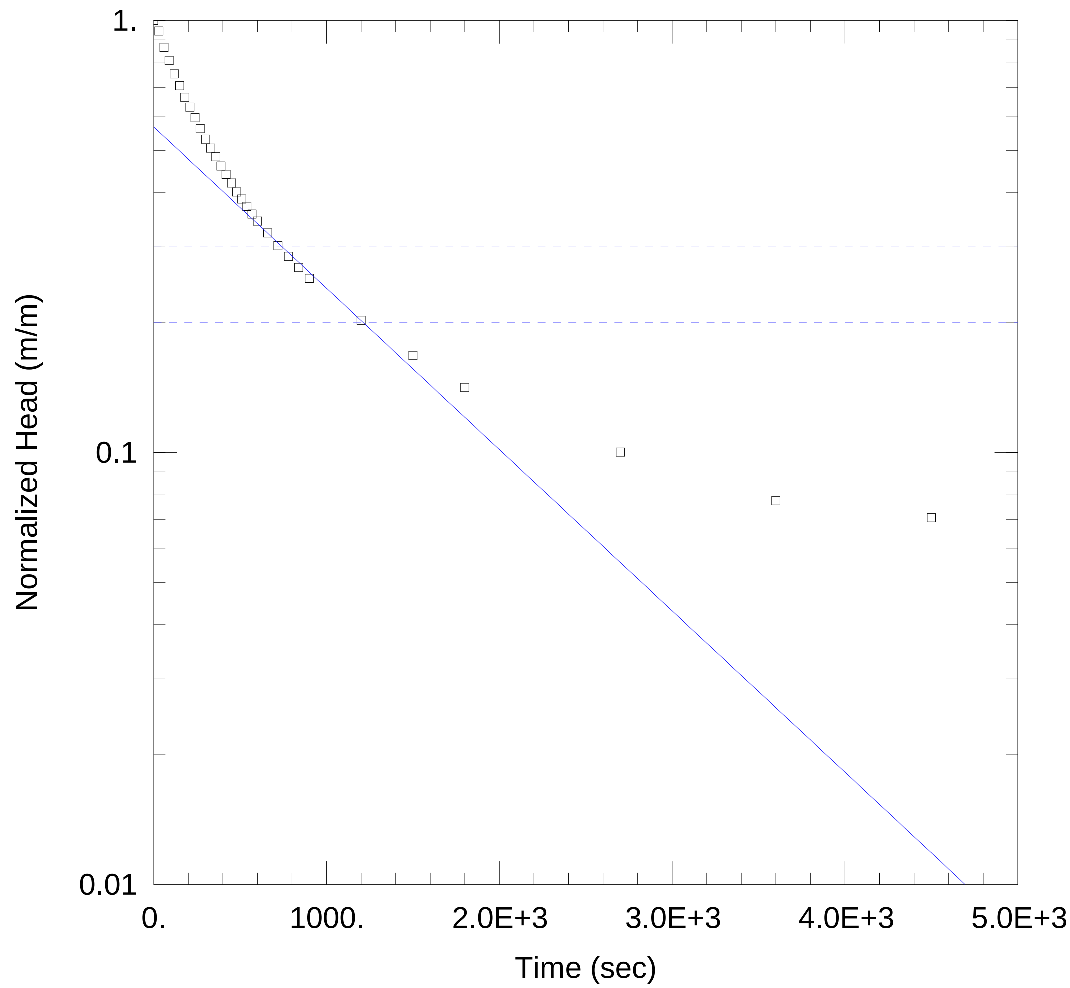
WELL DATA (1A)

Initial Displacement: 3.04 m Static Water Column Height: 2.58 m
Total Well Penetration Depth: 2.1 m Screen Length: 1.52 m
Casing Radius: 0.0254 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.274E-6 m/sec y0 = 3.782 m



WELL TEST ANALYSIS

Data Set: \...\3AD (B&R).aqt
Date: 05/20/14 Time: 14:10:00

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc.
Project: TB124004
Location: Dryden
Test Well: 3AD
Test Date: February 13, 2014

AQUIFER DATA

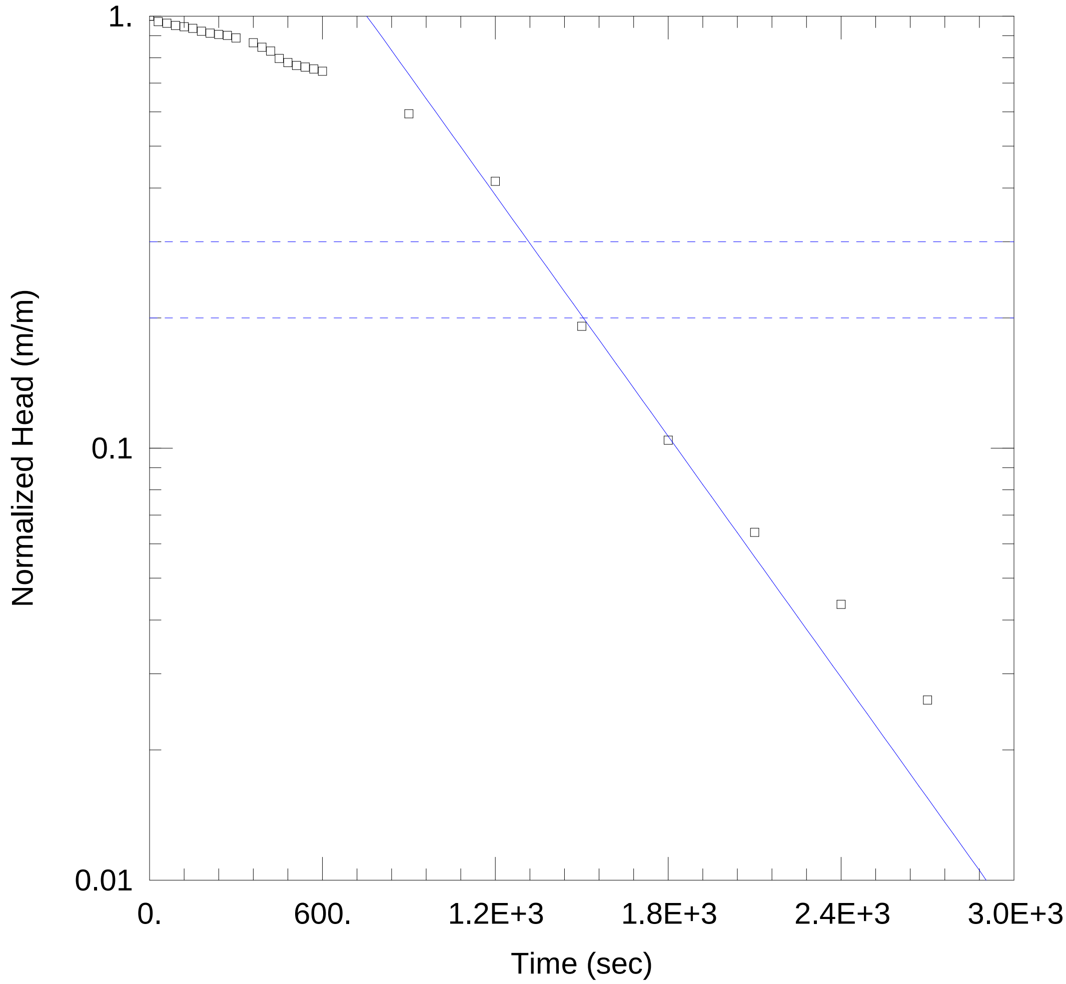
Saturated Thickness: 0.8 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (3AD)

Initial Displacement: 6.09 m
Static Water Column Height: 10.77 m
Total Well Penetration Depth: 0.8 m
Screen Length: 0.8 m
Casing Radius: 0.0254 m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 4.609E-7 m/sec
y0 = 3.449 m



WELL TEST ANALYSIS

Data Set: \...\3AS (B&R).aqt
Date: 05/20/14 Time: 14:10:28

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc.
Project: TB124004
Location: Dryden
Test Well: 3AS
Test Date: February 13, 2014

AQUIFER DATA

Saturated Thickness: 4.75 m Anisotropy Ratio (Kz/Kr): 0.1

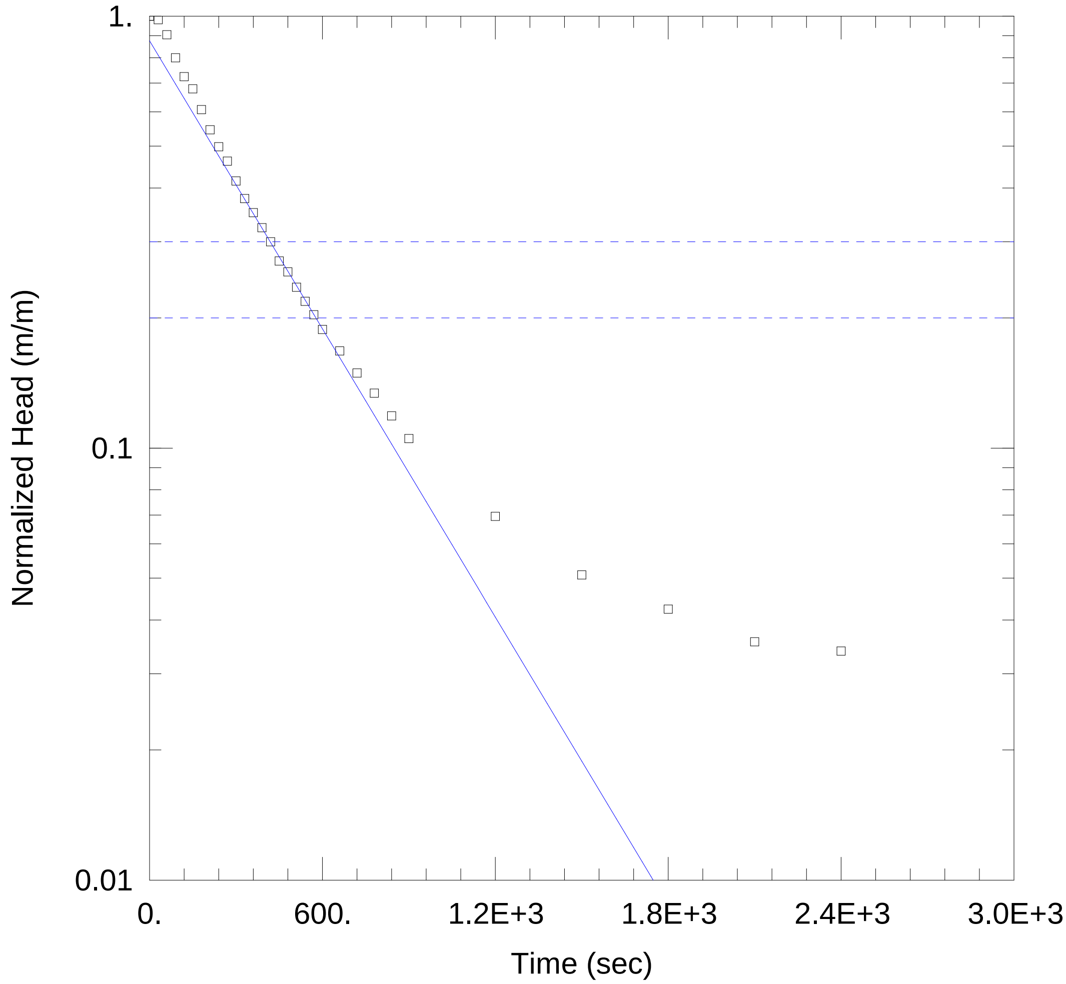
WELL DATA (3AS)

Initial Displacement: 3.45 m Static Water Column Height: 3.65 m
Total Well Penetration Depth: 3.65 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.125 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 7.089E-7 m/sec y0 = 17.37 m



WELL TEST ANALYSIS

Data Set: \...\5A (B&R).aqt
Date: 05/20/14 Time: 14:11:13

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc
Project: TB124004
Location: Dryden
Test Well: 5A
Test Date: February 10, 2014

AQUIFER DATA

Saturated Thickness: 7.74 m Anisotropy Ratio (Kz/Kr): 0.1

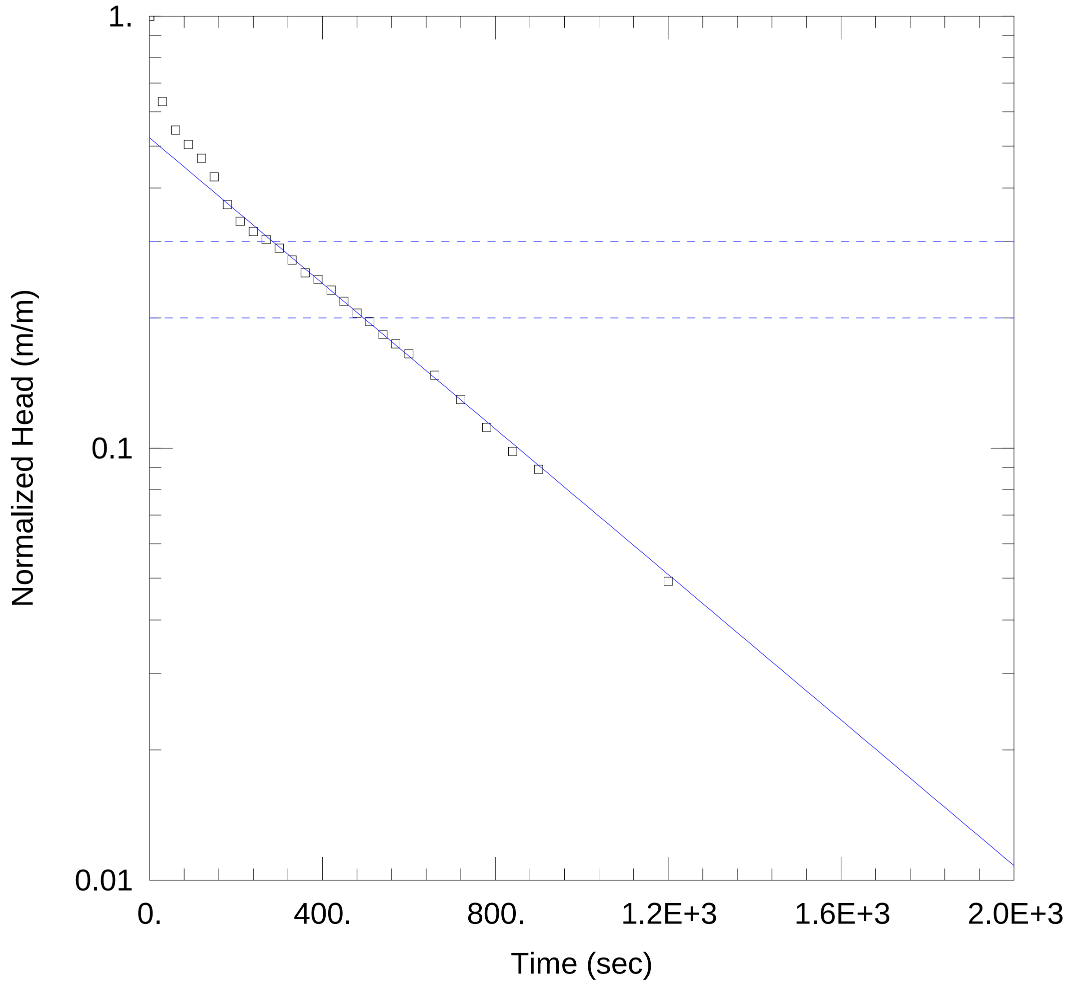
WELL DATA (5A)

Initial Displacement: 5.9 m
Total Well Penetration Depth: 7.74 m
Casing Radius: 0.0254 m
Static Water Column Height: 7.74 m
Screen Length: 3.05 m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.062E-6 m/sec y0 = 5.168 m



WELL TEST ANALYSIS

Data Set: \...\6D (B&R).aqt
Date: 05/20/14 Time: 14:11:45

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc.
Project: TB124004
Location: Dryden
Test Well: 6D
Test Date: February 11, 2014

AQUIFER DATA

Saturated Thickness: 1.63 m
Anisotropy Ratio (Kz/Kr): 0.1

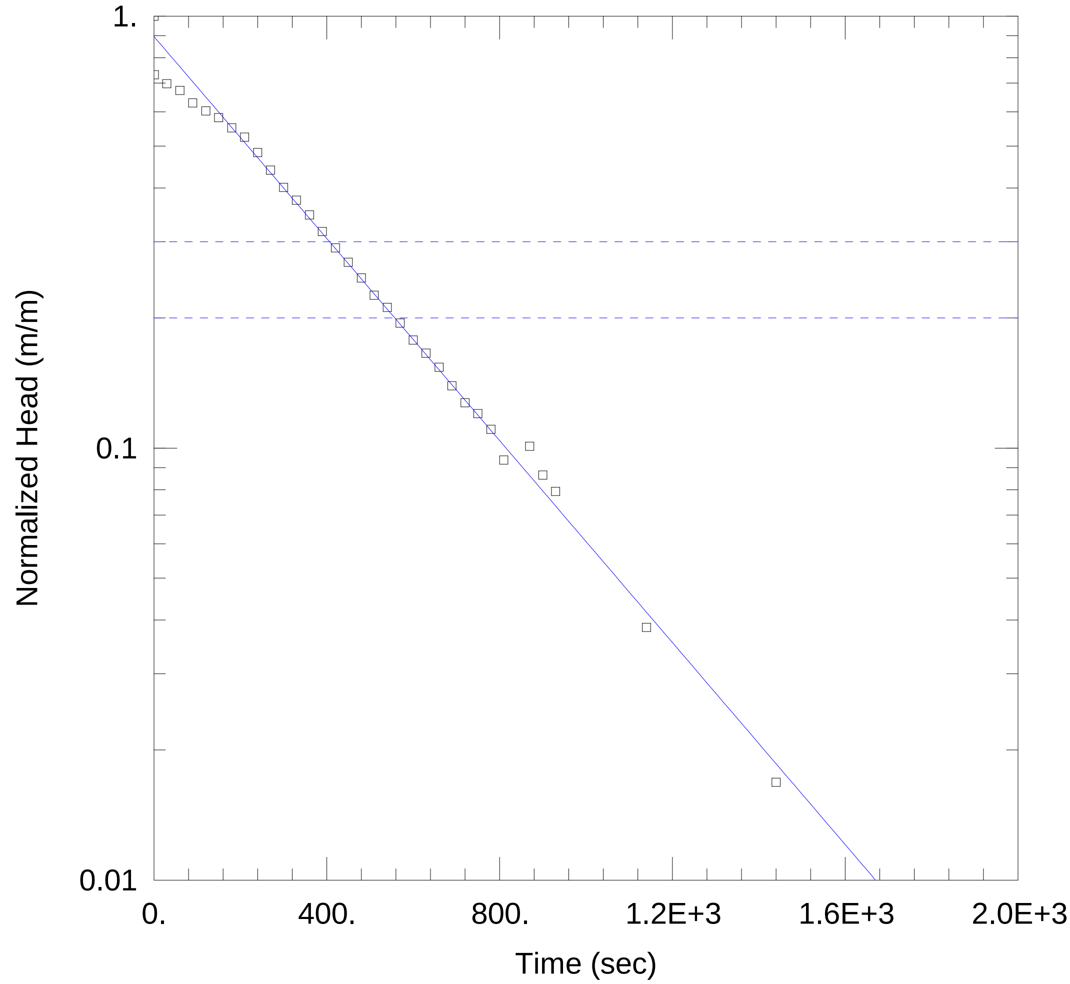
WELL DATA (6D)

Initial Displacement: 2.24 m
Static Water Column Height: 3.13 m
Total Well Penetration Depth: 1.5 m
Screen Length: 1.5 m
Casing Radius: 0.0254 m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.077E-6 m/sec
y0 = 1.17 m



WELL TEST ANALYSIS

Data Set: \...\7A (B&R).aqt
Date: 05/20/14 Time: 14:12:03

PROJECT INFORMATION

Company: AMEC
Client: Treasury Metals Inc.
Project: TB124004
Location: Dryden
Test Well: 7A
Test Date: February 11, 2014

AQUIFER DATA

Saturated Thickness: 1.2 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (7A)

Initial Displacement: 4.16 m
Total Well Penetration Depth: 1.2 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.9 m
Screen Length: 1.2 m
Well Radius: 0.125 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.172E-6 m/sec y0 = 3.73 m

APPENDIX D

PACKER TESTING ANALYSIS

Borehole*	Packer Test #	Date	Type	Top Depth (mbgs)	Bottom Depth (mbgs)	Centre (mbgs)	Average K (m/s)	'Differential' K** (m/s)	Static Head (mbgs)	Vertical Interval (upper)	Vertical Interval (lower)
TL13321	PT1	February 15, 2013	Constant Head Test	18	27	22.16	5.3E-07	N/A		4.43	4.43
TL13321	PT2	February 15, 2013	Rising Head Test	24	44	33.98	1.9E-07	N/A	3.83	10.34	10.34
TL13321	PT3	February 15, 2013	Rising Head Test	44	86	65.00	2.2E-07	N/A	4.69	20.68	20.68
TL13321	PT4	February 16, 2013	Rising Head Test	86	127	106.36	3.5E-08	N/A	4.63	20.68	20.68
TL13321	PT5	February 16, 2013	Rising Head Test	127	168	147.72	3.8E-08	N/A	6.18	20.68	20.68
TL13321	PT6	February 16, 2013	Rising Head Test	168	210	189.08	2.6E-08	N/A	5.12	20.68	20.68
TL13321	PT7	February 17, 2013	Rising Head Test	210	251	230.45	2.4E-08	N/A	4.47	20.68	20.68
TL13321	PT8	February 18, 2013	Rising Head Test	254	301	277.72	1.2E-08	N/A	6.50	23.64	23.64
						AVERAGE	1.3E-07				

Borehole	Packer Test #	Date	Type	Top Depth (mbgs)	Bottom Depth (mbgs)	Centre (mbgs)	Average K (m/s)	'Differential' K** (m/s)	Static Head (mbgs)	Vertical Interval (upper)	Vertical Interval (lower)
TL13317	PT1	February 11, 2013	Rising Head Test	17	27	21.67	1.9E-06	N/A	2.85	4.92	4.92
TL13317	PT2	February 11, 2013	Rising Head Test	27	47	36.93	1.1E-06	N/A	2.85	10.34	10.34
TL13317	PT3	February 11, 2013	Rising Head Test	47	89	67.95	1.1E-06	N/A	3.50	20.68	20.68
TL13317	PT4	February 12, 2013	Rising Head Test	83	127	104.88	2.8E-07	N/A	3.78	22.16	22.16
TL13317	PT5	February 12, 2013	Rising Head Test	127	168	147.72	4.9E-08	N/A	3.43	20.68	20.68
TL13317	PT6	February 12, 2013	Rising Head Test	168	210	189.08	7.7E-08	N/A	2.85	20.68	20.68
TL13317	PT7	February 13, 2013	Rising Head Test	210	251	230.45	4.8E-08	N/A	4.86	20.68	20.68
						AVERAGE	6.5E-07				

Borehole	Packer Test #	Date	Type	Top Depth (mbgs)	Bottom Depth (mbgs)	Centre (mbgs)	Average K (m/s)	'Differential' K** (m/s)	Static Head (mbgs)	Vertical Interval (upper)	Vertical Interval (lower)
TL13315	PT1	February 7, 2013	Rising Head Test	15	18	16.45	4.0E-07	N/A	1.21	1.73	1.73
TL13315	PT2	February 7-8, 2013	Rising Head Test	25	36	30.70	4.0E-07	N/A	1.00	5.67	5.67
TL13315	PT3a	February 8, 2013	Rising Head Test	43	73	57.98	1.3E-06	N/A	1.98	14.77	14.77
TL13315	PT3b	February 8, 2013	Rising Head Test	43	73	57.98	1.1E-06	N/A	1.52	14.77	14.77
TL13315	PT4	February 8, 2013	Rising Head Test	80	109	94.27	1.9E-08	N/A	1.28	14.77	14.77
TL13315	PT5	February 9, 2013	Rising Head Test	116	145	130.73	3.9E-08	N/A	0.64	14.77	14.77
TL13315	PT6	February 9, 2013	Rising Head Test	189	218	203.39	4.1E-08	N/A	4.24	14.77	14.77
TL13315	PT7	February 10, 2013	Rising Head Test	225	255	239.80	7.6E-08	N/A	1.40	14.81	14.81
TL13315	PT8	February 10, 2013	Rising Head Test	225	255	239.80	1.6E-07	N/A	2.53	14.81	14.81
						AVERAGE	3.9E-07				

Borehole	Packer Test #	Date	Type	Top Depth (mbgs)	Bottom Depth (mbgs)	Centre (mbgs)	Average K (m/s)	'Differential' K** (m/s)	Static Head (mbgs)	Vertical Interval (upper)	Vertical Interval (lower)
TL0855	PT1	April 18, 2012	Rising Head Test	237	424	330.44	3.0E-08	N/A	2.92	93.50	93.50
TL0855	PT2	April 18, 2012	Rising Head Test	197	424	310.55	2.5E-08	1.5E-09	2.87	113.39	113.39
TL0855	PT3	April 18, 2012	Rising Head Test	149	424	286.44	2.2E-08	7.9E-09	3.13	137.51	137.51
TL0855	PT4	April 18, 2012	Rising Head Test	101	424	262.32	2.9E-08	6.9E-08	3.21	161.62	161.62
TL0855	PT9	April 18, 2012	Rising Head Test	88	424	255.97	1.2E-08	1.0E-09	2.85	167.97	167.97
TL0855	PT5	April 18, 2012	Rising Head Test	78	424	250.90	1.4E-08	8.0E-08	2.92	173.05	173.05
TL0855	PT6	April 18, 2012	Rising Head Test	78	424	250.90	1.4E-08	N/A	2.93	173.05	173.05
TL0855	PT7	April 18, 2012	Rising Head Test	52	424	238.20	2.5E-08	1.7E-07	3.18	185.74	185.74
TL0855	PT8	April 18, 2012	Rising Head Test	27	424	225.51	2.8E-08	7.2E-08	3.33	198.43	198.43
						AVERAGE	2.2E-08				
Borehole	**Packer Test #**	**Date**	**Type**	**Top Depth (mbgs)**	**Bottom Depth (mbgs)**	**Centre (mbgs)**	**Average K (m/s)**	**'Differential' K** (m/s)**	**Static Head (mbgs)**	**Vertical Interval (upper)**	**Vertical Interval (lower)**
TL10111	PT1	April 22, 2012	Rising Head Test	168	182	174.72	1.6E-06	N/A	3.07	7.17	7.17
TL10111	PT2	April 22, 2012	Rising Head Test	111	182	146.41	4.8E-07	2.0E-07	3.06	35.47	35.47
TL10111	PT3	April 22, 2012	Rising Head Test	84	182	132.83	1.2E-07	1.0E-09	3.19	49.06	49.06
TL10111	PT4	April 22, 2012	Rising Head Test	54	182	118.11	1.7E-07	3.4E-07	3.25	63.77	63.77
TL10111	PT5	April 22, 2012	Rising Head Test	27	182	104.53	2.0E-08	1.0E-09	3.38	77.36	77.36
						AVERAGE	4.8E-07				
Borehole	**Packer Test #**	**Date**	**Type**	**Top Depth (mbgs)**	**Bottom Depth (mbgs)**	**Centre (mbgs)**	**Average K (m/s)**	**'Differential' K** (m/s)**	**Static Head (mbgs)**	**Vertical Interval (upper)**	**Vertical Interval (lower)**
TL11195	PT1	April 23, 2012	Rising Head Test	224	537	380.79	2.3E-08	N/A	0.57	156.45	156.45
TL11195	PT2	April 24, 2012	Rising Head Test	179	537	358.02	2.1E-08	7.3E-09	0.62	179.22	179.22
TL11195	PT3	April 24, 2012	Rising Head Test	136	537	336.51	1.6E-08	1.0E-09	0.38	200.73	200.73
TL11195	PT4	April 24, 2012	Rising Head Test	90	537	313.74	1.8E-08	3.6E-08	0.59	223.50	223.50
TL11195	PT5	April 24, 2012	Rising Head Test	45	537	290.97	1.4E-08	1.0E-09	0.72	246.27	246.27
						AVERAGE	1.8E-08				

* TL13 boreholes are hydrogeology holes that where the bottom of the hole was tested as it advanced. Other holes are existing exploration holes that were tested by progressively raising a single packer

** Estimated for exploration hole testing only. The 'differential' K refers to an estimate of the K for the non-overlapping section of two successive test intervals, both starting at the bottom of the hole. The calulation cannot be performed where the transmissivity of the longer inteval is larger than that of the shorter interval. In this case a low value of 1E-09 m/s is assigned, highlighted in grey.

APPENDIX E

GROUNDWATER CHEMISTRY DATA

Table E1 Summary of Dissolved Major Ions and Anions in Groundwater

			Parameters	pH	Conductivity	Total Ammonia	Dissolved Chloride	Nitrate	Nitrite	Nitrate + Nitrite	Sulphate	Alkalinity	Acidity	Total Cyanide	Hardness
			Units		µS/cm	as N mg/L	mg/L	as N mg/L	as N mg/L	as N mg/L	mg/L	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg/L	mg/L as $CaCO_3$
			ODWS	6.5-8.5			250	10[d]	1[d]	1[d]		30-500		0.2	
			PWQO	6.5-8.5										0.005	
	UTM 15		**CEQG**	6.5-9											
Station Name	Easting	Northing	Date												
BH1A	528742	5513247	11-Jun-13	6.88	319	<0.020	48	0.33	<0.020	0.33	18.3	63	24.8	<0.0020	124
BH1A			10-Jul-13	6.84	339	<0.020	49.6	0.304	<0.020	0.304	21.5	73.1	15	<0.0020	122
BH1A			14-Aug-13	7.14	321	<0.020	48	0.22	<0.020	0.22	20.1	61.2	11	<0.0020	121
BH1A			17-Oct-13	6.79	321	<0.020	46.6	0.153	<0.020	0.153	21.7	66.9	19	<0.0020	105
BH1A			28-Nov-13	6.79	306	<0.020	46.5	0.104	<0.020	0.104	18.8	60	15	<0.0020	117
BH1A			19-Dec-13	6.8	316	<0.020	46.2	0.066	<0.050	0.066	14.7	65	12	<0.0020	114
BH2A	529967	5512940	11-Jun-13	7.38	475	0.288	26.2	0.065	<0.020	0.065	51.4	160	21.2	<0.0020	231
BH2A			10-Jul-13	6.83	475	0.105	34.5	<0.030	<0.020	<0.030	57.2	138	18.0	<0.0020	219
BH2A			14-Aug-13	7.14	451	0.327	36.5	<0.030	<0.020	<0.030	58	114	9	<0.0020	203
BH2A			17-Oct-13	6.97	487	0.0999	45.9	<0.030	<0.020	<0.030	75.1	98.9	22	<0.0020	199
BH2A			28-Nov-13	6.84	494	0.195	51.7	<0.030	<0.020	<0.030	86.6	94	18	<0.0020	222
BH2A			19-Dec-13	6.95	555	0.106	59.6	<0.050	<0.050	<0.050	101	77	8	<0.0020	224
BH3A-D	529308	5512354	11-Jun-13	8.11	356	0.237	6.33	<0.030	<0.020	<0.030	30.2	*1270*	3.4	<0.0020	314
BH3A-D			10-Jul-13	7.59	379	0.209	0.33	0.128	<0.020	0.128	4.76	239	10	<0.0020	203
BH3A-D			14-Aug-13	8.19	359	0.181	6.87	<0.030	<0.020	<0.030	29.6	156	3	<0.0020	172
BH3A-D			17-Oct-13	8	353	0.309	6.76	<0.030	<0.020	<0.030	29.8	160	4	<0.0020	154
BH3A-D			28-Nov-13	8.02	334	0.349	6.33	<0.030	<0.020	<0.030	27.7	158	6.0	<0.0020	178
BH3A-D			19-Dec-13	8	376	0.042	6.8	<0.050	<0.050	<0.050	27.7	160	2	<0.0020	177
BH3A-S	529308	5512354	11-Jun-13	7.8	323	0.051	0.37	0.151	<0.020	0.151	3.8	174	11.2	<0.0020	169
BH3A-S			10-Jul-13	8.03	371	0.257	7.15	<0.030	<0.020	<0.030	30.4	309	3	<0.0020	186
BH3A-S			14-Aug-13	7.81	294	0.024	0.49	0.165	<0.020	0.165	3.34	152	3.0	<0.0020	156
BH3A-S			17-Oct-13	7.65	371	0.111	0.24	0.14	<0.020	0.14	4.14	190	10.0	<0.0020	175
BH3A-S			28-Nov-13	7.45	341	0.084	1.11	0.185	<0.020	0.185	4.07	217	6	<0.0020	200
BH3A-S			19-Dec-13	7.7	500	<0.020	<2.0	<0.105	<0.050	<0.105	4.7	251	7.0	<0.0020	220
BH4A	527596	5512426	11-Jun-13	7.48	376	0.030	0.56	0.177	<0.020	0.177	35.3	161	5	<0.0020	159
BH4A			10-Jul-13	7.22	347	0.262	0.91	0.031	<0.020	0.031	35	155	15	<0.0020	168
BH4A			14-Aug-13	7.63	343	0.049	0.3	<0.030	<0.020	<0.030	33.9	146	15	<0.0020	170
BH4A			17-Oct-13	7.54	326	0.096	0.27	<0.030	<0.020	<0.030	28	149	10	<0.0020	140
BH4A			28-Nov-13	7.21	313	0.058	0.33	<0.030	<0.020	<0.030	34.9	141	15	<0.0020	143
BH4A			19-Dec-13	7.39	359	0.027	<2.0	<0.050	<0.050	<0.050	34.2	152	9	<0.0020	155
BH5A	527794	5511715	11-Jun-13	7.71	486	0.346	0.91	<0.030	<0.020	<0.030	17	430	15.2	<0.0020	255
BH5A			10-Jul-13	7.70	517	0.362	3.54	<0.030	<0.020	<0.030	18.1	593	12	<0.0020	269
BH5A			14-Aug-13	7.82	503	0.322	0.76	<0.030	<0.020	<0.030	17.5	264	11	<0.0020	258
BH5A			17-Oct-13	7.6	506	0.42	0.52	<0.030	<0.020	<0.030	19.4	276	12	<0.0020	252
BH5A			28-Nov-13	7.57	499	0.394	0.52	<0.030	<0.020	<0.030	19.9	274	10	<0.0020	264
BH5A			19-Dec-13	7.67	538	0.326	<2.0	<0.050	<0.050	<0.050	19.6	286	9	<0.0020	267

Table E1 Summary of Dissolved Major Ions and Anions in Groundwater

			Parameters	pH	Conductivity	Total Ammonia	Dissolved Chloride	Nitrate	Nitrite	Nitrate + Nitrite	Sulphate	Alkalinity	Acidity	Total Cyanide	Hardness
			Units		µS/cm	as N mg/L	mg/L	as N mg/L	as N mg/L	as N mg/L	mg/L	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg/L	mg/L as $CaCO_3$
			ODWS	6.5-8.5			250	10[d]	1[d]	1[d]		30-500		0.2	
			PWQO	6.5-8.5										0.005	
	UTM 15		CEQG	6.5-9											
Station Name	Easting	Northing	Date												
BH6D	526907	5511924	11-Jun-13	7.77	393	0.119	0.94	0.619	<0.020	0.619	24.2	*2160*	25	<0.0020	301
BH6D			10-Jul-13	7.77	254	0.197	0.69	0.087	<0.020	0.087	4.68	313	6	<0.0020	116
BH6D			14-Aug-13	7.98	331	0.246	0.51	0.114	<0.020	0.114	5.24	175	6.0	<0.0020	133
BH6D			17-Oct-13	7.90	225	0.115	0.41	0.1	<0.020	0.1	4.58	99.3	15.0	<0.0020	89.8
BH6D			28-Nov-13	7.25	228	0.098	0.53	0.205	<0.020	0.205	6.99	100	14.0	<0.0020	201
BH6D			19-Dec-13	7.43	255	0.17	<2.0	0.244	<0.050	0.244	7.8	158	5.0	<0.0020	109
BH7A	526298	5511547	11-Jun-13	8.14	540	0.255	0.29	0.037	<0.020	0.037	8.57	*671*	11.8	<0.0020	304
BH7A			10-Jul-13	7.77	457	0.203	0.64	<0.030	<0.020	<0.030	12.2	*1810*	11	<0.0020	245
BH7A			14-Aug-13	7.98	434	0.203	0.44	0.099	<0.020	0.099	11.4	228	7.0	<0.0020	175
BH7A			17-Oct-13	7.89	393	0.317	0.41	0.056	<0.020	0.056	13.5	237	7.0	<0.0020	222
BH7A			28-Nov-13	7.77	311	0.266	0.47	<0.030	<0.020	<0.030	13.6	167	6.0	<0.0020	182
BH7A			19-Dec-13	7.75	338	0.314	<2.0	<0.050	<0.050	<0.050	14.1	169	4.0	<0.0020	161
BH8A	528520	5511143	11-Jun-13	7.76	561	0.054	<0.10	0.061	<0.020	0.061	1.01	335	19.0	<0.0020	318
BH8A			10-Jul-13	7.42	593	0.026	0.18	0.049	<0.020	0.049	1.76	324	22.0	<0.0020	327
BH8A			14-Aug-13	7.73	572	0.026	0.17	0.045	<0.020	0.045	0.94	313	24	<0.0020	334
BH8A			17-Oct-13	7.39	568	0.083	<0.10	0.041	<0.020	0.041	0.83	340	47	<0.0020	301
BH8A			28-Nov-13	7.27	535	0.022	0.15	0.033	<0.020	0.033	0.81	329	23	<0.0020	313
BH8A			19-Dec-13	7.36	603	<0.020	<2.0	<0.050	<0.050	<0.050	<2.0	354	16	<0.0020	302

Notes: PWQO: Provincial Water Quality Objective (provided for information purposes only)
CEQG: Canadian Environmental Quality Guidelines (Protection of Aquatic Freshwater Life)
ODWS: Ontario Drinking Water Standard as per O. Reg 169/03

bold Concentration is above the PWQO
[boxed] Concentration is above the CEQG
italic Concentration is above the ODWS

^^ PWQO and/or CEQG is an interim value
a Aesthetic Objective
b Aesthetic Objective for sodium in drinking water is 200 mg/L
c When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people
d Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen)
e Applies to water at point of consumption. Since lead is a component in some plumbing systems,first flush water may contain higher concentrations of lead than water that has been flushed for five minutes
f 0.005 mg/L if pH<6.5 or 0.1 mg/L if pH>6.5
g For hardness of 350 mg/L CaCO3
i For hardness > 75 mg/L CaCO3
o Operational Guideline

Table E2 Summary of Dissolved Metals in Groundwater

	Parameters	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Mercury
	Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
	ODWS	0.1	0.006	0.025	1			5	0.005		0.05		0.100	0.3[a]	0.01			0.05	0.001
	PWQO	0.075^^	0.02^^	0.005^^		1.1[i]		0.2^^	0.0005		0.001	0.0009	0.005	0.3	0.025				0.0002
	CEQG	0.005-0.1[f]		0.005				1.5	0.0001[g]		0.001		0.004[g]	0.3	0.007[g]				0.000026
Station Name	Date																		
BH1A	11-Jun-13	0.0059	<0.00060	<0.0010	0.044	<0.0010	<0.0010	<0.050	0.000041	36.2	<0.0010	**0.00213**	<0.0010	<0.020	<0.0010	<0.050	8.24	*0.081*	<0.000010
BH1A	10-Jul-13	<0.0050	<0.00060	<0.0010	0.042	<0.0010	<0.0010	<0.050	0.00005	35.2	<0.0010	**0.00113**	<0.0010	<0.020	<0.0010	<0.050	8.3	*0.053*	<0.00010
BH1A	14-Aug-13	<0.0050	<0.00060	<0.0010	0.038	<0.0010	<0.0010	<0.050	0.000039	34.5	<0.0010	0.00079	<0.0010	<0.020	<0.0010	<0.050	8.39	0.049	<0.000010
BH1A	17-Oct-13	0.018	<0.00010	0.00015	0.0383	<0.00050	<0.000050	<0.010	0.000038	30	0.00018	0.00049	0.00136	<0.010	<0.000050	0.0068	7.32	0.033	<0.00010
BH1A	28-Nov-13	<0.0050	<0.00060	<0.0010	0.036	<0.0010	<0.0010	<0.050	0.000034	33.3	<0.0010	0.00055	<0.0010	<0.020	<0.0010	<0.050	8.29	0.031	<0.000010
BH1A	19-Dec-13	<0.0050	<0.00060	<0.0010	0.045	<0.0010	<0.0010	<0.050	0.000066	33.6	<0.0010	**0.00196**	<0.0010	<0.020	<0.0010	<0.050	7.33	*0.073*	<0.000010
BH2A	11-Jun-13	0.0061	<0.00060	0.0029	0.034	<0.0010	<0.0010	<0.50	<0.000017	67.1	<0.0010	**0.00133**	<0.0010	<0.020	<0.0010	<0.050	15.5	*0.437*	<0.000010
BH2A	10-Jul-13	0.024	<0.00060	0.0037	0.028	<0.0010	<0.0010	<0.05	<0.000017	76.1	<0.0010	<0.00050	<0.0010	***0.925***	<0.0010	<0.050	7.13	*0.576*	<0.00010
BH2A	14-Aug-13	0.0288	<0.00060	0.003	0.023	<0.0010	<0.0010	<0.050	<0.000017	71.3	<0.0010	<0.00050	<0.0010	***0.874***	<0.0010	<0.050	6.17	*0.578*	<0.000010
BH2A	17-Oct-13	0.0241	<0.00010	0.00179	0.0209	<0.00050	<0.000050	0.035	<0.000010	70.5	0.00024	0.00016	0.00024	***0.986***	<0.000050	<0.0050	5.56	*0.480*	<0.00010
BH2A	28-Nov-13	0.0135	<0.00060	0.0028	0.023	<0.0010	<0.0010	<0.050	<0.000017	75.8	<0.0010	<0.00050	<0.0010	***0.648***	<0.0010	<0.050	7.82	*0.580*	<0.000010
BH2A	19-Dec-13	0.0153	<0.00060	0.0025	0.016	<0.0010	<0.0010	<0.050	<0.000017	80.1	<0.0010	<0.00050	<0.0010	***1.54***	<0.0010	<0.050	5.84	*0.602*	<0.000010
BH3A-D	11-Jun-13	***5.27***	<0.00060	<0.010	0.11	<0.010	<0.010	<0.050	<0.00017	83.7	**0.015**	**0.0063**	0.023	***8.59***	<0.010	<0.50	25.4	*0.412*	<0.000010
BH3A-D	10-Jul-13	<0.0050	<0.00060	<0.0010	0.039	0.0033	<0.0010	<0.050	<0.000017	54.7	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	16.1	*0.088*	<0.00010
BH3A-D	14-Aug-13	<0.0050	<0.00060	0.004	0.038	<0.0010	<0.0010	<0.050	<0.000017	47.9	<0.0010	<0.00050	<0.0010	0.027	<0.0010	<0.050	12.7	*0.094*	<0.000010
BH3A-D	17-Oct-13	0.0045	0.00018	**0.00544**	0.0413	<0.00050	<0.000050	0.016	<0.000010	42.3	<0.00010	<0.00010	0.00016	0.032	<0.000050	0.006	11.8	*0.089*	<0.00010
BH3A-D	28-Nov-13	0.0129	<0.00060	**0.0051**	0.028	<0.0010	<0.0010	<0.050	<0.000017	49.4	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	13.2	*0.099*	<0.000010
BH3A-D	19-Dec-13	0.0052	<0.00060	0.0037	0.032	<0.0010	<0.0010	<0.050	<0.000017	49.7	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	13	*0.085*	<0.000010
BH3A-S	11-Jun-13	0.0051	<0.00060	<0.0010	0.028	<0.0010	<0.0010	<0.05	<0.000017	48.1	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	11.9	*0.083*	<0.000010
BH3A-S	10-Jul-13	***0.223***	<0.00060	0.0033	0.044	<0.0010	<0.0010	<0.05	0.00002	52.5	<0.0010	<0.00050	<0.0010	0.141	<0.0010	<0.050	13.3	*0.115*	<0.00010
BH3A-S	14-Aug-13	0.0051	<0.00060	<0.0010	0.015	<0.0010	<0.0010	<0.050	<0.000017	43.5	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	11.6	0.031	<0.000010
BH3A-S	17-Oct-13	0.0059	<0.00010	0.00066	0.0318	<0.00050	<0.000050	<0.010	<0.000010	46.3	<0.00010	0.00018	0.00043	<0.010	<0.000050	<0.0050	14.5	*0.074*	<0.00010
BH3A-S	28-Nov-13	<0.050	<0.00060	0.0014	0.029	<0.010	<0.0010	<0.50	<0.000017	52.7	<0.0010	<0.00050	<0.0010	0.068	<0.0010	<0.50	16.6	*0.090*	<0.000010
BH3A-S	19-Dec-13	<0.0050	<0.00060	<0.010	0.031	<0.0010	<0.0010	<0.50	<0.000017	57	<0.010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	18.8	*0.052*	<0.000010
BH4A	11-Jun-13	<0.0050	<0.00060	<0.0010	0.021	<0.0010	<0.0010	<0.050	<0.000017	42.8	<0.0010	0.00053	0.001	<0.020	<0.0010	<0.050	12.7	*0.117*	<0.000010
BH4A	10-Jul-13	0.0072	<0.00060	<0.0010	0.027	<0.0010	<0.0010	<0.050	<0.000017	47.2	<0.0010	**0.00163**	<0.0010	***0.332***	<0.0010	<0.050	12.2	*0.882*	<0.00010
BH4A	14-Aug-13	<0.0050	<0.00060	<0.0010	0.022	<0.0010	<0.0010	<0.050	<0.000017	49.3	<0.0010	**0.00099**	<0.0010	0.035	<0.0010	<0.050	11.3	*0.815*	<0.000010
BH4A	17-Oct-13	0.0066	<0.00010	0.00041	0.0245	<0.00050	<0.000050	0.018	<0.000010	39.7	<0.00010	**0.00123**	0.00035	0.235	<0.000050	0.0075	9.86	*0.943*	<0.00010
BH4A	28-Nov-13	<0.0050	<0.00060	<0.0010	0.023	<0.0010	<0.0010	<0.050	<0.000017	40.7	<0.0010	**0.00132**	<0.0010	0.17	<0.0010	<0.050	10.1	*0.895*	<0.000010
BH4A	19-Dec-13	<0.0050	<0.00060	<0.0010	0.022	<0.0010	<0.0010	<0.050	<0.000017	45.6	<0.0010	**0.00104**	<0.0010	0.039	<0.0010	<0.050	10	*0.884*	<0.000010

Table E2 Summary of Dissolved Metals in Groundwater

	Parameters	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Strontium	Tellurium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zinc	Zirconium
	Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
	ODWS				0.01[a]		200[b]							0.02		5[a]	
	PWQO	0.04^^	0.025		0.1	0.0001				0.0003^^			0.03^^	0.005^^	0.006^^	0.02	0.004^^
	CEQG	0.073^^	0.15[g]		0.001	0.0001				0.0008				0.015		0.03	
Station Name	Date																
BH1A	11-Jun-13	<0.0010	0.004	3.95	<0.0010	<0.00010	13.50	0.1010	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH1A	10-Jul-13	<0.0010	0.0041	3.9	<0.0010	<0.00010	14.90	0.0954	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	0.0054	<0.0010
BH1A	14-Aug-13	<0.0010	0.0042	4.01	<0.0010	<0.00010	16.60	0.0978	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH1A	17-Oct-13	0.000601	0.00378	3.45	0.00013	<0.000010	13.60	0.0957	<0.00060	<0.000050	<0.00010	<0.00030		0.000137	0.00025	<0.0050	<0.0050
BH1A	28-Nov-13	<0.0010	0.0035	3.19	<0.0010	<0.00010	15.40	0.0987	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH1A	19-Dec-13	<0.0010	0.0065	4.19	<0.0010	<0.00010	11.10	0.1010	<0.0010	<0.00030	<0.0010	<0.0020	0.019	<0.0050	<0.0010	0.0056	<0.0010
BH2A	11-Jun-13	<0.0010	<0.0020	2.71	<0.0010	<0.00010	8.91	0.1090	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH2A	10-Jul-13	<0.0010	<0.0020	2.39	<0.0010	<0.00010	13.90	0.1310	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	0.0035	<0.0010
BH2A	14-Aug-13	<0.0010	<0.0020	2.36	<0.0010	<0.00010	14.00	0.1380	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	0.0011
BH2A	17-Oct-13	0.000089	0.0003	2.07	0.00036	<0.000010	14.50	0.1440	<0.00060	<0.000050	0.00016	0.00084		0.000084	0.00055	<0.0050	<0.0050
BH2A	28-Nov-13	<0.0010	<0.0020	2.35	<0.0010	<0.00010	15.10	0.1510	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH2A	19-Dec-13	<0.0010	<0.0020	2.27	<0.0010	<0.00010	16.30	0.1610	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	0.0012
BH3A-D	11-Jun-13	<0.010	<0.020	<5.0	<0.010	<0.0010	8.60	0.1160	<0.010	<0.0030	<0.010	0.083	<0.10	<0.050	**0.015**	**0.031**	<0.010
BH3A-D	10-Jul-13	<0.0010	<0.0020	1.24	<0.0010	<0.00010	5.27	0.0882	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-D	14-Aug-13	0.0017	<0.0020	2.68	<0.0010	<0.00010	10.70	0.0784	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-D	17-Oct-13	0.00159	0.0007	2.5	<0.00010	<0.000010	9.47	0.0730	<0.00060	<0.000050	0.00011	<0.00030		0.0014	0.00044	<0.0050	<0.0050
BH3A-D	28-Nov-13	0.0016	<0.0020	2.4	<0.0010	<0.00010	10.20	0.0836	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	0.0032	<0.0010
BH3A-D	19-Dec-13	0.0017	<0.0020	2.44	<0.0010	<0.00010	9.63	0.0784	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-S	11-Jun-13	<0.0010	<0.0020	1.04	<0.0010	<0.00010	3.84	0.0728	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-S	10-Jul-13	0.0021	<0.0020	2.89	<0.0010	<0.00010	8.63	0.0854	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-S	14-Aug-13	<0.0010	<0.0020	1.09	<0.0010	<0.00010	4.20	0.0599	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-S	17-Oct-13	0.000786	0.00044	1.26	0.0001	<0.000010	5.16	0.0799	<0.00060	<0.000050	<0.00010	<0.00030		0.00103	0.00097	<0.0050	<0.0050
BH3A-S	28-Nov-13	<0.0010	<0.0020	1.26	<0.0010	<0.00010	7.40	0.0928	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH3A-S	19-Dec-13	0.001	<0.0020	1.48	<0.010	<0.00010	6.81	0.1040	<0.010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH4A	11-Jun-13	<0.0010	0.0028	3.44	<0.0010	<0.00010	19.50	0.0669	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH4A	10-Jul-13	0.001	0.0041	7.09	<0.0010	<0.00010	9.23	0.1060	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH4A	14-Aug-13	<0.0010	0.0044	7.69	<0.0010	<0.00010	10.50	0.1110	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	0.003	<0.0010
BH4A	17-Oct-13	0.000825	0.00453	7.32	<0.00010	<0.000010	8.98	0.1040	<0.00060	<0.000050	0.00017	<0.00030		0.000517	0.00066	<0.0050	<0.0050
BH4A	28-Nov-13	<0.0010	0.0041	7.04	<0.010	<0.00010	9.41	0.1010	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	0.0034	<0.0010
BH4A	19-Dec-13	<0.0010	0.0033	7.67	<0.0010	<0.00010	9.85	0.1160	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010

Table E2 Summary of Dissolved Metals in Groundwater

	Parameters	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Mercury
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	ODWS	0.1	0.006	0.025	1			5	0.005		0.05		0.100	0.3[a]	0.01			0.05	0.001
	PWQO	0.075^^	0.02^^	0.005^^		1.1[i]		0.2^^	0.0005		0.001	0.0009	0.005	0.3	0.025				0.0002
	CEQG	0.005-0.1[f]		0.005				1.5	0.0001[g]		0.001		0.004[g]	0.3	0.007[g]				0.000026
Station Name	Date																		
BH5A	11-Jun-13	<0.050	<0.0060	<0.010	<0.10	0.0011	<0.010	<0.050	<0.00017	73.1	<0.010	<0.0050	<0.010	0.37	<0.010	<0.50	17.5	0.341	<0.000010
BH5A	10-Jul-13	<0.0050	<0.00060	0.003	0.075	<0.0010	<0.0010	<0.050	<0.000017	76.7	<0.0010	<0.00050	<0.0010	0.385	<0.0010	<0.050	18.9	0.356	<0.00010
BH5A	14-Aug-13	<0.050	<0.00060	0.0041	0.076	<0.010	<0.0010	<0.5	<0.000017	73.8	<0.0010	<0.00050	<0.0010	0.373	<0.0010	<0.50	18	0.376	<0.000010
BH5A	17-Oct-13	0.0026	<0.00010	0.00351	0.0842	<0.00050	<0.000050	<0.010	<0.000010	72	<0.00010	0.00022	<0.00010	0.398	<0.000050	0.0062	17.6	0.329	<0.00010
BH5A	28-Nov-13	<0.050	<0.0060	<0.010	<0.10	<0.010	<0.010	<0.50	<0.000017	74.3	<0.010	<0.0050	<0.010	0.46	<0.010	<0.5	19	0.325	<0.000010
BH5A	19-Dec-13	<0.050	<0.00060	0.0034	0.061	<0.010	<0.0010	<0.50	<0.000017	75.8	<0.010	<0.00050	<0.0010	0.692	<0.0010	<0.50	18.9	0.350	<0.000010
BH6D	11-Jun-13	9.06	<0.0060	<0.010	0.18	0.0023	<0.010	<0.050	<0.00017	79.5	0.027	0.0146	0.031	9	<0.010	<0.50	25	0.556	<0.000010
BH6D	10-Jul-13	0.0098	<0.00060	<0.0010	0.0120	<0.0010	<0.0010	<0.050	<0.00017	33.7	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	7.8	0.029	<0.00010
BH6D	14-Aug-13	0.0057	<0.00060	<0.0010	0.011	<0.0010	<0.0010	<0.050	<0.000017	38.1	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	9.12	0.013	<0.000010
BH6D	17-Oct-13	0.0053	<0.00010	0.0002	0.00872	<0.00050	<0.000050	<0.010	<0.000010	25.7	0.00022	<0.00010	0.00042	<0.010	<0.000050	<0.0050	6.25	0.010	<0.00010
BH6D	28-Nov-13	<0.050	<0.0060	<0.010	<0.10	<0.010	<0.010	<0.50	<0.00017	56	<0.010	<0.0050	<0.010	<0.20	<0.010	<0.50	14.9	<0.010	<0.000010
BH6D	19-Dec-13	0.0059	<0.00060	<0.0010	0.011	<0.0010	<0.0010	<0.050	<0.000017	30.9	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	7.68	0.008	<0.000010
BH7A	11-Jun-13	1.73	<0.00060	<0.010	0.11	0.01	<0.010	<0.500	<0.00017	78.2	<0.010	<0.0050	<0.010	2.7	<0.010	<0.50	26.5	0.319	<0.000010
BH7A	10-Jul-13	0.0055	<0.00060	0.0036	0.078	<0.0010	<0.0010	<0.050	<0.00017	67.4	<0.0010	<0.00050	<0.0010	0.097	<0.0010	<0.050	18.7	0.305	<0.00010
BH7A	14-Aug-13	0.0053	<0.00060	0.00310	0.063	<0.0010	<0.0010	<0.050	<0.000017	50	<0.0010	<0.00050	<0.0010	<0.020	<0.0010	<0.050	12.3	0.226	<0.000010
BH7A	17-Oct-13	0.0029	<0.00010	0.00134	0.0632	<0.00050	<0.000050	<0.010	<0.000010	59.9	<0.00010	0.00016	0.00023	0.017	<0.000050	0.0093	17.6	0.228	<0.00010
BH7A	28-Nov-13	<0.0050	<0.00060	0.00250	0.057	<0.0010	<0.0010	<0.050	<0.000017	52.6	<0.0010	<0.00050	<0.0010	0.054	<0.0010	<0.050	12.4	0.242	<0.000010
BH7A	19-Dec-13	0.0067	<0.00060	0.00200	0.043	<0.0010	<0.0010	<0.050	<0.000017	47.8	<0.0010	<0.00050	<0.0010	0.176	<0.0010	<0.050	10	0.219	<0.000010
BH8A	11-Jun-13	<0.0050	<0.00060	<0.0010	0.046	<0.0010	<0.0010	<0.050	0.00003	85.8	<0.0010	0.00258	0.0034	<0.020	<0.0010	<0.050	25.1	0.102	<0.000010
BH8A	10-Jul-13	<0.0050	<0.00060	<0.0010	0.059	<0.0010	<0.0010	<0.050	0.000032	90.9	<0.0010	0.00159	0.0101	<0.020	<0.0010	<0.050	24.3	0.150	<0.00010
BH8A	14-Aug-13	<0.050	<0.00060	<0.010	<0.1	<0.010	<0.010	<0.50	<0.00017	91.9	<0.010	<0.0050	0.022	<0.2	<0.010	<0.50	25.3	0.168	<0.000010
BH8A	17-Oct-13	0.0033	<0.00010	0.00027	0.0511	<0.00050	<0.000050	<0.010	0.000017	82.6	0.00046	0.00093	0.045	0.025	<0.000050	0.0186	23	0.068	<0.00010
BH8A	28-Nov-13	<0.050	<0.0060	<0.010	<0.1	<0.010	<0.010	<0.50	<0.00017	86.1	<0.010	<0.0050	0.017	<0.20	<0.010	<0.5	23.9	0.031	<0.000010
BH8A	19-Dec-13	<0.050	<0.00060	<0.010	<0.10	<0.010	<0.010	<0.50	<0.00017	83.6	<0.010	<0.0050	0.021	<0.0020	<0.010	<0.50	22.7	0.023	<0.000010

Table E2 Summary of Dissolved Metals in Groundwater

	Parameters	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Strontium	Tellurium	Thallium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zinc	Zirconium
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	ODWS				0.01[a]		200[b]							0.02		5[a]	
	PWQO	0.04^^	0.025		0.1	0.0001				0.0003^^			0.03^^	0.005^^	0.006^^	0.02	0.004^^
	CEQG	0.073^^	0.15[g]		0.001	0.0001				0.0008				0.015		0.03	
Station Name	Date																
BH5A	11-Jun-13	<0.010	<0.020	<5.0	<0.010	<0.0010	7.60	0.1280	<0.010	<0.0030	<0.010	<0.020	<0.10	<0.050	<0.010	<0.030	<0.010
BH5A	10-Jul-13	0.0017	<0.0020	4.03	<0.0010	<0.00010	8.74	0.1370	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH5A	14-Aug-13	0.0017	<0.0020	4.21	<0.0010	<0.00010	8.00	0.1430	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH5A	17-Oct-13	0.00143	0.00068	4.04	<0.00010	<0.000010	7.32	0.1260	<0.00060	<0.000050	<0.00010	<0.00030		0.00119	0.00042	>0.0050	>0.0050
BH5A	28-Nov-13	<0.0010	<0.020	<5.0	<0.010	<0.0010	7.90	0.1260	<0.010	<0.0030	<0.010	<0.020	<0.10	<0.050	<0.010	<0.030	<0.010
BH5A	19-Dec-13	0.0011	<0.0020	4.1	<0.0010	<0.00010	7.40	0.1270	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH6D	11-Jun-13	<0.010	<0.020	<5.0	<0.010	<0.0010	5.60	0.0830	<0.010	<0.0030	<0.010	0.044	<0.10	<0.050	0.02300	0.047 (boxed)	<0.010
BH6D	10-Jul-13	<0.0010	<0.0020	1.61	<0.0010	<0.00010	3.20	0.0496	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	0.0034	<0.0010
BH6D	14-Aug-13	<0.0010	<0.0020	1.43	<0.0010	<0.00010	3.65	0.0433	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH6D	17-Oct-13	0.000264	0.0003	1.19	0.00032	<0.000010	2.51	0.0343	<0.00060	<0.000050	<0.00010	<0.00030		0.000256	0.00056	<0.0050	<0.0050
BH6D	28-Nov-13	<0.010	<0.020	<5.0	<0.010	<0.0010	5.90	0.0630	<0.010	<0.0030	<0.010	<0.020	<0.10	<0.050	<0.010	<0.030	<0.010
BH6D	19-Dec-13	<0.0010	<0.0020	1.03	<0.0010	<0.00010	3.72	0.0426	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH7A	11-Jun-13	<0.010	<0.020	<5.0	<0.010	<0.0010	8.30	0.1850	<0.010	<0.0030	<0.010	0.13	<0.10	<0.050	<0.010	<0.030	<0.010
BH7A	10-Jul-13	0.003	<0.0020	3.68	<0.0010	<0.00010	7.53	0.1460	<0.0010	<0.00030	<0.0010	<0.0200	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH7A	14-Aug-13	0.0024	<0.0020	3.82	<0.0010	<0.00010	5.09	0.0943	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH7A	17-Oct-13	0.00183	0.0006	3.22	<0.00010	<0.000010	6.36	0.1290	<0.00060	<0.000050	<0.00010	<0.00030		0.00408	0.00136	<0.0050	<0.0050
BH7A	28-Nov-13	0.0015	<0.0020	3.13	<0.0010	<0.00010	4.95	0.0909	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH7A	19-Dec-13	0.001	<0.0020	3.03	<0.0010	<0.00010	4.12	0.0790	<0.0010	<0.00030	<0.0010	<0.0020	<0.010	<0.0050	<0.0010	<0.0030	<0.0010
BH8A	11-Jun-13	0.0031	0.0024	3.61	<0.0010	<0.00010	6.02	0.1610	<0.0010	<0.00030	<0.0010	<0.0020	0.297	<0.0050	<0.0010	0.0051	<0.0010
BH8A	10-Jul-13	0.0034	0.0025	3.88	<0.0010	<0.00010	5.36	0.1310	<0.0010	<0.00030	<0.0010	<0.0200	0.379	<0.0050	<0.0010	0.0069	<0.0010
BH8A	14-Aug-13	<0.010	<0.020	<5.0	<0.010	<0.0010	5.30	0.1180	<0.010	<0.0030	<0.010	<0.020	0.58	<0.050	<0.010	<0.030	<0.010
BH8A	17-Oct-13	0.00291	0.00389	4.08	<0.00010	<0.000010	4.95	0.1360	<0.00060	<0.000050	<0.00010	<0.00030		0.00196	0.0007	<0.0050	<0.0050
BH8A	28-Nov-13	<0.010	<0.020	<5.0	<0.010	<0.0010	5.00	0.1110	<0.010	<0.0030	<0.010	<0.020	0.21	<0.050	<0.010	<0.030	<0.010
BH8A	19-Dec-13	<0.010	<0.020	<5.0	<0.010	<0.0010	4.8	0.1080	<0.010	<0.0030	<0.010	<0.020	0.21	<0.0050	<0.010	<0.030	<0.010

^^ PWQO and/or CEQG is an interim value
a Aesthetic Objective
b Aesthetic Objective for sodium in drinking water is 200 mg/L
c When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people
d Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen)
e Applies to water at point of consumption. Since lead is a component in some plumbing systems,first flush water may contain higher concentrations of lead than water that has been flushed for five minutes
f 0.005 mg/L if pH<6.5 or 0.1 mg/L if pH>6.5
g For hardness of 350 mg/L CaCO3
i For hardness > 75 mg/L CaCO3
o Operational Guideline

bold — Concentration is above the PWQO
(box) — Concentration is above the CEQG
italic — Concentration is above the ODWS

APPENDIX F

AMEC E&I LIMITATIONS

LIMITATIONS

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:

   (a) The Standard Terms and Conditions which form a part of our January 31, 2014 Professional Services Contract;

   (b) The Scope of Services;

   (c) Time and Budgetary limitations as described in our Contract; and,

   (d) The Limitations stated herein.

2. No other warranties or representations, either expressed or implied, are made as to the professional services provided under the terms of our Contract, or the conclusions presented.

3. The conclusions presented in this report were based, in part, on visual observations of the site and attendant structures. Our conclusions cannot and are not extended to include those portions of the site or structures which were not reasonably available, in AMEC's opinion, for direct observation.

4. The environmental conditions at the site were assessed, within the limitations set out above, having due regard for applicable environmental regulations as of the date of the inspection. A review of compliance by past owners or occupants of the site with any applicable local, provincial or federal by-laws, orders-in-council, legislative enactments and regulations was not performed.

5. The site history research included obtaining information from third parties and employees or agents of the owner. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.

6. Where testing was performed, it was carried out in accordance with the terms of our contract providing for testing. Other substances, or different quantities of substances testing for, may be present on site and may be revealed by different of other testing not provided for in our contract.

7. Because of the limitations referred to above, different environmental conditions from those stated in our report may exist. Should such different conditions be encountered, AMEC must be notified in order that it may determine if modifications to the conclusions in the report are necessary.

8. The utilization of AMEC's services during the implementation of any remedial measures will allow AMEC to observe compliance with the conclusions and recommendations contained in the report. AMEC's involvement will also allow for changes to be made as necessary to suit field conditions as they are encountered.

9. This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or in part, or any reliance thereon, or decisions made based on any information of conclusions in the report, is the sole responsibility of such third party. AMEC accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.

10. This report is not to be given over to any third party for any purpose whatsoever without the written permission of AMEC.

11. Provided that the report is still reliable, and less than 12 months old, AMEC will issue a third-party reliance letter to parties client identifies in writing, upon payment of the then current fee for such letters. All third parties relying on AMEC's report, by such reliance agree to be bound by our proposal and AMEC's standard reliance letter. AMEC's standard reliance letter indicates that in no event shall AMEC be liable for any damages, howsoever arising, relating to third-party reliance on AMEC's report. No reliance by any party is permitted without such agreement.

APPENDIX M-2

AMEC MEMORANDUM

MEMO

To	**Mark Wheeler**	File no	**TB124004**
From	**Martin Shepley**	cc	**Simon Gautrey**
Tel	**905 312 0700 #245**		
Fax	**905 312 0771**		
Date	**29th September, 2014**		

Subject **Groundwater Level and Quality Monitoring Program, Goliath Project**

AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC), proposes a groundwater monitoring program herein in anticipation of regulatory requirements to monitor changes in groundwater levels and quality in response to the proposed development of the Goliath Mine to the east of Dryden, Ontario.

AMEC has performed a detailed assessment of the effects on the groundwater system caused by the proposed open pit and underground mine and major infrastructure, specifically the TMA and WRSA (AMEC, August 2014, Hydrogeological Pre-Feasibility / EA Support Study, Goliath Project). Groundwater modelling by AMEC indicates that groundwater level declines are potentially expected within several kilometers of the open pit. The modelling also indicates that water will infiltrate into the ground beneath the Tailings Management Area (TMA) and Waste Rock Stockpile Area (WRSA), and from there migrate primarily to nearby seepage ditches and the dewatered open pit.

The dewatering and infiltration will have two different effects on the local groundwater system, with dewatering resulting in lowering of groundwater levels around the open pit, while infiltration from onsite facilities may potentially change groundwater quality close to the facilities. In both cases, monitoring is usually required to assess the predicted effects. The proposed groundwater monitoring program is designed to confirm if actual drawdown and changes in groundwater quality follow the predicted pattern, and provide sufficient time for corrective action if necessary. It is assumed that the results of the groundwater monitoring program will be reviewed and reported to the Ministry of Environment and Climate Change on an annual basis.

Regarding groundwater level drawdown, the potential for consequent deleterious effects on the yield of private wells is the main concern identified. This was considered in AMEC's 2014 report with a preliminary risk assessment, which identified private wells in the area located to the immediate west of the project site on Thunder Lake as at moderate to high risk to well interference. Private wells in the areas to the south of the open pit around Wabigoon were considered of lower risk. These areas together with the calculated Zone of Influence (ZOI) are shown on Figure 1. The degree to which individual wells will be affected is likely to vary depending on local hydrogeological conditions, the well construction and pumping levels/rates.

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Regarding groundwater quality, some leakage was predicted out of both the WRSA and TMA during the period the mine is in operation and prior to capping of these facilities, but with the majority of resultant discharge occurring respectively to the dewatered open pit and seepage collection ditches around the TMA. Subsequent to capping of these facilities, very low amounts of leakage from the TMA and the WRSA were predicted with eventual discharge to primarily Blackwater Creek, but also Hoffstrom's Bay Creek, Thunder Lake Tributary #3 and Thunder Lake.

Type of Groundwater Monitoring Wells

Groundwater monitoring wells will be either for groundwater sampling or groundwater level recording, with some wells serving both purposes. The primary horizon for groundwater flow is the shallow bedrock (SBR) and, when present, the Basal Sand (BS) that occurs at the base of the fine-grained, clay dominated glaciolacustrine deposits (the dominant overburden of the project area). Most monitoring wells will be screened within either the SBR or BS, or possibly both depending on ground conditions encountered during drilling. In the vicinity of the TMA a Sand-Clay/Silt-Sand sequence occurs. In this location wells should be nested to sample the surficial sand (SS) and BS if the Sand-Clay/Silt-Sand sequence is encountered (i.e. similar to the existing BH3A Shallow and BH3A Deep). The well screen in the SS will monitor the performance of the seepage collection ditches in collecting shallow horizontal groundwater flow out of the TMA, whereas the well screen in the BS will provide monitoring for vertical leakage out of the base of the TMA.

Review of Present Groundwater Monitoring Installations

The locations of the current groundwater monitoring installations are shown on Figure 1. Three groups are distinguished:

1. The 2013 groundwater quality wells. All of these wells are in good locations for monitoring groundwater quality around the TMA or groundwater levels around the proposed open pit. All are screened to either the SBR, BS or both, with the exception of BH5A, which is screened to the bottom of the glaciolactustrine clays[1]. It is possible that two of the wells could be destroyed on construction of the WRSA and overburden stockpile (BH4A and BH5A respectively).
2. The 2014 vibrating wire piezometer (VWP) nests located in Intermediate Bedrock (IBR). One of these will be destroyed on construction of the open pit.
3. Stand pipes installed in the 2014 geotechnical boreholes. Two of these will be destroyed with the construction of the TMA. The use of these stand pipes for future monitoring is limited as they are screened to the top of the overburden and are not screened to either SBR or BS.

It is expected that a total of ten well screens and piezometers (six single-screen wells, one nested well and one nested VWP) of the current groundwater monitoring installations will be used for the future groundwater monitoring network:

[1] The bottom of BH5A is considered to be at the top of bedrock based on auger refusal. An elevated value of hydraulic conductivity (~1E-06 m/s) indicates this well may be affected by flow in weathered SBR.

- Four of the single-screen wells are suitable for monitoring groundwater levels in the SBR and/or BS in response to dewatering to the west and south of the open pit at distal (BH7A and BH8A) and proximal (BH5A and BH6D) locations. If BH5A is destroyed during construction of the overburden stockpile, it could be replaced during operation of the mine.
- The east-west striking mineralized zone is expected to have elevated bedrock hydraulic conductivities, which could influence the extension of the drawdown cone towards the west. The western VWP nest (TL131121) lies in a strategic location for measuring the groundwater pressure during dewatering around the mineralized zone to the west of open pit.
- Three of the wells are located around the TMA (BH1A, BH2A and BH3A) and one well close to the WRSA (BH6D) are suitable for groundwater quality monitoring. BH2A is in an up-gradient location and would provide background groundwater quality data during operation of the TMA.

An additional eight monitoring locations are required (Figure 1) for the future groundwater monitoring network:

- An additional three wells (NW1, NW2 and NW3) are required close to the perimeter of the TMA for groundwater quality monitoring. It is assumed that these will be nested with a screen in the SS and the BS/SBR (i.e. top and bottom of Sand-Clay/Silt-Sand sequence).
- An additional three wells (NW4, NW5 and NW6) with single screens in BS/SBR are required to the west of the open pit in distal locations to monitor groundwater levels between Thunder Lake and the perimeter of Treasury Metals property. Two of these would also be used for groundwater quality monitoring of the WRSA (NW4 and NW5);
- An additional two wells (NW7 and NW8) with single screens in BS/SBR are required to the south of the open pit in distal locations to monitor groundwater levels along the perimeter of Treasury Metals property in the direction of Wabigoon.

A summary of the proposed groundwater monitoring network is provided in Table 1.

All the installations of the groundwater monitoring network should be constructed and/or modified where necessary to include protective casings and markings, and if required, a barricade to prevent damage by heavy equipment during mine construction and operation.

Groundwater Level Monitoring

There are 9 single screen monitoring wells and 1 nested VWP in the groundwater level monitoring program with a total of 11 monitoring well screen and piezometers. These are generally completed in the SBR and/or BS where the most drawdown is expected to be observed.

Manual water level measurements should continue on a monthly basis in the existing wells. However, prior to mining all wells should be equipped with pressure transducers set to record water levels once per day, and downloaded on a quarterly basis. Two of the wells should be equipped with a barologger to allow data correction for barometric effects. A data logger should be obtained for the VWP nested piezometer and a similar recording and downloading frequency should be undertaken for this installation. Installation of new wells and pressure transducers/loggers should be done a year prior to mine construction.

Groundwater Quality Monitoring
There are 4 single screen and four nested well locations in the groundwater quality monitoring program with a total of 12 monitoring well screens. These wells are to be screened in the SBR and/or BS with the nested well locations having an additional screen in the SS where Sand-Clay/Silt-Sand sequence is present.

Where wells are part of the groundwater quality program, it would be expected that they are sampled at a frequency of four times per year. Water levels would be taken prior to sampling. The following parameters (suites) are recommended:

- Metals (dissolved);
- Cyanide in monitoring wells around TMA (Total, Free and WAD for first year, then Total and WAD thereafter);
- Major anions and cations; and
- In-situ field parameters (temperature, Eh, pH, dissolved oxygen).

Several existing wells in the proposed groundwater quality monitoring program have been sampled for as part of baseline studies with the earliest sampling dating from June 2013. These wells should be continued to be sampled on a quarterly basis. Quarterly sampling is the expected frequency for the groundwater quality program prior to and during mine construction and operation. The new wells should be installed a year prior to mine construction to collect one year of pre-construction and mining data for these wells.

Mine Closure
Groundwater quality monitoring would be continued until both the TMA and WRSA are capped. Termination of the program would be expected following a satisfactory review of the monitoring data collected during mine operation.

Closure

Should you have any questions regarding this memo or require more information, please feel free to contact the undersigned at (905) 312-0700.

Sincerely,
AMEC Environment & Infrastructure
a Division of AMEC Americas Limited

Prepared by:	Reviewed by:
<Original signed by>	<Original signed by>
Martin Shepley, D.Phil., M.Sc., P.Geo. Associate Hydrogeologist	Simon Gautrey, M.Sc., MBA, P.Geo. Senior Associate Hydrogeologist

Table 1: Location and Type of Groundwater Monitoring Wells in Proposed Goliath Groundwater Monitoring Network

Well ID	Location	Type	Screened Units	Monitoring Objective
BH1A	West of TMA, Nursery Road	Quality	BS/SBR	Down-gradient water quality of TMA
BH2A	East of TMA, Blackwater Creek	Quality	BS/SBR	Upstream of TMA – background groundwater quality in basal sand/shallow bedrock
BH3A-S BH3A-D	South of TMA, Blackwater Tributary 2	Quality	SS BS	Down-gradient water quality of TMA in shallow sand Down-gradient water quality of TMA in basal sand
BH5A (or replacement well in similar location)	South of Open Pit, proximal	Level	SBR[1]	Water level proximal to open pit. Given the location on the edge of the overburden stock pile, it is possible that this hole will have to be replaced during the operational life of the mine
BH6D	West of Open Pit and WRSA, proximal	Quality and level	BS	Water level proximal to open pit and down-gradient of WRSA
BH7A	West of Open Pit, distal	Level	BS	Water levels distal to open pit, east of Thunder Lake
BH8A	South of Open Pit, distal	Level	BS	Water levels distal to open pit, north of Wabigoon. Furthest downstream monitoring of groundwater quality
TL13121-S TL13121-D	West of Open Pit, proximal	VWP	IBR – 64 mbgs IBR – 223 mbgs	Pressure response to dewatering in open pit in intermediate bedrock along mineralized zone
New well #1 (nested)	North of TMA	Quality	SS and BS/SBR	Northern edge of TMA – nested piezometer assuming presence of Sand-Clay/Silt-Sand sequence
New well #2 (nested)	North-west of TMA, Nursery Road	Quality	SS and BS/SBR	Down-gradient water quality – nested piezometer assuming presence of Sand-Clay/Silt-Sand sequence
New well #3 (nested)	South-west of TMA, Nursery Road	Quality	SS and BS/SBR	Down-gradient water quality – nested piezometer assuming presence of Sand-Clay/Silt-Sand sequence
New well #4	North-west of Open Pit and WRSA	Quality and level	BS/SBR	Down-gradient water quality of WRSA and water levels distal to open pit, east of Thunder Lake
New well #5	West of Open Pit and WRSA	Quality and level	BS/SBR	Down-gradient water quality of WRSA and water levels distal to open pit, east of Thunder Lake
New well #6	West of Open Pit, distal	Level	BS/SBR	Water levels distal to open pit, east of Thunder Lake
New well #7	South of Open Pit, distal	Level	BS/SBR	Water levels distal to open pit, north of Wabigoon

Well ID	Location	Type	Screened Units	Monitoring Objective
New well #8	South of Open Pit, distal	Level	BS/SBR	Water levels distal to open pit, north of Wabigoon

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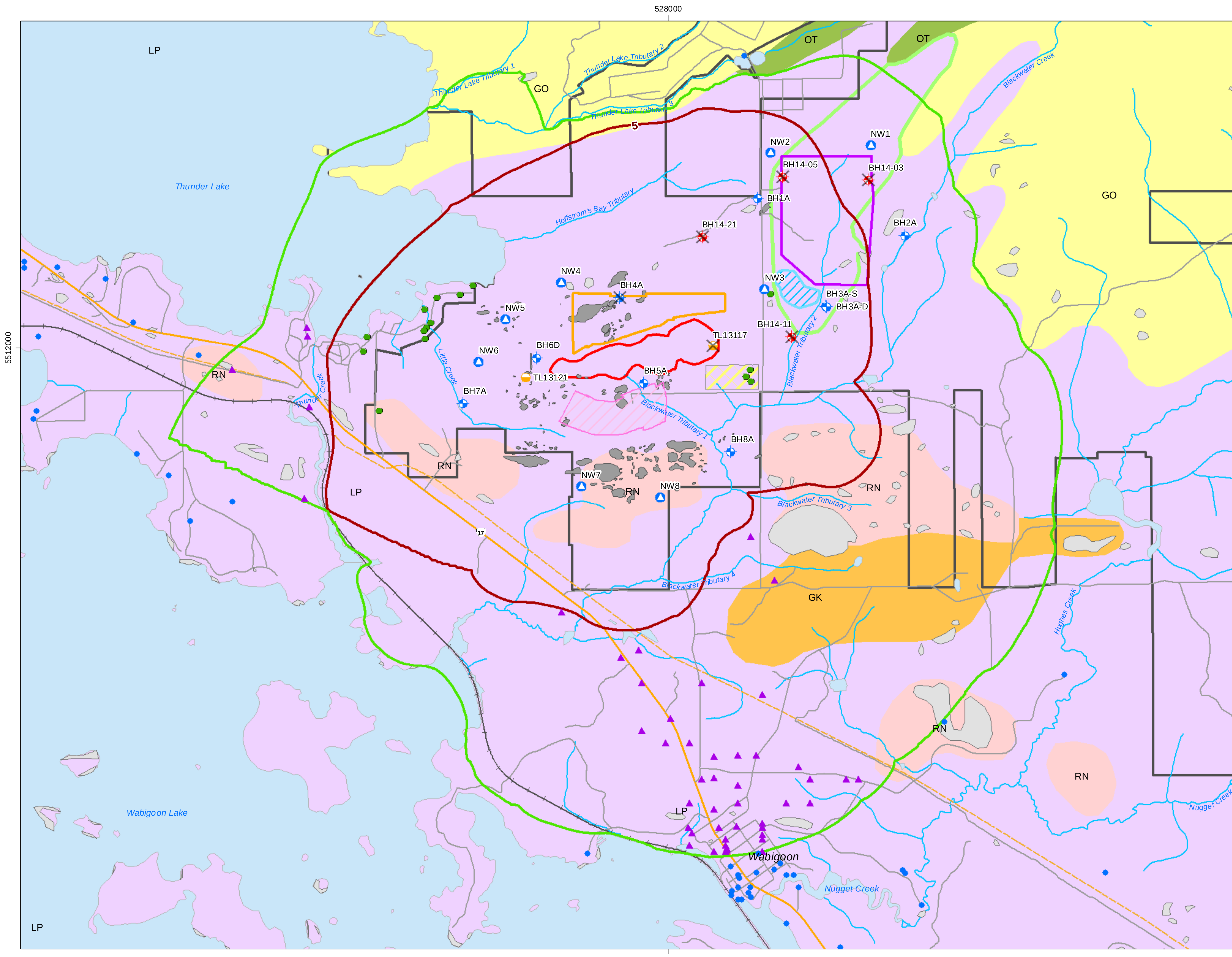


HYDROGEOLOGICAL PRE-FEASIBILITY / EA SUPPORT STUDY

Goliath Project

Figure 1

Proposed Groundwater Monitoring Network

Legend

- 2013 Monitoring Well
- 2014 Geotechnical Hole with Standpipe
- Proposed New Well Locations for Groundwater Monitoring Network
- Exploration Hole with Vibrating Wire Piezometer
- Private MOE Water Well outside of ZOI
- Private MOE Water Well within ZOI boundary
- Private MOE Water Well within 5 m ZOI
- Base Case 5 m Drawdown
- Extent of Zone of Influence
- Proposed Open Pit
- Lowgrade Stockpile
- Overburden Stockpile
- Waste Rock Storage Area
- Tailings Management Area
- Tailings Management Pond
- Treasury Metals Property Boundary

Surficial Geology

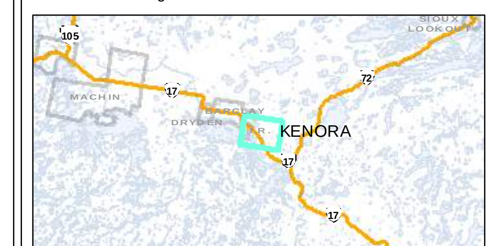
- Sand - Clay / Silt - Sand Boundary

Landform

- GK: Kame
- GO: Glaciofluvial Outwash
- LB: Raised Beach
- LP: Glaciolacustrine Plain
- OT: Organics
- RN: Bedrock Knob

Bedrock Outcrop Mapping

- Beakhouse and Pigeon, 2003
- Treasury Metals
- idicates well not proposed for future groundwater monitoring network



Source: National Topographic Database, 052F09, 052F10, 052F15, and 052F16, 1:10 000 nominal scale.
Source: Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Ontario Geological Survey, Miscellaneous Release--Data 160. 1:100,000 scale

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project #: TB124004
Date: August, 2014
Client: Ontario Infrastructure & Lands

Drawn by: DF
Checked by: MS
Revision No.: 2

UTM NAD 83
Zone 15N
1:30,000

Kilometers 0 0.2 0.4 0.6 0.8 1

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LIMITATIONS

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:
   - (a) The Standard Terms and Conditions which form a part of our January 31, 2014 Professional Services Contract;
   - (b) The Scope of Services;
   - (c) Time and Budgetary limitations as described in our Contract; and,
   - (d) The Limitations stated herein.
2. No other warranties or representations, either expressed or implied, are made as to the professional services provided under the terms of our Contract, or the conclusions presented.
3. The conclusions presented in this report were based, in part, on visual observations of the site and attendant structures. Our conclusions cannot and are not extended to include those portions of the site or structures which were not reasonably available, in AMEC's opinion, for direct observation.
4. The environmental conditions at the site were assessed, within the limitations set out above, having due regard for applicable environmental regulations as of the date of the inspection. A review of compliance by past owners or occupants of the site with any applicable local, provincial or federal by-laws, orders-in-council, legislative enactments and regulations was not performed.
5. The site history research included obtaining information from third parties and employees or agents of the owner. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.
6. Where testing was performed, it was carried out in accordance with the terms of our contract providing for testing. Other substances, or different quantities of substances testing for, may be present on site and may be revealed by different of other testing not provided for in our contract.
7. Because of the limitations referred to above, different environmental conditions from those stated in our report may exist. Should such different conditions be encountered, AMEC must be notified in order that it may determine if modifications to the conclusions in the report are necessary.
8. The utilization of AMEC's services during the implementation of any remedial measures will allow AMEC to observe compliance with the conclusions and recommendations contained in the report. AMEC's involvement will also allow for changes to be made as necessary to suit field conditions as they are encountered.
9. This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or in part, or any reliance thereon, or decisions made based on any information of conclusions in the report, is the sole responsibility of such third party. AMEC accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.
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