REPORT

Level 1 and Level 2 Hydrogeological and Hydrological Assessments for the Childs Pit/Quarry Extension

Town of Bracebridge, Ontario

Submitted to:

Fowler Construction Company Limited
1206 Rosewarne Dr., P.O. Box 630
Bracebridge, Ontario
P1L 1T9

Submitted by:

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario
K2H 5B7

+1 613 592 9600

1895639

June 2020

Distribution List

1 e-copy	MHBC Planning Limited
1 e-copy	Golder Associates Ltd.

Executive Summary

Fowler Construction Company Limited (Fowler) is applying for a Category 1, Class A license (Pit Below Water) and a Category 2, Class A license (Quarry Below Water) under the *Aggregate Resources Act* (ARA), and a Town of Bracebridge Zoning By-law Amendment under the *Planning Act* to permit an extension to their existing Childs Pit/Quarry operation (referred to herein as the “Extension Lands”). The proposed Extension Lands are located directly to the south of the existing licensed area. The area proposed to be licensed under the *ARA* is 163.1 hectares (ha) and the proposed extraction area is 143.2 ha. The licensing of the Extension Lands would also include a setback reduction along the common boundaries with the existing licensed area. This setback reduction covers an area of 1.3 ha. The proposed final quarry floor base elevation for the Extension Lands is variable and ranges between 270 metres above sea level (m ASL) and 320 m ASL.

The existing licensed area and existing licensed area of extraction under the current Ministry of Natural Resources and Forestry (MNRF) license for the Childs Pit/Quarry are 234.7 ha and 202.0 ha, respectively. The existing Childs Pit/Quarry and the Extension Lands are located in the Town of Bracebridge, District of Muskoka, Ontario. The existing Childs Pit/Quarry is currently licensed to be operated in a series of phases and lifts with final approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). These approved final floor elevations for the existing Childs Pit/Quarry are substantially lower than the lowest proposed floor elevation for the Extension Lands which has been established at a minimum (lowest) floor elevation of 270 m ASL.

Given that Fowler proposes to operate both the existing Childs Pit/Quarry and the Extension Lands simultaneously in a phased approach with consistent floor elevations between the two properties, the impact assessment presented in this report does not consider full extraction on the existing Childs Pit/Quarry property down to the currently approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). The impact assessment presented in this report considers **interim quarry floor elevations** for the existing Childs Pit/Quarry which are similar to the proposed **final floor elevations** for the Extension Lands.

The work program associated with the preparation of this document included 11 distinct tasks, as follows, data review and compilation; receptor identification; bedrock drilling program; monitoring well installation program; hydraulic conductivity testing program; groundwater level monitoring program; private well survey; surface water level and flow monitoring program; water balance analysis; groundwater flow modelling and impact assessment.

The current study completed by Golder Associates Ltd. identified low hydraulic conductivity bedrock in the vicinity of the site, and limited connection between shallow groundwater and surface water features. Based on the results of this hydrogeological and hydrological investigation for the Extension Lands, the proposed additional quarry development will protect sensitive surface water and sensitive groundwater receptors during the operational period and under rehabilitated conditions. During the operational and rehabilitation periods, a multi-disciplinary monitoring program will be implemented for the purpose of verifying that the development of the proposed Extension Lands is not adversely impacting surface water or groundwater receptors (including private wells).

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Background and Site Description

Fowler Construction Company Limited (Fowler) operates a number of pits and quarries in central and eastern Ontario. The materials extracted from these sites are used for road construction, road maintenance, site development, parking lots, golf course construction and landscaping, etc. Fowler operates the existing Childs Pit/Quarry in accordance with License No. 918881 issued by the Ministry of Natural Resources and Forestry (MNRF). The existing licensed area and existing licensed area of extraction under the current MNRF license for the Childs Pit/Quarry are 234.7 hectares (ha) and 202.0 ha, respectively.

Under this existing license, the Childs Pit/Quarry is to be operated in a series of phases with a final approved floor elevation of 195 metres above sea level (m ASL) for the extraction area east of the Hydro easement and a final floor elevation of 190 m ASL for the extraction area west of the Hydro easement. The Hydro easement traverses the existing Childs Pit/Quarry in a north-south orientation and effectively divides the existing licensed Childs Pit/Quarry into a western extraction area (with a final floor elevation of 190 m ASL) and an eastern extraction area (with a final floor elevation of 195 m ASL).

Fowler is applying for a Category 1, Class A license (Pit Below Water) and a Category 2, Class A license (Quarry Below Water) under the *Aggregate Resources Act* (ARA), and a Town of Bracebridge Zoning By-law Amendment under the *Planning Act* to permit an extension to their existing Childs Pit/Quarry operation (referred to herein as the "Extension Lands" or "extension"). The general location of the existing Childs Pit/Quarry and the Extension Lands are shown on Figure 1. As shown on Figure 1, the existing Childs Pit/Quarry and the Extension Lands are bounded by the North Branch of the Muskoka River to the west and Bonnie Lake Road to the east.

The Extension Lands are located directly to the south of the existing licensed area. The area proposed to be licensed under the *ARA* is 163.1 ha and the proposed extraction area is 143.2 ha. The licensing of the Extension Lands would also include a setback reduction along the common boundaries with the existing licensed area. This setback reduction covers an area of 1.3 ha. The proposed final quarry floor base elevation for the Extension Lands is variable and ranges between 270 m ASL and 320 m ASL. The boundaries of the licensed area and limit of extraction for the existing Childs Pit/Quarry and the proposed boundaries for the Extension Lands are shown on Figure 2.

The legal description for the existing Childs Pit/Quarry is as follows:

- Part Lot 13, Concession 9, and Part Lot 13 and Lot 14, Concession 10, and Lots 14, 15 & 16, Concession 11, and Part Lots 14 & 15, Concession 12
- Road Allowance between Lots 15 & 16, Concession 11, and Road Allowance between Concessions 10 & 11 in front of lots 14, 15 & 16
- Town of Bracebridge (Geographic Township of Macaulay), District of Muskoka

The legal description for the Extension Lands is as follows:

- Lots 15 & 16, Concession 10 and Part Lots 14-17, Concession 9
- Road Allowance Between Lots 15 & 16, Concession 10
- Part of Road Allowance Between Lots 15 & 16, Concession 9
- Town of Bracebridge (Geographic Township of Macaulay), District of Muskoka

The existing Childs Pit/Quarry permits below water extraction and is licensed to ship an unlimited tonnage per year. The existing entrance/exit is located on Bonnie Lake Road and with the exception of local deliveries, trucks exiting the quarry travel south on Bonnie Lake Road. The maximum permitted hours of operation for the quarry are Monday to Sunday 24 hours per day excluding statutory holidays. The current operations on the existing Child Pit/Quarry involve bedrock, sand and gravel extraction. The existing license allows for blasting and processing on-site, and processing equipment is currently located on the pit floor in the north portion of the existing Childs Pit/Quarry.

The proposed extension will have the same hours of operation and utilize the existing entrance/exit, and existing haul route. The license for the Extension Lands is proposed to permit shipping a maximum of 2,000,000 tonnes per year.

Golder Associates Ltd. (Golder) was retained by Fowler to complete the necessary hydrogeological and hydrological studies to support the applications under the *ARA* and the *Planning Act*. This report presents the combined results of the hydrogeological and hydrological studies completed in support of a site plan license application for a Category 1, Class A license (Pit Below Water) and a Category 2, Class “A” (Quarry Below Water). These studies were conducted for the purpose of addressing the requirements for Hydrogeological Level I and Level II studies as described in Sections 2.2.1 and 2.2.2 of the Report Standards for Category 2 Application as presented in the Aggregate Resources of Ontario, Provincial Standards Version 1.0.

As noted above, the existing Childs Pit/Quarry is currently licensed to be operated in a series of phases and lifts with final approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). These approved final floor elevations for the existing Childs Pit/Quarry are substantially lower than the lowest proposed floor elevation for the Extension Lands which has been established at a minimum (lowest) floor elevation of 270 m ASL.

Given that Fowler proposes to operate both the existing Childs Pit/Quarry and the Extension Lands simultaneously in a phased approach with consistent floor elevations between the two properties, the impact assessment presented in this report does not consider full extraction on the existing Childs Pit/Quarry property down to the currently approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). The impact assessment presented in this report considers **interim quarry floor elevations** for the existing Childs Pit/Quarry which are similar to the proposed **final floor elevations** for the Extension Lands. In summary, for the existing Childs Pit/Quarry property, the interim quarry floor elevations are considered in the context of the impact assessment presented herein and any extraction operations below these proposed interim quarry floor elevations on the existing Childs Pit/Quarry property would be subject to the completion of an updated hydrogeological and hydrological impact assessment at some point in the future.

Figure 3 illustrates the **interim quarry floor elevations** for the existing Childs Pit/Quarry and the proposed **final floor elevations** for the Extension Lands in both plan and cross-sectional views. These quarry floor elevations are used in the context of the cumulative impact assessment presented in this report.

These studies also take into consideration the setback reductions along the common boundaries between the existing Childs Pit/Quarry and the proposed Childs Pit/Quarry Extension which represents an area of about approximately 1.3 ha.

The results of the ecological studies are presented in a separate Natural Environment Level I and Level II Report (RiverStone, 2020).

1.2 Scope of Hydrogeological and Hydrological Study

The main objectives of the hydrogeological and hydrological studies were to:

- Characterize the existing hydrogeological and hydrological conditions in the vicinity of the existing Childs Pit/Quarry and Extension Lands.
- Assess potential impacts on groundwater and surface water associated with operation and rehabilitation of the existing quarry and proposed extension based on the quarry development scenario presented in Section 1.1.

The work program consisted of the following:

- Data review and compilation
- Receptor identification
- Borehole drilling program
- Monitoring well installation program
- Hydraulic conductivity testing program
- Groundwater level monitoring program
- Private Well Survey
- Surface water level and flow monitoring program
- Water balance analysis
- Groundwater flow modelling and impact assessment

1.3 Document Structure

This report is organized into a main text and supporting tables, figures and appendices. The text provides a discussion of the following:

- Regional setting (Section 2.0)
- Summary of previous investigations (Section 3.0)
- Study methodology (Section 4.0)
- Site-specific conditions based on a summary of the completed work program, as well as data gathered as part of previous investigations (Sections 5.0 and 6.0)
- Receptor Identification (Section 7.0)

- Groundwater flow modelling results (Section 8.0)
- Water Balance (Section 9.0)
- An impact assessment focused on assessing the potential impacts associated with the development of the Extension Lands (Section 10.0)
- Complaints response program (Section 11.0)
- Proposed water monitoring programs (Section 12.0)
- Summary and conclusions (Section 13.0).

The qualifications and experience of the report authors are presented in Appendix L.

2.0 REGIONAL SETTING

2.1 Physiography/Topography

Chapman and Putnam (1984) indicate that the study area is located within the Georgian Bay Fringe physiographic region. This physiographic region is described as having very shallow soil and bare rock knobs. The overburden that is present within this physiographic region is typically a sandy soil and is identified as bedrock drift deposits that are thin and discontinuous.

The topography in the vicinity of the site is shown on Figure 4. At the site, the ground surface elevations range from approximately 295 m ASL to 335 m ASL. The ground surface is generally highest within the Extension Lands and to the east of the site, and the topography generally slopes down to the west towards the North Branch of the Muskoka River. In the southern portion of the site, the topography slopes towards the south in the direction of Sage Creek.

2.2 Geology and Hydrogeology

2.2.1 Surficial Geology

The regional surficial geological setting of the existing Childs Pit/Quarry and Extension Lands is illustrated on Figure 5.

The North Branch of the Muskoka River follows the ancestral discharge routes associated with the final retreat of the Laurentide Ice Sheet from the area. Consequently, the vast majority of the existing Childs Pit/Quarry property is underlain by thick ice-contact stratified deposits (Map Unit 6) associated with this ancestral discharge route. Along the eastern limits of the existing Childs Pit/Quarry property, the area is underlain by shallow or exposed bedrock (Map Units 1 and 2).

The Extension Lands are characterized by the presence of shallow or exposed bedrock with limited overburden cover (Map Units 1 and 2). Disbursed across the property are deposits of glacial till (Map Unit 5a). Along the southeast periphery of these lands, deposits of coarse-grained glaciolacustrine deposits are mapped as Map Unit 9c on Figure 5.

On both the existing Childs Pit/Quarry property and the Extension Lands, pockets of organic deposit are present (Map Unit 20 on Figure 5).

2.2.2 Bedrock Geology

The regional bedrock geological setting of the Childs Pit/Quarry and proposed Childs Pit/Quarry Extension is illustrated on Figure 6. In general, the property is located in the Central Gneiss Belt of the Grenville Province. In As shown on Figure 6, the existing pit/quarry and proposed extension are mapped to be underlain by Precambrian migmatitic rocks and gneisses of uncertain protolith (Map Unit 41). Additional details on the site-specific bedrock geology is presented in Section 5.1.2 of this report.

2.2.3 Hydrogeology

Extensive deposits of coarse and permeable overburden, capable of supplying sufficient quantities of groundwater for domestic use, are not prevalent in the vicinity of the nearest residential development adjacent to the site along Bonnie Lake Road. The majority of the private wells are completed within the bedrock although dug wells do exist in areas with a sufficient thickness of permeable overburden materials. In general, the bedrock is considered the principal aquifer for water supply in the area.

Unweathered and unfractured metamorphic rocks (such as the grey gneiss or monzogranite seen at the site in the cored boreholes) have primary porosities (i.e., natural volume of void space) that are typically less than two percent, and primary permeabilities close to zero. Secondary porosity and permeability are commonly developed through fracturing and weathering of the rock. Fractured metamorphic rocks may exhibit secondary porosities up to 10 percent (Freeze and Cherry, 1979). Groundwater flow within such bedrock aquifers is primarily through secondary porosity from fractures that have developed.

Well yields tend to be highly variable in metamorphic rocks, with the variability reflecting the differences in the extent and degree of fracturing and weathering. Information provided in the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) indicates that the private wells in the area are primarily completed in red and grey/black granite, which is interpreted to be the gneisses identified on the geological mapping of the area. For private wells within 500 metres (m) of the site, the well yields vary between 4 Litres per minute (L/min) and 30 L/min, with the average being 18 L/min.

2.3 Hydrology

The study area is within the Muskoka River watershed. This watershed has a drainage area of approximately 4,670 square kilometres (km^2), which outlets into Georgian Bay (Ontario Ministry of Natural Resources (MNR), Ontario Power Generation (OPG), Orillia Power Generation Corporation, Bracebridge Generation Ltd., Algonquin Power Fund (Canada) Inc., 2018). The most prominent waterbody features in the general area include Lake Muskoka located approximately 10 kilometres (km) to the southwest of the proposed Extension Lands (with a local drainage area of 116 km^2), Lake of Bays approximately 2 km to the northeast with a drainage area of 60 km^2, and Lake Rosseau, approximately 13 km west from the site. The regional hydrology, most prominent water features and the site are shown on Figure 7.

There are several watercourses in the vicinity of the site. The main surface water features of interest to this study are Sage Creek, located adjacent to the south boundary of the Extension Lands draining a catchment area of approximately 5,417 ha, and the North Branch of the Muskoka River, located adjacent to the west boundary of the site, with a catchment area of approximately 148,820 ha at the current point of drainage from the site. The Muskoka River in turn drains south before reaching Lake Muskoka. The Muskoka River ultimately enters Georgian Bay approximately 138 km downstream from the site draining a catchment area of approximately 4,670 km^2 (4,670,000 ha). Sage Creek flows west draining lands located to the east of the site and reaches the confluence point with the Muskoka River south of the southeast corner of the existing Childs Pit/Quarry, comprising a catchment area of approximately 5,417 ha at the discharge point.

Runoff from most of the existing Childs Pit/Quarry and the northern part of the Extension Lands (herein referred to as Zone A) flows nominally northwest towards the Muskoka River. The boundary for Zone A is shown on Figure 8. Drainage from the existing license flows via a watercourse (herein referred to as MR-North; see location on Figure 9) to the current point of drainage from the quarry. The rest of the drainage within the Muskoka River catchment occurs predominantly via a secondary watercourse (i.e., MR-South on Figure 9) conveying local flow from the existing Childs Pit/Quarry to the Muskoka River, discharging just south of MR-North. The portion of MR-North within the existing Childs Pit/Quarry license area is already approved for extraction and the connectivity of the remaining catchment area within the Extension Lands will be disconnected from the Muskoka River. The surface water from MR-North will drain into the existing Childs Pit/Quarry, be collected in the sump and discharged in accordance with MECP permits. The MR-South catchment is already within the approved extraction area of the existing quarry. Additionally, small, typically intermittent, tributaries with headwaters located within the existing Childs Pit/Quarry discharge to the Muskoka River, mostly as overland flow, as shown on Figure 9.

Runoff from the remaining southern part of the Extension Lands (herein referred to as Zone B) reports to Sage Creek in the form of overland flows and several small tributaries. The boundary for Zone B is shown on Figure 8. The remaining portion at the southwestern corner of the existing Childs Pit/Quarry area reports to the downstream reach of Sage Creek, close to the confluence with the Muskoka River. The divide between the Muskoka River and Sage Creek catchments, and relevant sub-catchments extending onto the existing Childs Pit/Quarry and Extension Lands are presented in Figure 8. Drainage from Zone B is conveyed via several small intermittent drainage features and one small perennial tributary nominally southwards towards Sage Creek as shown on Figure 9.

2.4 Ecological Context

The study area is located in the Georgian Bay Fringe physiographic region (Chapman and Putnam 1984). In general, the Georgian Bay Fringe has low relief and ranges in ground elevation from 350 m ASL in the east to 177 m ASL along Georgian Bay. The study area lies within Ecodistrict 5E-8 and includes deciduous and mixed-forest communities characteristic of this region (Henson and Brodribb, 2005). The communities mapped in the study area include one anthropogenic meadow community, ten upland forest communities, and seven wetland communities (RiverStone, 2020).

In addition to the mixture of forests and wetlands, the general landscape surrounding the Extension Lands contains a large active pit/quarry and adjacent rural residential properties. The north branch of the Muskoka River flows adjacent to and west of a portion of the study area and a permanent coldwater creek, Sage Creek, is located to the south of the Extension Lands. Several other permanent and intermittent creeks were also identified. There are some linear openings throughout the area including gravel roads and a large Hydro corridor. The Sage Creek Subaquatic Fan is located along the north branch of the Muskoka River on the eastern bank and was recommended as a Natural Heritage Site in the Natural Heritage Evaluation of Muskoka by Reid and Bergsma (1994).

The ecological context is described in detail in the Natural Environment Level I and Level II Report (RiverStone, 2020). The on-site watercourses presented on the figures within this report are based on information provided by RiverStone Environmental Solutions Inc (Riverstone). On site wetlands were delineated by Riverstone as shown on Figure 2, along with MNRF wetland mapping.

3.0 PREVIOUS HYDROGEOLOGICAL INVESTIGATIONS

Harden Environmental Services Ltd. (2012) completed a hydrogeological investigation at the existing Childs Pit/Quarry property. The scope of this investigation included site visits, review of water well records and the drilling of a new well which was referred to as the "Scalehouse Well", sampling of water from the Scalehouse Well and stream flow measurements in Sage Creek. Based on the testing of the Scalehouse Well completed in 2012, it was estimated that the hydraulic conductivity of the Precambrian bedrock in the vicinity of this well was 4.5×10^{-10} metres per second (m/s).

The primary conclusions from the Harden Environmental Services Ltd. (2012) were as follows:

- The water quantity and quality presently obtained in wells along Bonnie Lake Road will not be affected by the proposed bedrock mining.
- Groundwater contribution to Sage Creek from the bedrock aquifer is negligible and neither flow conditions nor temperature of Sage Creek will be affected by the mining activities.
- Evaporation from the quarry lake will have a negligible impact on the hydrology of Sage Creek and the North Branch of the Muskoka River.
- The capture of runoff by the quarry will not significantly change the flow in Sage Creek and the North Branch of the Muskoka River.

Hydrogeological data collected as part of this previous investigation have been utilized, where appropriate, during the preparation of this report. The Scalehouse Well is referred to as TW12-1 by Golder in this current report.

4.0 STUDY METHODOLOGY

4.1 Receptor Identification

As part of the current investigation, an initial site visit was conducted to identify potential receptors, to select borehole locations and surface water monitoring stations and to observe site topography and general site conditions. Potential receptors in the vicinity of the existing Childs Pit/Quarry and the Extension Lands that could be affected by the progressive pit/quarry development were identified as discussed in the following subsections.

4.1.1 Groundwater Receptors

The MECP water well records within the WWIS were plotted on a map (centred on the existing Childs Pit/Quarry and Extension Lands) to aid in the assessment of groundwater use within the area. The water well records were examined to determine the general yield and depth of identified private supply wells.

4.1.2 Surface Water Receptors

MNRF provincial mapping, detailed site topography at 2-m contours (MNRF, 2015) and field data collected during the initial site reconnaisance and periodic site visits completed by Golder between 2018 and 2019 were reviewed to identify and confirm local and regional drainage features. Watercourses within the existing Childs Pit/Quarry and Extension Lands correspond to features surveyed and mapped by Riverstone. Some of these watercourses were classified as key surface water receptors because of their potential to be changed as a result of the development of the Extension Lands and/or their environmental relevance.

A description of the key surface water features identified within the existing Childs Pit/Quarry and Extension Lands, including an indication and rationale for whether further assessments are required for each surface water receptor, is described below. The nomenclature used to differentiate surface water receptors refers to the catchment name (i.e., MR stands for Muskoka River and SC for Sage Creek) followed by a unique identifier related to the associated monitoring station (if applicable). The surface water receptors described below are shown on Figure 9.

- MR-North: watercourse with headwaters originating within the Extension Lands immediately north of the divide between the Sage Creek and Muskoka River watersheds. This watercourse flows north towards a ponded area, which is monitored at SW-1, and continues flowing north through a wetland feature before turning west across the existing Childs Pit/Quarry towards its confluence with the Muskoka River. The catchment of this watercourse is estimated at 182.7 ha and represents 31 percent of the Extension Lands. The hydrology of the portion of MR-North catchment, which falls within the Extension Lands (50.7 ha), is evaluated in detail in this study. The portion of MR-North within the existing license area was already approved for extraction and the connectivity of the remaining catchment area within the Extension Lands will be disconnected from the Muskoka River. Surface water from the feature will drain into the existing Fowler Childs Pit/Quarry, be collected in the sump and discharged in accordance with MECP permits.
- MR-South: watercourse with headwaters originating within the existing Childs Pit/Quarry area and currently drains to the Muskoka River south of MR-North. This feature originates on the existing Childs Pit/Quarry and does not drain significant parts of the Extension Lands; as such, is evaluated at the catchment level (i.e. Muskoka River). The MR-South catchment is within the approved extraction area of the existing quarry.
- Muskoka River (MR): the Muskoka River is evaluated immediately downstream of the confluence with MR-North. Given the large catchment size at the point of analysis (148,820 ha) in comparison with the area affected by the Extension Lands (163.1 ha), effects are anticipated to be minimal. However, this feature is still considered a key receptor and subject to further evaluation in this report.
- SC-3: a tributary with headwaters originating immediately south of the divide of Sage Creek and Muskoka River watersheds, within the Extension Lands and reporting directly to Sage Creek. This feature is monitored at station SW-3 and was found to have flow during all monitoring events. It was subsequently classified as a permanent watercourse and is subject to further evaluation in this report.
- SC-3B: suspected drainage feature with headwaters originating immediately south of the divide of Sage Creek and Muskoka River watersheds, within the Extension Lands, and located in a low-lying area draining into SC-3 near the confluence with Sage Creek. This feature, monitored at station SW-3B, was found to be dry during most of the summer and outflow to SC-3 was never observed. Field observations and topographic data suggest that surface water in this feature is not connected to Sage Creek during most of the year with discharge events likely only taking place during the spring freshet and intense precipitation events. This feature has been excluded from detailed evaluation given its ephemeral/intermittent flow regime but has been evaluated at the catchment level (i.e., Sage Creek).
- SC-4: a tributary with headwaters originating immediately south of the divide of Sage Creek and Muskoka River watersheds, within the Extension Lands and reporting directly to Sage Creek. This feature is monitored at station SW-4 and was found to be dry during most of the summer and fall. When flow was present at the monitoring station, it was negligible (less than 2 Litres per second (L/s). This watercourse has been excluded from detail evaluation given its intermittent flow regime but has been evaluated at the catchment level (i.e. Sage Creek).

- SC-6: a tributary with headwaters originating immediately south of the divide of Sage Creek and Muskoka River watersheds, within the Extension Lands and reporting directly to Sage Creek. This feature is monitored at station SW-6 and was found to be dry during summer and flowing during spring and fall months. This watercourse is further evaluated in this study given the observed flow conditions.
- Sage Creek (SC): Sage Creek is evaluated immediately upstream of the confluence with the Muskoka River. Given the large catchment size at the point of analysis (5,417 ha) in comparison to the area affected by the Extension Lands (163.1 ha), effects are anticipated to be minimal. However, this feature is still considered a key receptor and subject to further evaluation.

4.2 Borehole Drilling Program

The borehole locations and the cone probe hole locations are shown on Figure 2.

4.2.1 Phase 1 Drilling Program

The first phase of the borehole drilling program was conducted between November 2 and 3, 2015. This overburden borehole drilling program was completed by Choice Sonic Drilling Ltd. The drilling program was monitored in the field by a staff member from Golder. The boreholes were identified as OB-1, OB-2, OB-3, OB-4 and OB-5.

Boreholes OB-1, OB-2 and OB-3 were drilled to depths of 7.62 m, 7.92 m and 2.44 m, respectively. At each of these boreholes, bedrock was encountered at depths ranging from 1.37 metres below ground surface (mbgs) to 6.71 mbgs. The upper part of the bedrock was cored at these borehole locations. The bedrock recovered at each borehole location was a granitic gneiss.

Borehole OB-4 was drilled to a total depth of 30.18 mbgs and was terminated in the overburden (i.e., bedrock was not encountered in the borehole). Borehole OB-5 was drilled to a total depth of 20.42 mbgs and encountered 19.20 metres of overburden overlying granitic gneiss.

During the drilling program, continuous soil/overburden and cored bedrock samples were recovered from the boreholes. Golder field staff reviewed the samples recovered from the boreholes and collected samples of each representative soil/overburden type encountered in the boreholes. The soil samples collected were provided to Fowler for the purpose of conducting laboratory grain size distribution analyses. Representative samples of the cored bedrock were also provided to Fowler.

The Record of Borehole Sheets for boreholes OB-1, OB-2, OB-3, OB-4 and OB-5 are provided in Appendix A.

Fowler provided Golder with the results of the grain size distribution analyses on the samples collected from the boreholes and these grain distribution analyses were then plotted on the Golder Grain Size Distribution curves which are presented in Golder (2016).

4.2.2 Phase 2 Drilling Program

The second phase of the borehole drilling program was conducted between December 2 and 13, 2015. This bedrock borehole drilling program was completed by George Downing Estate Drilling Ltd. using diamond drill techniques. The drilling program was monitored in the field by a staff member from Golder. The boreholes were identified as DDH15-1, DDH15-2 and DDH15-3.

Boreholes DDH15-1, DDH15-2 and DDH15-3 were drilled to depths of 30 m, 91.6 m and 29.9 m, respectively. At each of these boreholes, bedrock was encountered at depths ranging from 0.6 mbgs to 0.7 mbgs. The bedrock recovered at each borehole location was a grey gneiss and monzogranite.

During the drilling program, continuous cored bedrock samples (HQ-size) were recovered from the boreholes. Golder field staff reviewed the core samples recovered from the boreholes and placed the rock core in the core boxes which were delivered to Fowler for storage.

The logs for boreholes DDH15-1, DDH15-2 and DDH15-3 are provided in Appendix A.

Upon completion of the drilling of each borehole, a second shallower cored borehole was drilled adjacent to the deeper cored borehole to facilitate the installation of shallower monitoring wells in the separate cored boreholes as discussed in Section 4.3.

4.2.3 Phase 3 Drilling Program

The third phase of the borehole drilling program was conducted on July 13, 2018. This bedrock borehole drilling program was completed by Marshall Well Drilling using air percussion drilling techniques. The drilling program was monitored in the field by a staff member from Golder. The borehole was identified as BH18-04.

Boreholes BH18-04 was drilled to a depth of 33.7 metres with the bedrock surface being encountered approximately 3 metres below a surficial fill layer.

The Record of Borehole Sheet for borehole BH18-04 is provided in Appendix A.

4.2.4 Cone Probe Investigation Program

In an attempt to better characterize the overburden thickness across the existing Childs Pit/Quarry and the Extension Lands, Fowler retained a contractor to complete a cone probe hole investigation program that involved driving a probe to refusal with the refusal being interpreted as the bedrock surface. The contractor drove 34 cone probe holes across the property. The cone probe hole locations are shown on Figure 2 and are numbered from 1 to 38 (with no cone probe holes numbered 15, 16, 18 or 35). At cone probe hole locations 4, 19, 28, 29 and 30, the depth to bedrock was determined using hand excavation techniques due to the shallow depth of overburden cover over bedrock at these locations. The depth of the cone probe holes ranged from 0.15 to 43.28 metres.

4.3 Monitoring Well Installation

Following borehole drilling, monitoring intervals were constructed to allow for the measurement of groundwater levels (and determination of groundwater elevations), within the bedrock and overburden at the site and the completion of in-situ horizontal hydraulic conductivity testing and the assessment of vertical gradients within the bedrock. The positions of the screened intervals in each borehole were selected based on the reported water bearing zone(s) as noted by Golder during drilling, visual examination of the rock core/rock chips for bedrock wells, as well as the desire to have the screened intervals spanning the depth of overburden and bedrock to be extracted at the site.

4.3.1 Overburden Monitoring Wells

Locations OB-2, OB-4 and OB-5 were each instrumented with one monitoring well installation in the overburden. All monitoring wells at OB-2, OB-4 and OB-5 were constructed of 0.051-m diameter, threaded, PVC slot #10 screen and solid risers. Silica sand was placed in the boreholes around the screened portions of the monitors and bentonite was used to provide seals above the screened intervals. A near surface concrete or bentonite seal was installed within each borehole. The borehole locations and elevations (ground surface and top of monitoring well pipes) were surveyed by Golder in 2018.

The construction details and surveyed elevations for the overburden monitoring intervals installed during the current investigation are presented on the borehole logs in Appendix A, and a summary of the well completion details is provided in Table 1 below.

Table 1: Overburden Well Completion Details (OB-2, OB-4 and OB-5)

Location	Ground Surface Elevation (m ASL)	TOP Elevation (m ASL)	Screened Interval* (m ASL)
OB-2	303.82	304.69	297.42 – 298.94
OB-4	307.43	308.26	278.78 – 281.83
OB-5	310.35	311.25	291.15 – 294.20

Notes:
TOP – top of monitoring well pipe (i.e., measuring point for groundwater levels).
* Screened interval does not include the sand pack above/below the screen.

4.3.2 Bedrock Monitoring Wells

Locations DDH15-1, DDH15-2 and DDH15-3 were each instrumented with two monitoring well installations at specific depth intervals. Each monitoring interval is in a separate borehole. Locations BH18-4 was instrumented with three monitoring well installations at specific depth intervals. All three monitoring intervals were installed within one 0.15-metre diameter air percussion borehole.

All monitoring wells at DDH15-1, DDH15-2 and DDH15-3 and BH18-4 were constructed of 0.032-m diameter, threaded, PVC slot #10 screen and solid risers. Silica sand was placed in the boreholes around the screened portions of the monitors and bentonite was used to provide seals above the screened intervals. A near surface concrete or bentonite seal was installed within each borehole. The borehole locations and elevations (ground surface and top of monitoring well pipes) were surveyed by Golder in 2018.

For locations having multiple monitoring wells, the deepest monitoring well installation at the drilling location is designated as monitoring well “A”, with each successively shallower monitoring well at each borehole designated as “B” and “C”, where appropriate. The monitoring wells were developed following their installation prior to undertaking hydraulic conductivity testing and groundwater level measurements. The construction details and surveyed elevations for the bedrock monitoring intervals installed during the current investigation are presented on the borehole logs in Appendix A, and a summary of the well completion details is provided in Table 2 below.

Table 2: Bedrock Well Completion Details (DDH15-1, DDH15-2 and DDH15-3 and BH18-4)

Location	Ground Surface Elevation (m ASL)	TOP Elevation (m ASL)	Screened Interval* (m ASL)
DDH15-1A	334.00	334.92	303.90 – 312.85
DDH15-1B	334.00	334.90	319.05 – 328.25
DDH15-2A	331.95	332.86	240.35 – 263.95
DDH15-2B	331.95	332.90	311.40 – 322.80
DDH15-3A	323.88	324.80	293.98 – 303.13
DDH15-3B	323.88	324.82	309.13 – 318.38
BH18-4A	327.24	328.12	294.17 – 303.92
BH18-4B	327.24	328.14	305.29 – 314.44
BH18-4C	327.24	328.16	315.96 – 322.97

Notes:
TOP – top of monitoring well pipe (i.e., measuring point for groundwater levels).
* Screened interval refers to the gravel pack around and above/below the screen.

4.4 Hydraulic Conductivity Testing

Well response tests were carried out in the monitoring intervals installed in DDH15-1, DDH15-2 and DDH15-3 and BH18-4 using the rising/falling head method. The well response tests provide an estimate of the horizontal hydraulic conductivity of the bedrock adjacent to the monitoring well interval. Well response tests were not completed in OB-2, OB-4 and OB-5 because the wells were dry following installation. For the overburden locations, data from grain size curves for samples gathered during drilling were used to estimate the hydraulic conductivity of the overburden using the Hazen Method (Hazen 1892).

Following well development at DDH15-1, DDH15-2 and DDH15-3 and BH18-4, the Waterra tubing and foot valve in each monitoring interval was removed and the monitoring wells were allowed to recover before hydraulic testing was completed at a later date.

The falling-head test consists of rapidly inserting a slug of known volume into the monitoring well. The subsequent decline in groundwater level within the well is then monitored over time. Once the groundwater level returned to the original static level, or close to the original static level, the rising-head test is initiated. The rising-head test consists of rapidly removing the slug and monitoring the subsequent rise in groundwater level within the monitoring well over time. The details regarding the locations of the test intervals for each monitoring well are provided on the borehole logs in Appendix A.

4.5 Groundwater Level Monitoring

Monitoring of groundwater levels was conducted in the overburden and bedrock monitoring intervals installed during the current field investigation as well as test well TW12-1 installed by others. For reference, the water well record showing the completion details for TW12-1 is provided in Appendix A. Depths to water were measured relative to the surveyed top of the casing and were recorded to the nearest centimetre. The water elevations in the monitoring wells were calculated by subtracting the measured depth to water from the top of pipe reference elevations. Groundwater elevations have been measured ten times at the site between June 2018 and April 2020.

4.6 Private Well Survey

As part of the current study, a private well survey was completed along Bonnie Lake Road located to the east of the existing Fowler Childs Pit/Quarry and Extension Lands. Based on a review of the available water well record data for supply wells in the vicinity of the site, it was noted that the static water levels recorded on the water well records at the time of drilling were often significantly lower then the groundwater levels measured in the on-site monitoring wells. Due to the low hydraulic conductivity of the bedrock in the vicinity of the site, it was thought that the private wells may not have fully recovered when the ‘static’ water level was measured and recorded (by the drilling contractor) on the water well records. The purpose of the private well survey was to confirm the location of the private wells in the vicinity of the site and which of the identified wells are actively being used for water supply, to obtain additional information on well construction details, and where permission was granted, measure the water level within the private wells.

The section of Bonnie Lake Road included in the private well survey was from approximately 1235 Bonnie Lake Road in the south to 1548 Bonnie Lake Road in the north, which is a linear distance of about 2.5 kilometres (see Figure 10). This portion of Bonnie Lake Road is referred to as the private well survey study area. Based on the initial review of water well records along Bonnie Lake Road, some of the residences within the private well survey study area obtain their water supply from overburden wells.

As part of the private well survey, Golder visited the properties within the study area and provided the homeowners with a paper survey to complete. The survey was used to gathered information on well location, well completion details and general comments on water quality and quantity. If the supply well was accessible, and the homeowner agreed, a groundwater level was measured as part of the well survey. In addition, five wells were fitted with a datalogger that was set to record the water level in the well every five minutes. A ‘baro logger’ was installed at the existing Childs Pit/Quarry to measure atmospheric pressure. This allowed the recorded water levels at the private wells to be corrected for changes in barometric presser. The data loggers were left in place for approximately six weeks to provided additional information on water level fluctuation within the supply wells, as well as details on the typical drawdown within the well associated with domestic use and to assist with estimating the recovery times following water taking from the wells. The water level monitoring portion of the private well survey focused on wells completed in the bedrock. The private well survey results are provided in Section 5.4.

A private well survey was previously completed for Fowler prior to the completion of a road construction project along Bonnie Lake Road. The results of the previous well survey were made available to Golder and were used, where applicable, to supplement the information gathered as part of the private well survey completed for the current investigation. For reference, the available information from the previous private well survey is provided in Appendix B.

4.7 Surface Water Level and Flow Monitoring

For the surface water component of the field program, a total of eleven field visits were completed, three in 2018 and the remaining eight in 2019, during the ice-free period. The overall objectives of the monitoring program were to understand flow patterns at key surface water receptors by collecting and documenting water levels, flows and water quality at these features.

The initial site reconnaissance identified Sage Creek and the Muskoka River as the ultimate surface water receptors but identified some local un-named tributaries as key receptors (refer to Section 4.1.2). The monitoring program was designed to characterize these local tributaries, and to understand flow patterns in Sage Creek and the Muskoka River.

Given the size and relevance of the Muskoka River, hydrologic information for this system is widely available and therefore was excluded from Golder’s monitoring program. The monitoring stations included in the field program are described as follows and shown on Figure 9.

- SW-1: outlet from the ponded area on MR-North watercourse, which is an un-named tributary of the Muskoka River. This monitoring point is associated with a key surface water receptor and is further evaluated in this study. The monitoring point is located upstream of the evaluation point.
- SW-2: Sage Creek, immediately downstream from the confluence with SC-3.
- SW-3: un-named Sage Creek tributary associated with catchment SC-3, immediately upstream of the confluence with Sage Creek. This monitoring point is associated with a key receptor and is further evaluated in this study.
- SW-3B: un-named Sage Creek tributary associated with catchment SC-3B. This is a low-lying area which may experience occasional discharge to Sage Creek only during spring melt and following intense precipitation events.
- SW-4: un-named Sage Creek tributary associated with catchment SC-4.
- SW-5: Sage Creek, at the confluence with SC-6.
- SW-6: un-named Sage Creek tributary associated with catchment SC-6, immediately upstream of the confluence with Sage Creek. This monitoring point is associated with a key receptor and is further evaluated in this study.

The details of the monitoring program and key observations are summarized as follows:

- A staff gauge was installed at each surface water monitoring location. The staff gauge was attached to a steel ‘T’-post which was installed in the channel bed. Water level measurements are read from the staff gauge in conjunction with spot flow measurements. The monitoring station elevations were surveyed relative to mean sea level using a GPS surveyor. Water levels are recorded in m ASL.
- Continuous water level measurements and flow estimates were obtained at SW-1, SW-2, SW-3, SW-3B, SW-5 and SW-6 since October 2018, and SW-4 since November 2018. Logger monitoring at SW-3B was discontinued in November 2018 as the suspected drainage feature did not have any identifiable flow. The continuous water level data were logged at 15-minute intervals.
- Manual flow measurements were collected monthly at monitoring stations to verify and refine stage-discharge rating curve relationships. Spot flow measurements were completed using the velocity-area method. Representative channel cross-sections were generally established and marked at each surface water station. A tape measure was extended the length of each cross-section during the measurement event. Streamflow velocities and corresponding water depth were collected at various intervals along the cross-section: at 0.10 m to 0.20 m spacing for the majority of watercourses. Current velocities were recorded with a HACH Electromagnetic Flow Meter Model FH950 (EM Flow Meter) at 60% of the total water depth (for water depths less than 0.50 m) or at both 20% and 80% and then averaged (for water depths greater than 0.50 m). Velocity and depth measurements were obtained by wading channels at all the monitoring stations. For those stations where flow measurements where sufficient and within a relevant range, rating curves were developed and used with continuous level measurements to estimate continuous flow hydrographs.
- Water quality monitoring events at surface water station locations were completed on a quarterly basis in 2019. All water samples were stored in sample bottles, pre-charged with preservative (as required), provided by the laboratory. Samples were sent under a chain of custody documentation to Bureau Veritas (formerly known as Maxxam Analytics) and analyzed for total metals, pH, common anions, total suspended solids and other general water quality parameters.

5.0 SITE GEOLOGY AND HYDROGEOLOGY

The hydrogeological and hydrological assessment for the licensing of the Extension Lands included borehole drilling, groundwater level monitoring, hydraulic conductivity testing, surface water level and flow monitoring, water balance assessment and the development of a groundwater flow model for the determination of quarry dewatering influences on the surrounding groundwater levels and surface water features. Where appropriate, data collected as part of previous investigations completed at the existing Childs Pit/Quarry are discussed. This section presents the findings of the geology/hydrogeology field investigations and the development of a site hydrogeological conceptual model. Section 6.0 presents the findings of the surface water field investigation.

5.1 Geology

5.1.1 Surficial Geology – Boreholes and Cone Probe Holes

Borehole OB-1 was drilled on the north part of the existing licensed Childs Pit/Quarry. This borehole encountered 6.7 metres of fine to coarse sand overlying the granitic gneiss bedrock. The subsurface conditions encountered in borehole OB-1 are consistent with the presence of ice-contact stratified deposits (Map Unit 6) as shown on Figure 5.

Borehole OB-5 was drilled to the south of borehole OB-1 and closer to the active sand pit extraction operation on the existing licensed Childs Pit/Quarry. This borehole encountered 19.2 metres of sand and gravel, fine to coarse sand, silty sand and gravelly sand overlying granitic gneiss bedrock. The overburden deposits are representative of the ice-contact stratified deposits (Map Unit 6) as shown on Figure 5.

Borehole OB-4 was drilled within the confines of the active sand pit extraction operation on the existing licensed Childs Pit/Quarry and encountered 30.2 metres of gravelly sand, sand, and sandy silt and was terminated in the overburden without encountering bedrock. These materials are representative of the aggregate currently being extracted from the active sand pit extraction operation and represent the significant thickness of ice-contact stratified deposits (Map Unit 6 on Figure 5) that was deposited along the western limit of the site adjacent to the North Branch of the Muskoka River.

Borehole OB-2 and OB-3 were drilled on the southern part of the existing Childs Pit/Quarry to the west of the Extension Lands. Borehole OB-2 encountered 5.3 metres of fine sand overlying the granitic gneiss bedrock. At borehole OB-3, 1.4 metres of fine to medium sand was present above the granitic gneiss bedrock. The subsurface conditions are generally consistent with the surficial geological mapping on this part of the site (i.e., the ice-contact stratified deposits (Map Unit 6) and the shallow bedrock unit (Map Unit 2) on Figure 5).

Table 3 presents the depth to refusal (i.e., assumed bedrock surface) based on the cone probe hole investigation program.

Table 3: Summary of Cone Probe Data

Cone Probe Hole Number	Depth to Refusal (m)	Cone Probe Hole Number	Depth to Refusal (m)
C-1	15.24	C-21	5.79
C-2	14.94	C-22	5.49
C-3	1.22	C-23	22.25
C-4	0.15	C-24	2.13
C-5	12.04	C-25	1.52
C-6	35.05	C-26	1.22
C-7	43.28	C-27	1.22
C-8	16.76	C-28	0.46
C-9	15.85	C-29	0.91
C-10	16.61	C-30	0.15
C-11	6.71	C-31	0.91
C-12	1.52	C-32	1.22
C-13	10.21	C-33	1.22
C-14	2.13	C-34	2.74
C-17	16.15	C-36	3.81
C-19	0.15	C-37	0.61
C-20	5.18	C-38	17.98

The locations of the cone probe holes are shown on Figure 2.

Based on the data obtained from the cone probe holes, the overburden thicknesses on the existing licensed Childs Pit/Quarry and Extension Lands can be generally subdivided into four zones.

Zones 1 covers the eastern part of the properties and includes cone probe holes C-36, C-24, C-34, C-3, C-4, C-26, C-25, C-27, C-32, C-28, C-31, C-29, C-37, C-30, C-33 and C-14 (from north to south). Zone 1 is an area of relatively thin overburden (generally less than 2 metres) overlying the bedrock surface.

Zone 2 is the area in the vicinity of the active sand pit extraction operation on the existing Childs Pit/Quarry and extends along the boundary of the site adjacent to the North Branch of the Muskoka River. Zone 2 includes cone probe holes (from north to south) C-17, C-1, C-2, C-6, C-5, C-7, C-8 and C-23 where the overburden thickness ranges from 12 metres to over 43 metres and is coincident with the ice-contact stratified deposits (Map Unit 6) as shown on Figure 5.

Zone 3 is the area along the south part of the property adjacent to Sage Creek. This area includes cone probe holes (west to east) C-9, C-10, C-11, C-12 and C-13 where the overburden thickness ranges between 6.7 and 16.6 metres with the exception of cone probe hole C-12 where 1.2 metres of overburden was encountered.

Zone 4 comprises the west part of the Extension Lands as well as the south part of the existing Childs Pit/Quarry (i.e., cone probe holes C-20, C-22, C-21, C-19 and C-38) where the overburden thickness is generally greater than 5 metres with the exception of cone probe hole C-19 (0.2 metres of overburden present).

5.1.2 Bedrock Geology

The two significant lithology types encountered by the three diamond drillholes DDH15-1, DDH15-2 and DDH15-3 were grey gneiss and monzogranite.

The grey gneiss was estimated to have 10% - 30% micaceous mineral content. The mineral composition of the gneiss is estimated to be granodioritic. The crystal size of the gneiss varied from fine to medium. The gneiss is commonly banded or veined by quartzofeldspathic rock with a larger crystal size. The colour of the gneiss is predominantly grey, with the quartzofeldspathic rock showing as pink. The gneiss has a laminated fabric and when struck tends to break along this foliation. Although varying in band thickness, intensity of quartzofeldspathic veining, and joint intensity, the main rock properties generally remained consistent.

The monzogranite was encountered at the bottom of borehole DDH15-2. A transition from the grey gneiss to the monzogranite was noted between 70.59 m and 84.11 m depth in this borehole and is shown on the borehole log in Appendix A. The rock that was attributed to being monzogranite was estimated to be nearly equal proportions of quartz, plagioclase, and alkali feldspar. Biotite is present and is estimated to comprise around 5% of the rock. The fabric of the rock is gneissic and it contains relict igneous textures. The crystal size of the monzogranite varies from fine to coarse. The monzogranite is occasionally to commonly banded by grey gneiss.

In boreholes OB-1, OB-2, OB-3 and OB-5, the bedrock core recovered was described as a granitic gneiss which is considered to be equivalent to the grey gneiss recovered from diamond drillholes DDH15-1, DDH15-2 and DDH15-3 where the grey gneiss was noted to have been commonly banded or veined by quartzofeldspathic (i.e., granitic) rock with a larger crystal size.

Overall, the bedrock identified in the boreholes completed at the site is consistent with the published geological mapping, which identifies Precambrian migmatitic rocks and gneisses of uncertain protolith in the vicinity of the site (see Map Unit 41 on Figure 6).

5.2 Hydraulic Conductivity

5.2.1 Overburden Hydraulic Conductivity

Because the overburden monitoring wells (OB-2, OB-4 and OB-5) were dry at the time of installation, grain size data from samples collected at each overburden drilling location (OB-1 through OB-5) were used to estimate the hydraulic conductivity for the local sand deposit. The samples selected at each location were the coarsest materials based on the available grain size data. The grain size data were used as input for the Hazen Method (Hazen, 1892) to provide an estimate of hydraulic conductivity for each sample. The grain size distribution plots for the samples used to estimate the hydraulic conductivity are provided in Appendix C. The estimates of hydraulic conductivity obtained using the Hazen Method are included in Table 4 below.

Table 4: Estimates of Overburden Hydraulic Conductivity (OB-1 through OB-5)

Sample ID	Sample Depth (m)	D_{10} (mm)*	Hydraulic Conductivity (m/s)
OB-1 SA4 and SA5	4.57 – 6.10	0.02	3×10^{-4}
OB-2 SA6	2.90 – 4.27	0.01	6×10^{-5}
OB-3 SA2	0.25 – 1.37	0.0075	3×10^{-5}
OB-4 SA24	23.77 – 25.30	0.022	5×10^{-4}
OB-5 SA11	18.14 – 18.90	0.02	4×10^{-4}

Notes: SA = Sample; *d_{10} = grain size diameter at which 10 percent of the sample by weight is finer and 90 percent is coarser

Overall, the hydraulic conductivity of the coarsest portions of the sand deposit at the site ranges from 3×10^{-5} m/s to 5×10^{-4} m/s and the geometric mean was 2×10^{-4} m/s. The estimated hydraulic conductivity of the sand deposit at the site falls within the typical range of silty sand to clean sand (Freeze and Cherry, 1979).

5.2.2 Bedrock Hydraulic Conductivity

A total of nine well response tests were carried out in the on-site bedrock monitoring intervals installed in DDH15-1 through DDH15-3 and BH18-4 using the rising- and falling-head methods described in Section 4.4. The results of the in-situ hydraulic conductivity testing are summarized in Table 5. The screened interval elevation and comments relating to the interval tested are also provided.

Table 5: Bedrock Hydraulic Conductivity Results (DDH15-1, DDH15-2, DDH15-3 and BH18-4)

Monitoring Well	Screened Interval Elevation* (m ASL)	Hydraulic Conductivity (m/s)	Material Tested	Comments
DDH15-1A	303.90 – 312.85	2×10^{-9}	Grey Gneiss	- -
DDH15-1B	319.05 – 328.25	6×10^{-9}	Grey Gneiss	- -
DDH15-2A	240.35 – 263.95	5×10^{-9}	Monzogranite	- -
DDH15-2B	311.40 – 322.80	4×10^{-9}	Grey Gneiss	- -
DDH15-3A	293.98 – 303.13	7×10^{-8}	Grey Gneiss	- -
DDH15-3B	309.13 – 318.38	3×10^{-7}	Grey Gneiss	- -
BH18-4A	294.17 – 303.92	8×10^{-12}	metamorphic bedrock	Drilled using a water well rig – no details detailed geology available
BH18-4B	305-29 – 314.44	1×10^{-9}	metamorphic bedrock	Drilled using a water well rig – no detailed geology available
BH18-4C	315.96 – 322.97	4×10^{-7}	metamorphic bedrock	Drilled using a water well rig – no detailed geology available

Note: * Screened interval refers to the gravel pack around and above/below the screen.

Due to slow recovery at some locations, not all rising/falling-head tests were monitored until 95 percent recovery was obtained. For all monitoring intervals, the hydraulic testing data was analyzed using the Hvorslev method (1951). To remain conservative, if the falling- and rising-head tests provided different results, the higher value was reported. The results of the hydraulic conductivity analyses are provided in Appendix D.

As part of previous work completed at the site, Harden Environmental Services Ltd. estimated the hydraulic conductivity of the bedrock at TW12-1 was approximately 4×10^{-10} m/s (Harden 2012).

The measured hydraulic conductivity in the bedrock at the site varies between 8 x10^{-12} m/s and 4 x 10^{-7} m/s. The low end of the range measured at BH18-4A (8 x10^{-12} m/s) is significantly lower than the hydraulic conductivity measured elsewhere on the site and may not be representative of the site at large. As such, to remain conservative the hydraulic conductivity value for BH18-4A was not used in the calculation of the geometric mean for the bedrock hydraulic conductivity at the site, which is estimated to be 1 x 10^{-8} m/s. The observed range in hydraulic conductivity is typical of metamorphic rock and is related to the degree of connection with water bearing fractures within the monitoring intervals tested.

The available bedrock hydraulic conductivity data for the site (excluding BH18-4A) was reviewed to identify trends relating to elevation (if any). The available monitoring intervals were divided by elevation into shallow bedrock (bottom of monitoring interval at or above 303 m ASL) and deep bedrock (majority of monitoring interval below 303 m ASL). The hydraulic conductivity data is summarized by elevation in Table 6 below.

Table 6: Bedrock Hydraulic Conductivity Summary by Elevation

Elevation Interval	Range in Hydraulic Conductivity (m/s)	Geometric Mean (m/s)
Shallow Bedrock	1 x 10^{-9} to 4 x 10^{-7}	1x10^{-8}
Deep Bedrock	5 x 10^{-9} to 7 x 10^{-8}	2x10^{-8}

As shown in the above table, the range in hydraulic conductivity and the geometric mean of the available data for the shallow and deep bedrock intervals are similar. The hydraulic conductivity for the bedrock at the site is not directly correlated with elevation.

5.3 Groundwater Elevations and Flow Directions

Figures E1 through E6 in Appendix E show groundwater elevations plotted versus time measured at OB-2, DDH15-1, DDH15-2, DDH15-3, BH18-4 and TW12-1. The groundwater elevation data used to generate Figures E1 through E6 are provided in Table E1 in Appendix E.

5.3.1 OB-2

Figure E1 presents groundwater elevation data measured at OB-2 between June 25, 2018 and April 6, 2020. As shown on Figure E1, the measured groundwater elevations at OB-2 are generally stable between June 2018 and March 2019 and is typically measured between 298 m ASL and 299 m ASL. An increase in the groundwater elevation of approximately two metres is measured during the spring melt in 2019. Following the 2019 spring melt, the groundwater elevation returns to the typical range observed at OB-2.

As shown in Table E1, the other monitoring wells completed in the overburden, OB-4 and OB-5, have been dry since they were installed.

5.3.2 DDH15-1

Figure E2 presents groundwater elevation data measured at DDH15-1A and DDH15-1B between June 25, 2018 and April 6, 2020. As shown on Figure E2, the groundwater elevations at DDH15-1A and DDH15-1B are generally stable and are typically measured between 330 m ASL and 332 m ASL. A decline in groundwater elevations is measured in both monitoring intervals between May 2019 and October 2019. This decline is considered to be typical of seasonal variations over the summer of 2019. The April 6, 2020 groundwater elevations were measured during the spring-melt and are similar to the groundwater elevations measured during the spring in 2019. During most monitoring sessions, the vertical gradient at DDH15-1 is slightly downward.

5.3.3 DDH15-2

Figure E3 presents groundwater elevation data measured at DDH15-2A and DDH15-2B between June 25, 2018 and April 6, 2020. As shown on Figure E3, the groundwater elevations at DDH15-2A and DDH15-2B are generally stable and typically vary by less than two metres at both monitoring intervals. The groundwater elevation at DDH15-2A is between 323 m ASL and 324.6 m ASL and the groundwater elevation at DDH15-2B is between 327.5 m ASL and 329.2 m ASL. A decline in groundwater elevations is measured in both monitoring intervals between May 2019 and October 2019. This decline is considered to be typical of seasonal variations over the summer of 2019. The April 6, 2020 groundwater elevations were measured during the spring-melt and are similar to the groundwater elevations measured during the spring in 2019. During all monitoring sessions, the vertical gradient at DDH15-2 are strongly downward.

5.3.4 DDH15-3

Figure E4 presents groundwater elevation data measured at DDH15-3A and DDH15-3B between June 25, 2018 and April 6, 2020. As shown on Figure E4, the groundwater elevations at DDH15-3A and DDH15-3B are generally stable and are typically measured between 320 m ASL and 323 m ASL. A decline in groundwater elevations is measured in both monitoring intervals between May 2019 and October 2019. This decline is considered to be typical of seasonal variations over the summer of 2019. The April 6, 2020 groundwater elevations were measured during the spring-melt and are within the ranges previously measured at DDH15-3A and DDH15-3B historically and are slightly lower than elevations measured during the spring in 2019. During most monitoring sessions, the vertical gradient at DDH15-3 is slightly downward.

5.3.5 BH18-4

Figure E5 presents groundwater elevation data measured at BH18-4A, BH18-4B and BH18-4C between November 16, 2018 and April 6, 2020. As shown on Figure E5, the groundwater elevations at BH18-4A increase slowly between November 2018 and May 2019 and decrease slightly between May 2019 and October 2019. The steady increase in groundwater elevations up to May 2019 are interpreted to represent the recovery of the groundwater level following the initial well development. The slow recovery of the water level at this location following development corresponds well with the low hydraulic conductivity estimated for this monitoring interval (8×10^{-12} m/s).

The trends in the groundwater elevations at BH18-4B and BH18-4C are similar; however, the groundwater level at BH18-4B was slower to return to static following well development. The groundwater elevations at both locations are generally stable, with a slight decline during the summer of 2019.

The April 6, 2020 groundwater elevations were measured at all three intervals during the spring-melt and are similar to the groundwater elevations measured during the spring in 2019. Following the recovery after the initial well development at BH18-4A and BH18-4B, the changes in groundwater elevations measured in the intervals at BH18-4 are attributed to seasonal variations.

The vertical gradients at BH18-4B are typically downward.

5.3.6 TW12-1

Figure E6 presents available groundwater elevation data for all bedrock monitoring wells at the site. As shown on Figure E6, the groundwater elevation data for TW12-1 displays the same general trends observed at the other bedrock monitoring wells on the site (i.e., generally stable water levels with declining levels during the summer of 2019 and a water level in spring 2020 that was similar to the water level measured spring 2019); however, the measured groundwater elevations at TW12-1 are lower than the other monitoring intervals at the site. The ground surface elevation at TW12-1 is lower than the other monitoring locations at the site and the base of TW12-1 is completed approximately 20 metres lower than any other monitoring location. The downward gradients observed at the site along with the greater depth of TW12-1, which is completed as an open hole, likely contribute to the lower groundwater elevations measured at this location.

5.3.7 Groundwater Flow Directions

5.3.7.1 Horizontal Groundwater Flow

A representative set of groundwater levels collected on May 10, 2019, were used to estimate the horizontal groundwater flow direction in the shallow and deep bedrock. As noted in Section 5.2.2, for discussion purposes the division between shallow bedrock and deep bedrock is at 303 m ASL. As is typical in low hydraulic conductivity rock, the groundwater flow direction in the shallow bedrock at the site generally follows topography. There is a local topographic high located between DDH15-1 and DDH15-2. The groundwater levels available from the shallow bedrock monitoring well locations (DDH15-1B, DDH15-2B, DDH15-3B and BH18-4B and BH18-4C) support an interpretation of radial flow away from the local high point following the topography. The groundwater elevations from the monitoring wells completed in the bedrock below 303 m ASL (DDH15-1A, DDH15-2A, DDH15-3A and BH18-4A) display the same general trend with horizontal groundwater flow generally following topography. Overall, at the site scale, the groundwater flow directions are generally towards the Muskoka River.

Given that the bulk hydraulic conductivity of the bedrock at the site is low (geometric mean of 1×10^{-8} m/s), and there are significant downward gradients at some locations, the volume of groundwater flowing horizontally is expected to be low.

5.3.7.2 Vertical Groundwater Flow

At all four multilevel monitoring wells installed at the site as part of the current investigation (DDH15-1, DDH15-2, DDH15-3 and BH18-4), the vertical gradients in the bedrock are typically downward indicating recharging conditions (see Figures E2, E3, E4 and E5 in Appendix E).

5.4 Private Well Survey

The initial private well survey along Bonnie Lake Road was completed between February 15, 2020 and February 25, 2020. A second set of water levels were collected on April 6, 2020 from the well locations where permission was provided. During the well survey, 27 properties were visited and the results are summarized in Table 7 below. The properties visited during the well survey were assigned names PW-1 through PW-27, and the locations are also identified on Figure 10.

Table 7: Private Well Survey Results

Location	Contact Made With Home Owner (yes/no)	Survey Completed (yes/no)	Bedrock Well or Overburden Well	Water Level Measurement (mbgs)*		Data Logger Installed (yes/no)
				Feb. 22 - 25, 2020	April 6, 2020	
PW-1	No – no one home; left letter	No	Bedrock (1)	NA	NA	No
PW-2	Yes – left survey	No	Overburden	NA	NA	No
PW-3	No	No	Overburden (1)	NA	NA	No
PW-4	Yes	Yes	Bedrock	NA	2.56	No
PW-5	Yes	Yes	Bedrock	NA	7.85	No
PW-6	No - no one home; left letter	No	Overburden (1)	NA	NA	No
PW-7	Yes	Yes	Bedrock	9.28	11.04	Yes
PW-8	Yes	Yes	Bedrock	2.10	1.91	Yes
PW-9	Yes	Yes	Bedrock	NA	NA	No
PW-10	No - home under renevations no where to leave letter	No	Bedrock (1)	NA	NA	No
PW-11	No – no one home; left letter	No	Bedrock (1)	NA	NA	No
PW-12	Yes – took survey	No	Bedrock (1)	NA	NA	No
PW-13	Yes	Yes	Bedrock	1.46	1.41	Yes
PW-14	No – no one home; left letter	No	Bedrock (1)	NA	NA	No
PW-15	Yes	Yes	Bedrock	9.92	NA	No
PW-16	No – no one home; left letter	No	Bedrock (1)	NA	NA	No
PW-17	Yes – took survey	No	Bedrock	NA	NA	No
PW-18	Yes	Yes	Bedrock	3.61	3.74	Yes
PW-19	Yes	Yes	Bedrock	3.89	6.33	No
PW-20	Yes	Yes	Bedrock	NA	2.39	No
PW-21	Yes	Yes	Bedrock	NA	NA	No
PW-22	Yes	Yes	Bedrock	9.66	10.85	Yes
PW-23	No - no one home; left letter	No	Overburden (1)	NA	NA	No
PW-24	Yes – took survey; information provided to Golder by phone	No	Overburden	NA	NA	No
PW-25	Yes	Yes	2 Bedrock Wells	7.33 (primary well)	6.41 (primary well)	No
PW-26	No - no one home; left letter	No	Overburden (1)	NA	NA	No
PW-27	No - no one home; left letter	No	Bedrock	NA	NA	No

Notes:
(1) information on well type was provided in the original pre-construction well survey completed for Fowler along Bonnie Lake Road (see Appendix B)
* water level mesurments were converted to mbgs using survey data provided by Fowler on April 27, 2020 for select private well locations

Copies of the well surveys completed during the private well survey are provided in Appendix F. The information obtained from the surveys (i.e., well locations, well completion details, measured groundwater levels, etc.) were used to assist in the completion of the private well impact assessment provided in Section 10.1.

Based on the groundwater level data included in Table 7, the water levels measured during the private well survey varied between 1.41 mbgs and 11.04 mbgs. The results of the detailed groundwater level data gathered using the data loggers installed in five of the private wells included in the well survey are discussed below.

5.4.1 Private Well Data Logger Data

As part of the private well survey, five water supply wells along Bonnie Lake Road (PW-7, PW-8, PW-13, PW-18 and PW-22) were fitted with a datalogger that was set to record the water level in the well every five minutes. The location of the wells where data loggers were installed are shown on Figure 10. The data loggers were left in place for approximately six weeks to provided additional information on water level fluctuation within the supply wells, as well as details on the typical drawdown within the well associated with domestic use and the recovery times following water taking from the wells. The water level data for locations PW-7, PW-8, PW-13, PW-18 and PW-22 are presented on Figures G1 through G5 and are discussed below.

5.4.1.1 PW-7

PW-7 is located east of the central portion of the Extension Lands (see location on Figure 10). During the monitoring period, PW-7 was in use supplying water for a private residence. The water level data recorded at PW-7 between February 23, 2020 and April 6, 2020 is presented on Figure G1 in Appendix G. As shown on Figure G1, the water level at PW-7 varies between 5.5 mbgs and 35.8 mbgs. There are frequent drops in the water level associated with the taking of water for domestic supply. The largest decline in the water level (approximately 27 metres) occurred at the start of the monitoring period, and the magnitude of the decline associated with the domestic water supply generally decreased over the remainder of the monitoring period. Based on the water level data presented on Figure G1, the typical decline in water level associated with domestic supply at PW-7 is approximately 16 metres or less.

Following each of the rapid declines in water level at PW-7, the water level gradually recovered toward the static level. Based on the available water level data, the static level at PW-7 was interpreted to be between 5.5 mbgs and 8.8 mbgs during the monitoring period. Following the larger declines in water level, recovery to near static required between 10 to 12 hours.

Overall, PW-7 appears to be capable of supplying the local demand for domestic water. The water level in the well returns to near static level each day, and there is no long-term decline in water levels observed at this location.

5.4.1.2 PW-8

PW-8 is located east of the central portion of the Extension Lands (see location on Figure 10). During the monitoring period, PW-8 was in use supplying water for a private residence. The water level data recorded at PW-8 between February 25, 2020 and April 6, 2020 is presented on Figure G2 in Appendix G. As shown on Figure G2, the water level at PW-8 varies between 1.6 mbgs and 3.4 mbgs. There are frequent small drops in the water level associated with the taking of water for domestic supply. The largest observed decline in the water level was approximately 1.5 metres, and the magnitude of the decline associated with the domestic water supply was generally consistent during the monitoring period. Based on the water level data presented on Figure G2, the typical decline in water level associated with domestic supply at PW-8 is approximately 1.2 metres or less.

Following each of the rapid declines in water level at PW-8, the water level recovered toward the static level. Based on the available water level data, the static level at PW-8 was interpreted to be between 1.6 mbgs and 1.9 mbgs during the monitoring period. Following the larger declines in water level, recovery to near static required between 4 to 8 hours.

Overall, PW-8 appears to be capable of supplying the local demand for domestic water. The declines in the water level associated with domestic use are minimal, the water level in the well returns to near static level each day, and there is no long-term decline in water levels observed at this location.

5.4.1.3 PW-13

PW-13 is located east of the northern portion of the Extension Lands (see location on Figure 10). During the monitoring period, PW-13 was in use supplying water for a private residence. The water level data recorded at PW-13 between February 23, 2020 and April 6, 2020 is presented on Figure G3 in Appendix G. As shown on Figure G3, the water level at PW-13 varies between 1.2 mbgs and 8.3 mbgs. There are frequent small drops in the water level and less frequent larger water level drops (i.e., once every 3 or 4 days) associated with the taking of water for domestic supply. The magnitude of the smaller declines in water level were typically approximately 1.6 metres or less. The magnitude of the larger less frequent declines in water level were approximately 6.8 to 7.0 metres.

Following each of the rapid declines in water level at PW-13, the water level recovered toward the static level. Based on the available water level data, the static level at PW-13 was interpreted to be between 1.3 mbgs and 1.5 mbgs during the monitoring period. Following the less frequent larger declines in water level, recovery to near static took between 4 to 4.5 hours.

Overall, PW-13 appears to be capable of supplying the demand for local domestic water. The water level in the well returns to near static level each day, and there is no long-term decline in water levels observed at this location.

5.4.1.4 PW-18

PW-18 is located northeast of the Extension Lands (see location on Figure 10). During the monitoring period, PW-18 was in use supplying water for a private residence. The water level data recorded at PW-18 between February 23, 2020 and April 6, 2020 is presented on Figure G4 in Appendix G. As shown on Figure G3, the water level at PW-18 varies between 2.8 mbgs and 20.6 mbgs. There are frequent small drops in the water level and less frequent larger water level drops (i.e., once every 4 days) associated with the taking of water for domestic supply. The magnitude of the smaller declines in water level were typically approximately 3.5 metres or less. The magnitude of the larger less frequent declines in water level were approximately 14 to 17 metres.

Following each of the rapid declines in water level at PW-13, the water level recovered toward the static level. Based on the available water level data, the static level at PW-13 was interpreted to be between 2.8 mbgs and 3.3 mbgs during the monitoring period. Following the less frequent larger declines in water level, recovery to near static required between 5 to 6 hours.

Overall, PW-13 appears to be capable of supplying the demand for domestic water. The water level in the well returns to near static level each day, and there is no long-term decline in water levels observed at this location.

5.4.1.5 PW-22

PW-22 is located northeast of the Extension Lands (see location on Figure 10). During the monitoring period, PW-22 was in use supplying water for a private residence. The water level data recorded at PW-22 between February 23, 2020 and April 6, 2020 is presented on Figure G5 in Appendix G. As shown on Figure G5, the water level at PW-22 varies between 6.5 mbgs and 25.8 mbgs. There are frequent drops in the water level associated with the taking of water for domestic supply. The largest decline in the water level (approximately 18 metres) occurred on March 24, 2020. Based on the water level data presented on Figure G5, the typical decline in water level associated with domestic supply at PW-22 is approximately 13 metres or less.

Following each of the rapid declines in water level at PW-22, the water level gradually recovered toward the static level. Based on the available water level data, the static level at PW-22 was interpreted to be between 6.5 and 8.5 mbgs during the monitoring period. Following the larger declines in water level, recovery to near static required between 12 to 16 hours.

Overall, PW-22 appears to be capable of supplying the demand for domestic water. The water level in the well returns to near static level each day, and there is no long-term decline in water levels observed at this location.

5.4.1.6 Summary

Table 8 below summarizes the maximum and typical water level decline observed in the private well as a result of domestic use, as well as the estimate yield of the well at the time of drilling (where available).

Table 8: Maximum and Typical Declines in Water Level Associated with Domestic Use (PW-7, PW-8, PW-13, PW-18 and PW-22)

Location	Maximum Decline in Water Level (m) Associated with Demestic Use	Typical Decline in Water Level (m) Associated with Domestic Use	Estimated Available Drawdown Based on Measured Static Level and Depth of Well (m)
PW-7	27	16	116.4
PW-8	1.5	1.2	34.9
PW-13	7	1.6	96.3
PW-18	17	3.5	119.1
PW-22	18	13	115.4

Based on the available water level data collected using the data loggers and the well completion details, all five wells appear to be capable of supplying the required water for domestic use.

5.5 Geological and Hydrological Conceptual Model

Data from a variety of sources were considered during the development of the conceptual model for the site including:

- Mapping data from the Natural Resources Values Information System, maps from the MNRF, and published geological mapping.
- Subsurface information was obtained from on-site drilling programs and from the MECP WWIS.
- At the local scale, references included previous investigations completed in the vicinity of the site.
- Historical field data were considered along with new data collected as part of the current study.

As described below, the data presented in the previous sections formed the basis for the development of the site conceptual model.

Based on published mapping, the vast majority of the existing Childs Pit/Quarry property is underlain by thick ice-contact stratified deposits. Along the eastern limits of the existing Childs Pit/Quarry property, the area is underlain by shallow or exposed bedrock. The Extension Lands are characterized by the presence of shallow or exposed bedrock with limited overburden cover. Within the study area, the bedrock surface is uneven, which can result in localized thicker deposits of overburden in the troughs between bedrock highs. Based on drilling completed at the site, the overburden thickness varies between 0.15 m and over 30.2 m.

Based on drilling completed at the site, the upper bedrock unit is a grey gneiss. The bedrock at the site has minimal primary porosities (i.e., natural volume of void space), and primary permeability close to zero. Groundwater flow within such bedrock is through secondary porosity from fractures that have developed. Based on bedrock core logged as part of the current investigation, there was slightly more weathering observed in the upper portion of the bedrock at two of the three cored boreholes. As such, a thin upper weathered zone is included in the conceptual model for the site where the bedrock occurs at or close to ground surface.

The measured hydraulic conductivity in the bedrock at the site varies between 8×10^{-12} m/s and 4×10^{-7} m/s and the geometric mean was estimated to be 1×10^{-8} m/s. Based on a review of the available data, hydraulic conductivity at the site is not correlated with elevation. Overall, the bedrock is interpreted to be massive, with no preferred fracture direction. Based on the observations made during core logging and available hydraulic conductivity data, water bearing fractures are observed at the site (resulting in slightly higher hydraulic conductivity measurements); however, a specific zone (i.e., depth or portion of the site) with consistently increased hydraulic conductivity was not identified.

Based on available water level data, the water table at the site is interpreted to be within the shallow bedrock between 1 m to 4 m below the bedrock surface. During wet portions of the year, because of the significant contrast in hydraulic conductivity between the overburden deposits and the underlying bedrock, it is expected that water would be found at the overburden/bedrock interface (i.e., perched on top of the lower hydraulic conductivity bedrock). The measured hydraulic gradients in the vicinity of the site are typically downward (i.e., recharging conditions). Local surface water features and seasonally wet areas in the vicinity of the site are not interpreted to be supported by significant groundwater discharge. For the site conceptual model, the local water features are interpreted to be primarily surface water fed with limited groundwater input.

As is typical in low hydraulic conductivity rock, the groundwater flow direction in the shallow bedrock at the site generally follows the topography. The groundwater elevations from the monitoring wells completed in the deeper bedrock display the same general trend with horizontal groundwater flow generally following topography. At the site scale, the groundwater flow directions are generally towards the Muskoka River. Given that the bulk hydraulic conductivity of the bedrock at the site is low (geometric mean of 1×10^{-8} m/s), and there are significant downward gradients at some locations, the volume of groundwater flowing horizontally is expected to be low.

The approved base elevation of the existing Childs Pit/Quarry is 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). The development plan for the existing Childs Pit/Quarry within this document assigns a base elevation for the existing pit/quarry between 240 m ASL to 300 m ASL (referred to as the interim quarry floor elevations). The proposed final quarry floor base elevation for the Extension Lands is variable and ranges between 270 m ASL and 320 m ASL. As such, the development plan included in the conceptual model for the site has variable base elevations for the existing Childs Pit/Quarry and the Extension Lands as depicted on Figure 3.

The above information was used to create the numerical model as described in Section 8.0.

6.0 SITE HYDROLOGY

Within the Extension Lands, tributaries leading to Sage Creek may experience surface water drainage alterations (catchment area changes as Sage Creek itself will not be altered), changed land uses within the Sage Creek and Muskoka River watershed, and the propagation of the groundwater level drawdown cone beneath the surface water features as a result of quarry dewatering. These changes have some potential to affect the key surface water receptor flow regimes (e.g., distribution of base flow and peak flows), cause channel erosion or affect water quantity and hence, were evaluated further as described in the following sections.

6.1 Surface Water Catchments

A review and analysis of MNRF provincial mapping, detailed site topography at 2 m contours (MNRF, 2015) and field data collected during the initial site reconnaissance and periodic site visits completed by Golder during 2018 and 2019 were reviewed to identify and confirm the drainage patterns and catchments for locations in the Muskoka River and Sage Creek watersheds. The data were used to generate catchment characteristics for the tributaries and Sage Creek at the monitoring locations.

A surface water divide is present within the Extension Lands as shown on Figure 8. Areas north of the divide contribute to the Muskoka River Tributary while areas to the south of the divide contribute to the Sage Creek Tributary. As a result of the development of the Extension Lands (i.e., an approximate area of 163.1 ha), there will be a minor modification to the shape of the catchment divide. This modified boundary between Zones A and B has been designed to facilitate operations while minimizing impacts on the water balance associated with change in the size of the catchment as the pit/quarry is developed on the Extension Lands.

As a result of the proposed development, areas in the Extension Lands that currently drain to MR-North, will become part of the quarry footprint, and will ultimately still report to the Muskoka River Tributary as quarry discharge via the discharge point (see Figure 8). The portion of MR-North within the existing Childs Pit/Quarry license area is already approved for extraction and the connectivity of the remaining catchment area within the Extension Lands will be disconnected from the Muskoka River. The surface water from MR-North will drain into the existing Childs Pit/Quarry, be collected in the sump and discharged in accordance with MECP permits and approvals. The proposed development within the Sage Creek catchment was purposely designed (by limiting the depth of extraction and engineering the slope to ensure positive gravity drainage to Sage Creek) to minimize the loss of drainage area to Sage Creek. There will be some alterations to the shape and minor changes to the size of the catchment areas associated with SC-3 and SC-6 (see Figure 9) to allow effective grading towards the surface water receptor. In addition, the proposed extraction area was limited within the catchments of key surface water features SC-3 and SC-6, given their potential ecological relevance (discussed in the accompanying Natural Environment Report (RiverStone, 2020)).

As a result of the proposed development within the Extension Lands, the total area reporting to the Muskoka River Tributary at the discharge point from the Extension Lands (AP-MR North as shown on Figure 9) to the existing licensed area, will be increased from 127.1 ha to 130.0 ha; the area within Sage Creek catchment will be reduced from 91.1 to 89.9. The difference in areas corresponds to the decrease in the area draining to Sage Creek, which, given the size of the catchment area, is determined to be negligible.

6.2 Water Quality

The water quality data for the existing Childs Pit/Quarry, gathered as part of the current investigation, included a total of four sampling events spaced out during the 2019 ice-free period (April, June, August and November). Samples were collected at monitoring stations in Sage Creek (SW-2 and SW-5), on the unnamed tributaries draining to Sage Creek (SW-3, SW-4, and SW-6) and at the water feature on-site (SW-1) only if flow was observed (SW-1 was frozen in April and SW-4 and SW-6 were dry in August). The water quality results were compared to Provincial Water Quality Objectives (PWQO) and Canadian Water Quality Guidelines (CWQG) and are provided in Table H1 in Appendix H. As shown in Table H1, generally baseline PWQO and CWQG exceedances were identified across most monitoring stations and sampling events for aluminum (with the exception of SW-2 and SW-3 in August), iron (with the exception of SW-4 and SW-6 in all events and SW-3 in June) and pH which was generally below the CWQG range (with the exception of August for SW-2 to SW-6 and SW-3 in November). Based on the results, pH appears to increase towards the downstream end of Sage Creek towards values within the recommended CWQG range with the lowest pH values observed generally in SW-1 and SW-4 and SW-6. The water quality results indicate that aluminum and iron concentrations are higher in the upstream portion of Sage Creek (SW-5) and reduced by approximately 50% at the downstream portion of the creek (SW-2) in June, August and November. For the samples taken from the surface water feature flowing through the existing Childs Pit/Quarry (SW-1), the iron and aluminum exceedances are less significant than those observed at Sage Creek; however, the pH at SW-1 reaches the lowest value amongst all monitoring stations. Two sample results for zinc were also shown to exceed PWQO interim values at SW-5 in August and SW1 in November. The results show that existing water quality, reflective of natural baseline conditions at the site, does not meet the PWQO for some key parameters. The exceedances are consistent with natural conditions in the area and are not related to the existing extraction operations. The Laboratory Certificates of Analysis for the 2019 sampling events conducted by Golder are included in Appendix H.

6.3 Surface Water Levels and Flows

Field measured / observed flow rates during the monitoring period are summarized in Table 9 below. Flows observed in all watercourses were considered low or stagnant during the monitoring period.

Table 9: Streamflow Measurements 2018 through 2019

Date	Observed or Measured Flow (m^3/s)						
	SW-1	SW-2	SW-3	SW-3B[3]	SW-4	SW-5	SW-6
15-Oct-18	0.003	0.012	0 [1]	0.000	NA [4]	NA [2]	0.003
1-Nov-18	0.019	0.131	0 [1]	0 [1]	0.002	NA [2]	0.009
29-Apr-19	0.052	NA [2]	0.006	0 [1]	0.001	NA [2]	0.010
20-Jun-19	0.012	0.985	0.002	NA[3]	<0.001	NA [2]	0.002
18-Jul-19	0.000	0.051	0.002	<0.001	0 [1]	0.029	0 [1]
29-Aug-19	0 [1]	0.012	0.001	NA [3]	0 [1]	0.006	Dry
18-Sep-19	0 [1]	0.010	0.001	NA [3]	0 [1]	0.013	Dry
17-Oct-19	0.001	0.184	0.001	NA [3]	0 [1]	0.167	Dry
25-Nov-19	0.011	0.411	0 [1]	NA [3]	0.001	NA [2]	0.004
Minimum Flow	**0.000**	**0.010**	**0.000**	**0.000**	**<0.001**	**0.006**	**0.002**
Median Flow	**0.011**	**0.091**	**0.001**	**0.000**	**0.001**	**0.021**	**0.004**
Maximum Flow	**0.052**	**0.985**	**0.006**	**<0.001**	**0.002**	**0.167**	**0.010**

Notes:
1. Flow observed stagnant and/or negligible.
2. Flow not available (NA). Flooded area which impeded safe access to monitoring station to conduct flow measurement.
3. Flow not available (NA). Continuous logger measurements discontinued on November 1, 2018 as logger was found out of water.
4. Monitoring station installed on November 1st, 2018.

Flow at station SW-1 (pond outlet into tributary of Muskoka River) was observed to be dry/stagnant during summer monitoring events. Levels at the upstream portion of Sage Creek (SW-5) and occasionally at the downstream reach (SW-2) were exceptionally high leading to flooded conditions during fall and spring monitoring events. Flows at the downstream portion of Sage Creek were measured, on average, to be approximate double those measured at the upstream reach (SW-5). Flow observations during the ice-free period yield a median value of 91 L/s at downstream station SW-2 and 21 L/s at upstream station SW-5.

The flows observed at the unnamed tributaries to Sage Creek indicate a wide range of hydraulic conditions amongst these features. The watercourse associated with catchment SC-3B (monitoring station SW-3B) was identified as a local low-lying area, which may overflow into Sage Creek only during occasional events (i.e., spring melt and/or extreme precipitation events) and was observed dry during all monitoring events, with the exception of July 2019. Watercourses associated with catchments SC-4 and SC-6 (monitored via SW-4 and SW-6, respectively) were observed dry or having stagnant/negligible flow during most of the summer and into the fall months. The watercourse associated with catchment SC-3 (monitored at SW-3) was found to have flow all year, but very small flows (below detection limit of field instrumentation) were recorded in the fall during 2018 and 2019.

Water levels displayed similar trends at all monitoring stations. The hydrographs developed based on logged hourly water levels during the ice-free period at the selected monitoring stations, are shown on Figures 11 to 16. Discrete measured water levels at the staff gauges, are summarized in Table 10 below and are also included in the corresponding figures. A survey completed by Golder on November 20, 2018 allowed for measurement of the geodetic elevations of surface water stations.

Water levels in Sage Creek at the downstream reach (SW-2) show a significant water level peak in the spring, as a response of snowmelt within the catchment and significant precipitation events, followed by water level recession into the summer season (see Figure 12). The hydrograph at the upstream station (SW-5) suggests beaver activity downstream of SW-5 which results in sustained water levels at this station into the summer and a significant response to precipitation events (see Figure 15). The water level range is in the order of 1.8 m (SW-5) and 2.0 m (SW-2) which is indicative of significant flooding at both stations, especially during spring.

Water levels at SW-3 showed a maintained peak during the spring freshet, followed by a sudden drop to baseflow levels, which were maintained throughout the entire monitoring period (see Figure 13). Water levels at SC-4 and SC-6 showed comparable trends characterized by some flows in spring and fall and dry periods during the summer with short-lived peaks associated with precipitation (see Figure 14 (SW-4) and Figure 16 (SW-6). The observed water level range is in the order of 0.4 m (SW-3), 0.3 m (SW-4) and 0.4 m (SW-6). Station SW-1 located within the Extension Lands showed a similar pattern to other stations except for significant variability during the summer season, which can be related to the presence of a natural control structure upstream which may provide control of water levels during summer (see Figure 11). Overall, water levels showed variations of approximately 0.65 m at SW-1.

The observations derived from the hydrographs across all monitoring stations were in agreement with the observed/measured flows and observed conditions. The response of water levels and discharge following precipitation events seem to occur without any significant lag time, as expected given the steep topography for the features within Sage Creek, and lack of storage features which could potentially store the surplus and moderate the peaks.

Table 10: Water Level Measurements at Staff Gauges 2018 through 2019

Date	Observed Water Levels at Staff Gauges [1]											
	SW-1		SW-2 [2]		SW-3		SW-4		SW-5 [2]		SW-6	
	cm	*m ASL*	cm	*m ASL*	cm	*m ASL*	cm	*m ASL*	cm	*m ASL*	cm	*m ASL*
15-Oct-18	57.0	314.691	27.0	269.874	13.0	271.322	--- [3]	--- [3]	40.0	289.956	16.0	294.265
1-Nov-18	63.5	314.756	46.5	270.069	2.5	271.217	10.5	293.300	48.0	290.036	18.0	294.285
19-Dec-18	58.0	314.701	56.5	270.169	12.0	271.312	20.0	293.395	46.0	290.016	16.0	294.265
8-Apr-19	64.0	314.761	69.0	270.294	14.0	271.332	17.0	293.365	84.0	290.396	23.0	294.335
29-Apr-19	63.0	314.751	124.2	270.846	37.5	271.567	15.0	293.345	71.7	290.273	18.0	294.285
20-Jun-19	57.0	314.691	54.0	270.144	12.0	271.312	10.5	293.300	72.0	290.276	13.0	294.235
18-Jul-19	45.0	314.571	25.0	269.854	11.0	271.302	--- [3]	--- [3]	26.5	289.821	0.0	294.105
29-Aug-19	33.0	314.451	21.0	269.814	11.0	271.302	--- [3]	--- [3]	21.5	289.771	0.0	294.105
18-Sep-19	39.8	314.519	21.5	269.819	11.0	271.302	--- [3]	--- [3]	21.5	289.771	0.0	294.105
17-Oct-19	48.0	314.601	34.0	269.944	11.5	271.307	--- [3]	--- [3]	40.0	289.956	7.8	294.183
25-Nov-19	56.8	314.689	39.8	270.002	11.0	271.302	--- [3]	--- [3]	58.3	290.139	17.6	294.281
Maximum	**64**	**314.761**	**124.2**	**270.846**	**37.5**	**271.567**	**20**	**293.395**	**84**	**290.396**	**23**	**294.335**
Median	**57**	**314.691**	**39.8**	**270.002**	**11.5**	**271.307**	**15**	**293.345**	**46**	**290.016**	**16**	**294.265**
Minimum	**33**	**314.451**	**21**	**269.814**	**2.5**	**271.217**	**10.5**	**293.300**	**21.5**	**289.771**	**0**	**294.105**

Notes:

1. Water levels measured on Staff Gauge. Elevation estimated based on survey conducted on 20-Nov-2018.
2. Flooding detected at station.
3. Water level not collected during the field visit. Dry conditions.

6.4 Rating Curves

A rating curve is the relationship between the water level and flow rate at a particular cross-section in a stream. Fully developed rating curves are usually one or a series of curves of the form $Q = a*Y^b$, where Q is the stream flow rate in cubic metres per second, Y is the water depth in metres above the controlling invert, a and b are a fitted coefficient and exponent, respectively. The watercourses were surveyed in 2018 and modelled using HEC-RAS. As described, water level records were obtained at stations SW1, SW2 and SW5 for the duration of the monitoring period. The flow observation for the rest of monitoring stations (SW-3, SW-3B, SW-4 and SW-6) did not provide enough information (mostly due to dry conditions or low flows), to develop reliable rating curves at these locations. The rating curves for stations SW-1, SW-2 and SW-5 detailing the relationship between water level and flow for the in-field measurements collected in 2018 and 2019 are presented on Figures I-1, I-2 and I-3, respectively, in Appendix I.

6.5 Proposed Water Management

The existing Childs Pit/Quarry and Extension Lands are located within two catchment areas (i.e., Sage Creek and Muskoka River). The portion within Muskoka River watershed corresponds, approximately with Zone A and the portion within the Sage Creek watershed corresponds, approximately, with Zone B (see Figure 8). During operations, water will be managed to minimize potential changes to the water balance as part of Fowler's integrated mitigation approach. In addition, the proposed development plan has been designed with consideration of these key surface water receptors. Specifically, for areas within Zone B (i.e., sloped towards Sage Creek), which will not be reporting to the quarry sump, additional controls will be put in place to ensure water quality is suitable prior to discharge to environment. These controls will include swales along the edge of Zone B and stormwater treatment for total suspended solids and will be designed and applied for approval under relevant legislation (e.g., the *Ontario Water Resources Act*) prior to commencing extraction.

A summary of the proposed water management during the operation and rehabilitation stages is summarized below:

- Operations: Extraction in Zone A will capture site runoff that would have drained mainly towards MR-North and eventually to the Muskoka River. Runoff and groundwater inflow reporting to the excavation area within Zone A (in the Extension Lands) will be pumped from the quarry sump to MR-North to minimize changes to the water balance. The portion of MR-North within the existing Childs Pit/Quarry license area is already approved for extraction and the connectivity of the remaining area within the Extension Lands will be disconnected from the Muskoka River. Extraction in Zone B will capture site runoff that would have drained mainly towards Sage Creek via a series of small un-named tributaries. Under operations, water will be directed towards Sage Creek by providing positive grading towards the creek. Furthermore, a portion of the water captured within Zone B will be collected and appropriately directed via passive drainage to SC-3 and SC-6 to minimize loss of water contribution on these features. During operations, a reduction in evapotranspiration and a corresponding increase in the amount of surface water runoff collected within the extraction areas is expected to occur. The drainage patterns will not be significantly affected at Sage Creek, Muskoka River, MR-North, SC-3 and SC-6 as a result of the proposed development during operations as runoff will continue to drain towards these features during operations.

- Rehabilitation: The Zone A footprint will be partially flooded and partially vegetated (with drainage from the vegetated areas being towards the flooded areas) and will outlet towards the Muskoka River via the most downstream reach of MR-North (see Figure 8). As a result of the proposed rehabilitation, water will be lost from the upper reach of the MR-North feature but will still report to the Muskoka River via the outflow point. The drainage pattern in the Zone B footprint will remain as per operations to ensure that sufficient water contribution is maintained draining towards Sage Creek. An increase in the evaporation and a corresponding decrease in the amount of surface water runoff collected within the proposed flooded area and ultimately reporting to the Muskoka River is expected to occur during rehabilitation. For Sage Creek and its tributaries (SC-3 and SC-6), evaporation and associated runoff is expected to be similar to existing conditions as the catchment area and land uses are similar to pre-development conditions.

7.0 RECEPTOR IDENTIFICATION

7.1 Groundwater Receptors

Water supply in the area surrounding the existing Childs Pit/Quarry and Extension Lands is primarily obtained from the bedrock. Based on a review of the MECP WWIS, and the results of the private well survey, there are approximately 33 water supply wells within 500 m of the site. The wells in the vicinity of the site primarily service the residential development to the east of the site located along Bonnie Lake Road. The majority of the wells are completed in bedrock; however, based on a review of the water well records, as well as observation made during the private well survey completed along Bonnie Lake Road, some of the residences in the vicinity of the site obtain their water supply from dug wells/shallow drilled wells completed in pockets of thicker overburden.

The primary hydrogeological consideration with respect to nearest water supply wells is the development of the groundwater level drawdown cone that is associated with quarry dewatering, and the potential for drawdown (depressurization) to cause an interruption of the water supply as a result of the lowering of water levels in the water supply wells. The potential for impacts to existing groundwater users is assessed as part of the impact assessment presented in Section 10.0.

Based on observations made in similar geological settings (i.e., pockets of coarse overburden infilling depressions within low hydraulic conductivity bedrock), dug wells/shallow drilled wells completed in the overburden obtain their water from the overburden material, and the underlying bedrock does not significantly contribute to the supply capacity of the wells. The water within the overburden wells tends to be recharged locally, and the water level/supply capacity of the wells are highly dependent on the magnitude and frequency of local precipitation events. Because the water table at the site is within the bedrock, drawdown associated with the development of the existing Childs Pit/Quarry and the Extension Lands will propagate through the bedrock. This drawdown within the low hydraulic conductivity bedrock will not influence the supply capacity of the overburden wells in the vicinity of the site. As such, the overburden wells are not considered in the water supply impact assessment presented in Section 10.

7.2 Surface Water Receptors

The most prominent surface water features in the general area include Muskoka River located immediately to the west of the existing Childs Pit/Quarry licensed area and Sage Creek located immediately to the south of the Extension Lands. Given their relative sizes, neither of these nearby water bodies are expected to be highly vulnerable to potential changes in their water balance conditions as a result of the proposed extraction within the Extension Lands; however, the expected changes are quantified using a high-level water balance assessment. The main surface water receptors, which have the potential to be affected by the proposed development are the watercourses associated with catchments MR-North, SC-3 and SC-6. Potential changes to these water features associated with the proposed development are quantified using a detailed water balance assessment.

The locations of the surface water features and assessment points (herein after referred as AP) selected to evaluate the potential changes to the water balance are shown on Figure 9 and are described below:

- AP-1: located in the Muskoka River, immediately downstream of the confluence with MR-North. This point is used to assess changes to the Muskoka River water balance.
- AP-2: located in Sage Creek, immediately upstream of the confluence with the Muskoka River. This assessment point is immediately downstream of monitoring location SW-2 and is used to assess changes to the Sage Creek water balance.
- AP-SC3: located in SC-3 catchment, immediately upstream of the confluence with Sage Creek. This assessment point matched the monitoring location SW-3 and is used to assess changes to the SC-3 catchment water balance.
- AP-SC6: located in SC-6 catchment, immediately upstream of the confluence with Sage Creek. This assessment point matched the monitoring location SW-6 and is used to assess changes to the SC-6 catchment water balance.
- AP-MR North: located in the MR-North watercourse, within the Extension Lands, prior to entering the existing Childs Pit/Quarry license area. This assessment point is used to assess changes to the MR-North water balance.

Potential effects on the water balance in these features were evaluated to support the evaluation of effects on their ecological function, which are discussed in the accompanying Natural Environment report prepared by others (RiverStone, 2020).

The primary considerations with respect to the identified surface water features are surface water drainage alterations (mainly catchment area changes), changed land uses and the propagation of the groundwater capture zone beneath the surface water features as a result of quarry dewatering. These changes have some potential to affect the receptor flow regimes (base flow and storm flow/flooding), channel erosion and water quality. These potential effects are considered as part of the impact assessment presented in Section 10.

Bonnie Lake is located approximately 1.5 kilometres to the east of the existing Childs Pit/Quarry and the Extension Lands. It is understood that surface water is drawn from Bonnie Lake for the purpose of supplying water to the Bonnie Lake Resort.

8.0 GROUNDWATER FLOW MODELLING

Groundwater flow modelling was completed to assist with estimates of groundwater inflow volumes and extents of groundwater drawdown associated with the development of the existing Childs Pit/Quarry to the interim quarry floor and the development of the Extension Lands. The site conceptual model described in Section 5.0 (groundwater elevations and flow directions, hydraulic conductivity of the bedrock units, etc.) was used as the basis for the development of a numerical groundwater flow model. A summary of the development, parameterization and calibration of the numerical groundwater flow model is provided in the sections below.

8.1 Methodology

8.1.1 Model Approach

The numerical groundwater flow model was constructed to represent the current conditions for the site based on the conceptual site model and calibrated through the adjustment of model parameters until an acceptable match was obtained between the simulated and observed conditions. The calibrated model was then modified to represent the development of the existing Childs Pit/Quarry to the interim quarry floor elevations, the development of the Extension Land to the final floor elevations and rehabilitated conditions. Predictive simulations were completed to estimate the potential groundwater inflows, extent of groundwater drawdown and changes to the groundwater inflow to key surface water receptors for both development and rehabilitated scenarios. In this assessment, groundwater drawdown level is represented relative to the current conditions at the site. Because the current Childs Pit/Quarry development is situated above the water table, it was assumed that current operations has had a negligible effect on the groundwater conditions in the vicinity of the site, and as such current conditions are similar to predevelopment conditions from a groundwater perspective.

8.1.2 Code Description

FEFLOW, a finite element modelling package developed by the DHI-WASY Institute in Germany (Diersch, 2009), was used as the numerical simulation tool for the assessment. FEFLOW is capable of simulating saturated and unsaturated groundwater flow, solute and heat transport in three dimensions. FEFLOW was selected for this work given its capabilities to efficiently discretize local features around the existing Childs Pit/Quarry and Extension Lands, yet maintain a relatively regional overall footprint with which to estimate changes in groundwater elevations and water balances. FEFLOW v7.1 was used to complete the simulations presented in this report.

8.1.3 General Modelling Assumptions

The groundwater flow system in the study area was represented as an "equivalent porous media" (EPM) at the scale of the extent of the simulated drawdown under consideration. Under this assumption, the rate of groundwater flow towards the quarry occurs as a function of the hydraulic gradient, the hydraulic conductivity, and the porosity of the aquifer. While groundwater flow in bedrock aquifers is controlled primarily by fractures, an EPM approach is commonly used to represent groundwater flow. This approach is considered reasonable provided the scale of the observation (i.e., in this case the dewatering of the existing pit/quarry and proposed extension) is greater than the scale of the individual fractures.

It should be recognized that the steady-state model does not account for seasonal variation in the overall water budget, but rather assumes that recharge rates and groundwater seepage rates are representative of long-term annual average conditions. The steady-state model also represents the maximum extent of groundwater impacts from quarry dewatering. Given that the expected duration of operations for the project is on the order of hundreds of years, the time to reach this maximum extent will be dependent on the rate of development of the existing Childs Pit/Quarry and Extension Lands. As such, the steady-state approach to calculating drawdown is considered reasonable.

The general assumptions and limitations of the groundwater flow model are summarized below.

Numerical Model (FEFLOW)

- Flow is laminar and steady and is governed by Darcy's Law (which is the equation the describes the flow of a fluid through a porous media).
- Groundwater flow is represented by an EPM.
- Hydraulic heads are vertically averaged within a given model layer.

Conceptual Model

- There is no vertical differentiation of the overburden deposits (i.e., the overburden units are modelled vertically as a single hydrostratigraphic unit).
- Overburden was assumed to be anisotropic at a ratio of 80 horizontal to 1 vertical. Bedrock was assumed to be anisotropic at a ratio of 10 horizontal to 1 vertical.
- The conceptual model was based upon data compiled as of October 2019.

Calibration

- Groundwater elevations derived from site-specific data and the private well survey were used in the calibration process. Groundwater elevation data from the MECP WWIS database were not considered as calibration targets (see discussion in section 8.2.1).
- Calibration was evaluated using a steady-state model with static recharge values, representing long-term annual average conditions.
- Because the current development of the existing Childs Pit/Quarry is situated above the water table there is currently no active dewatering occurring at the site. As such, estimates of groundwater flow were not available for use as a calibration target.
- Recharge estimates reflect deeper recharge and discharge characteristics of the groundwater flow system, and do not account for shallow infiltration and discharge to intermittent streams (i.e., interflow).
- A "regionalized" approach to model calibration was employed, such that parameter values were established for the hydrostratigraphic units on a regional scale.

8.1.4 Grid Discretization and Layering

The model mesh was defined using a 25 m element size in the area of the existing Childs Pit/Quarry and Extension Lands, transitioning to a 250 m element size at the model periphery. Vertically, the model consists of 19 numerical layers (i.e., the identified hydrostratigraphic units were subdivided into 19 numerical layers to allow for modelling flexibility). The hydrostratigraphic units are illustrated on Figure 17, and are defined as follows:

Model Layers 1 and 2 – The uppermost two layers represent the overburden (where it occurs) and bedrock exposed at surface. As shown on Figure 5, the overburden typically consists of a thin soil cover (less than 1 m of drift cover) over Precambrian bedrock. Alluvial deposits are present in the area of the Muskoka River and Sage Creek, which are adjacent to sand and gravel deposits found further upslope from the riverbank. A glacial till deposit (consisting of silty sand) is present in the southern portion of the model domain (Map Unit 5a on Figure 5). In places where the overburden thickness was less than 1 m, the underlying bedrock unit is represented in this layer (i.e., the minimum layer thickness is 0.5 m). The top of layer 1 is defined by ground surface based on the available provincial digital elevation model (DEM) data (MNRF, 2015).

Model Layers 3 through 19 – These model layers represent the Precambrian bedrock unit. The top of layer 3 is defined as the bedrock surface (where overburden is greater than 1 m thick), determined from lithological descriptions in the MECP WWIS database, site-specific borehole data, and geological mapping. The bottom of layer 19 is flat-lying at an elevation of 100 m ASL, representing a depth of approximately 200 metres below ground surface in the area of the existing Childs Pit/Quarry and Extension Lands. Layer elevations were selected to facilitate representation of the existing Childs Pit/Quarry and Extension Lands development, and to allow for suitable numerical computation of vertical hydraulic gradients.

8.1.5 Groundwater Flow Boundaries

The groundwater flow boundaries assigned in the model are illustrated on Figure 18. Fawn Lake (290 m ASL), Bonnie Lake (309 m ASL), and the Muskoka River have been assigned as constant head boundaries on model slice 1. This assignment is based on the assumption that the surface water catchments are sufficiently large that any changes to baseflow would not affect water levels in these water bodies. The remaining provincially mapped rivers, streams, and wetlands (including Sage Creek) have been assigned as seepage boundaries specified at ground surface elevation, which permit the discharge of water from the model.

As noted previously, the current Childs Pit/Quarry operation is situated above the water table and no active dewatering of the overburden or bedrock occurs at present. As such, flow boundaries representing the quarry operations were not required for the current conditions/calibration simulation.

8.1.6 Model Parameterization

The material properties assigned to the hydrostratigraphic layers are illustrated on Figure 17. Estimates of hydraulic conductivity of the bedrock unit were based on the results of the hydraulic response testing described in Section 5.2. The bedrock unit was assigned a horizontal hydraulic conductivity of 1×10^{-8} m/s in the model, which is approximately equal to the geometric mean of the hydraulic conductivity measurements within the bedrock following removal of one outlier value (8×10^{-12} m/s at BH18-4A). In areas where the overburden thickness was interpreted to be less than 1 m thick, the bedrock was assigned a hydraulic conductivity value of 1×10^{-7} m/s. The bedrock was assumed to have an anisotropy ratio of 10:1 (horizontal to vertical).

Overburden was assigned a uniform hydraulic conductivity value of 8×10^{-6} m/s within the model footprint based on the model calibration (discussed in Section 8.2.1 below). This value is approximately an order of magnitude lower than the hydraulic conductivity estimates of the overburden presented in Section 5.2.1, which were focused on the coarse layers within the local sand deposits in the vicinity of the on-site pit. Based on model calibration, the vertical hydraulic conductivity of the overburden was assigned a value of 1×10^{-7} m/s. *Note: because the calibration simulations were completed to steady-state conditions, consideration was not given to the storage parameters assigned in the calibrated model.*

Field measurements of groundwater recharge are not typically made as a part of regional-scale groundwater modelling studies. This is primarily because actual groundwater recharge is highly variable over short distances, as it depends strongly on many factors (i.e., soil type, slope, vegetation type and density, water table depth, surface topography, etc.) that are not consistent over the scale of the model, and single “spot” measurements would not be representative at the model scale. As such, the typical approach for specifying recharge in groundwater modelling studies involves dividing the model domain into areas that share common characteristics in terms of the factors controlling recharge, and assigning appropriate recharge values to those areas (Anderson and Woessner, 1992). This is consistent with the approach taken as a part of the current study. Recharge was applied to the top surface of the model to simulate annual average infiltration to the groundwater flow system from precipitation. The recharge distribution for the model is shown on Figure 18. This considers two main areas of recharge: where overburden thickness was interpreted to be greater than one metre thick a value of 165 mm per year (mm/yr) was used, and where bedrock was interpreted to be within one metre of ground surface a value of 5 mm/yr is used.

8.2 Results

8.2.1 Model Calibration

Calibration of the groundwater flow model was completed by adjusting the recharge rates in the overburden and bedrock outcrop zones, as well as adjustments to the hydraulic conductivity of the overburden unit until the simulated groundwater elevations and flow directions compared reasonably well to the observed conditions.

The primary data set used for calibration of the groundwater model was measurements of groundwater elevation obtained from 11 bedrock and overburden wells at 6 on-site monitoring locations. The target values for model calibration were based on measurements of groundwater elevation from on-site monitoring wells taken in mid-November 2018. These were supplemented with water level measurements recorded during a survey of private wells and MECP WWIS records for locations along Bonnie Lake Road, which were converted to groundwater elevations based on surveyed elevations, where available, and elevations from the DEM where survey elevations were not available.

WWIS data were also reviewed for the wider model area as a part of the model calibration process and were found to be unrepresentative of static groundwater elevations as compared to the data obtained from on-site monitoring wells. As such, WWIS data were excluded from the calibration process.

Figure 19 compares calculated to observed groundwater elevations and provides calibration statistics for the current conditions. A review of the figure allows the following observations:

- Generally, the simulated groundwater levels compare reasonably well with the measured groundwater levels for current conditions.
- For current conditions, the residual mean error was -0.8 m, the absolute mean error was 2.0 m, and the normalized RMS error was 7.6% for on-site monitoring wells.
- Groundwater elevations at private wells were generally simulated to be higher than measured values. This was considered reasonable because all the wells included in the well survey were being used to supply private residences, and therefore depending on how recently the well had been used, some measurements may not reflect static conditions. During the calibration process it was decided that no additional effort to improve the calibration at these wells should be made, as maintaining a simulated water level that is higher than the observed value at these points is conservative with respect to calculation of drawdown.

As indicated by the above-noted model calibration statistics there is not a strong bias in the simulated groundwater elevations either above or below the target values.

Figures 20 shows the simulated bedrock groundwater elevations following calibration of the model to current conditions in the deep and shallow bedrock. In the case of the existing Childs Pit/Quarry, extraction operations to date have primarily involved extraction of sand and gravel resources from above the groundwater table and thus the current extraction operation has resulted in negligible impact (i.e., lowering) to groundwater elevations in the bedrock. For this reason, the current conditions are considered to be equivalent to the predevelopment conditions from the perspective of effects on the groundwater system.

The simulated groundwater elevations indicate the groundwater flow direction generally follows topography, with high groundwater elevations on bedrock ridges, and localized areas of minor groundwater discharge to surface water features (i.e., wetlands and small water bodies). The local water features are interpreted to be primarily surface water fed with limited groundwater input. Groundwater flow directions in the model are generally towards the Muskoka River.

Overall, based on the results of the calibration process, the groundwater flow model provides a reasonable approximation of the site groundwater conditions in terms of groundwater elevations and flow directions, and is considered suitable for use in predictive simulations.

8.2.2 Forecast Simulations

To evaluate the potential influence of the quarry on the groundwater flow system as the quarry develops, the calibrated model (i.e., Scenario 0) was used as a starting point and adjustments were made to represent the quarry under future conditions. Specifically, the following scenarios were evaluated using the model:

- **Scenario 1 – Licensed Childs Pit/Quarry Development**: Development of the existing licensed Childs Pit/Quarry extraction area to the interim quarry floor configuration and existing conditions for the Extension Lands. This scenario represents the basis for evaluation of effects to water balances associated with the subsequent scenarios.

- **Scenario 2 – Full Development**: Development of the existing licensed Childs Pit/Quarry extraction area to the interim quarry floor configuration and development of the Extension Lands to the final quarry floor configuration. Scenario 2 takes into consideration the extraction of the setback reduction areas along the common boundaries between the existing Childs Pit/Quarry and the Extension Lands which represents an area of approximately 1.3 ha.
- **Scenario 3 – Rehabilitation**: Creation of a West Lake to the west of the Hydro easement and an East Lake to the east of the Hydro easement with the lake bottom elevations consistent with interim quarry floor configuration for the licensed Childs Pit/Quarry extraction area and the final quarry floor configuration for the Extension Lands. Where the quarry floor elevations are above the anticipated surface water elevation for the East Lake, these areas would be rehabilitated as an above water terrestrial landform. As part of the final rehabilitation plan for the Extension Lands, wetlands are proposed to be created by developing variable topography along the 300 m ASL bench (refer to Figure 3). Depressions between 0.1 m - 2.0 m deep will be constructed over an area of approximately 15 ha. Organic material, topsoil, substrates and cover materials, and structures will be placed along the shallow wetland edge to promote riparian and shoreline aquatic vegetation, amphibian breeding, and cover for other aquatic organisms. These surface treatments under the final rehabilitation scenario have no influence on the simulated residual groundwater drawdown under rehabilitation and the associated impact assessment presented in Section 10.0.

For each of the above scenarios, the model boundaries representing the quarry were adjusted to reflect the operation or rehabilitation condition. These are illustrated on Figure 21 for Scenarios 1 through 3. For Scenario 1 (licensed Childs Pit/Quarry development), seepage nodes were specified over the footprint of the licensed extraction area from ground surface to the interim quarry floor elevations. For Scenario 2 (full development) seepage nodes were specified over the footprint of the current license area to the interim quarry floor elevations and to the final quarry floor elevations in the Extension Lands. For Scenario 3 (rehabilitation) seepage nodes were specified over the footprint of the West Lake at an elevation of 290 m ASL and over the East Lake at an elevation of 295 m ASL (corresponding to the final anticipated water surface elevations of the lakes as per the existing license). These seepage boundaries were specified to a depth corresponding to the base of the interim quarry floor in the currently licensed area and the full extraction depth in the Extension Lands.

Results of the forecast simulations are presented in terms of the extent of drawdown relative to predevelopment conditions in the bedrock. Figures 22 through 24 illustrate the simulated drawdown in upper and deep bedrock for model Scenarios 1, 2, and 3, respectively. A review and discussion of the figures is presented in the following paragraphs.

As shown on Figure 22, the simulated drawdown under development of the existing Childs Pit/Quarry extraction area to the interim quarry floor configuration extends to a maximum of approximately 1,550 m towards the east (in the vicinity of Bonnie Lake), 700 m towards the north and south, and 1,000 m towards the west (as defined by the 1-m drawdown contour). Drawdown in the shallow bedrock was less extensive in all directions as compared to the drawdown in the deep bedrock, with a maximum of approximately 1,300 m towards the east.

As shown on Figure 23, the simulated drawdown under full development of the existing Childs Pit/Quarry extraction area to the interim quarry floor configuration and development of the Extension Lands to the final quarry floor configuration (Scenario 2) extends to a similar extent as compared to Scenario 1. One exception is in the southeast direction where the simulated drawdown under Scenario 2 extends approximately 200 m further towards the southeast than Scenario 1 (as defined by the 1-m drawdown contour). As was the case with Scenario 1, the drawdown in the deep bedrock is more extensive as compared to the shallow bedrock.

The simulated residual groundwater drawdown under rehabilitation is shown on Figure 24. This scenario involves the formation of two lakes (separated by the Hydro easement) that would be elevation-controlled by low points in topography at 290 m ASL (for the West Lake) and 295 m ASL for the East Lake. As shown on Figure 24, the simulated drawdown under rehabilitation (Scenario 3) extends to a maximum of approximately 1,500 m towards the east (in the vicinity of Bonnie Lake), 400 m towards the north and south, and 500 m towards the west (as defined by the 1-m drawdown contour). As was the case with Scenarios 1 and 2, the drawdown in the deep bedrock is more extensive as compared to the shallow bedrock.

8.2.3 Groundwater Seepage Rate Changes

The predicted quarry inflows and groundwater contributions to the identified assessment points during operational and rehabilitation conditions are discussed below. These data are combined with the results of the water balance presented in Section 9.3 to assess the overall impacts to the identified surface water receptors (see impact assessment in Section 10.2)

8.2.3.1 Quarry Inflows

The simulated groundwater inflows to the quarry for various scenarios are provided in Table 11 below.

Table 11: Summary of Quarry Inflows from Groundwater

Conditions	Quarry Inflow (m^3/d)
Scenario 0 – Current Conditions	0
Scenario 1 – Licensed Childs Pit/Quarry Development	1,180
Scenario 2 – Full Development	1,360
Scenario 3 – Rehabilitation	330

8.2.3.2 Groundwater Flow to Local Surface Water Receptors

The groundwater flow balance for key surface water features was calculated based on the model results. The surface water features included the drainage features within the MR-North, SC-6 and SC-3 catchments, Sage Creek between the Muskoka River and SC-6, and the Muskoka River between Sage Creek and the MR-South tributary (refer to Figure 9). A summary of the groundwater inflow to the various receptors is presented in Table 12 below.

Table 12: Groundwater Discharge to Key Surface Water Receptors

Scenario	Net Groundwater Discharge (m^3/d)				
	MR-North Catchment	SC-6 Catchment	SC-3 Catchment	Sage Creek Between Muskoka River and SC-6	Muskoka River between Sage Creek and MR-South Tributary
Scenario 0 – Current Conditions	18.8	60.7	20.9	486	2,892
Scenario 1 – Licensed Childs Pit/Quarry Development	5.4	58.7	12.2	467	1,923
Scenario 2 – Full Development	-	30.3	0.2	371	1,892
Scenario 3 – Rehabilitation	-	42.3	16.9	392	2,669

Based on the results of the groundwater modelling, the groundwater discharge is expected to decrease by from approximately 58.7 m^3/d to 30.3 m^3/d and from approximately 12.2 m^3/d to 0.2 m^3/d to the SC-6 and SC-3 catchments, respectively, at full development of operational conditions (Scenario 2 compared to Scenario 1). Under rehabilitation conditions (Scenario 3 compared to Scenario 1) groundwater discharge is expected to decrease from approximately 58.7 m^3/d to 42.3 m^3/d and increase from approximately 12.2 m^3/d to 16.9 m^2/d to the SC-6 and SC-3 catchments respectively.

Surface water flows are expected to contribute a greater portion of volume to Sage Creek and the Muskoka River as compared to groundwater flow under both existing and forecast scenarios. Under operational conditions (Scenario 2), water pumped from the quarry sump would be directed to the Muskoka River, while under rehabilitation (Scenario 3), overflow from the quarry lakes would be directed through gravity drainage to this feature. The overall flows to these surface water receptors are discussed in Section 9.0, and the overall impact is discussed in Section 10.2.

8.3 Sensitivity Analysis

The model was calibrated using the parameters that resulted in an acceptable match between simulated and observed conditions. In order to evaluate the relative sensitivity to key input parameters, additional simulations were completed where these parameters were varied and results of the simulations compared to the base case. Given the uncertainty associated with recharge applied to the model and the range in hydraulic conductivity estimates for the bedrock, these parameters were selected for evaluation in the context of the sensitivity analysis. Two additional simulations were completed; Sensitivity Run 1, where the hydraulic conductivity of the bedrock was increased by a factor of 5 (including both the shallow and deep bedrock), and; Sensitivity Run 2, where overburden recharge was reduced by approximately 40% (from 165 mm/yr to 100 mm/yr). Both sensitivity runs resulted in less favourable comparisons to calibration targets as compared to the base case parameterization, although both were generally considered to be acceptable.

Results of the sensitivity simulations are illustrated on Figure 25 in terms of the changes to the extent of the simulated drawdown (based on the 1-m contour in the deep bedrock) for the full development scenario (i.e., Scenario 2). As shown on the figure, the model results were relatively insensitive to the increase in bedrock hydraulic conductivity (Sensitivity Run 1), which resulted in a minor (10’s of metres) increase to the horizontal extent of drawdown to the north, west, and south. In localized areas to the east of the pit/quarry the drawdown extended up to approximately 180 m beyond the base case simulation. For the simulation where recharge was reduced by a factor of 2 (Sensitivity Run 2) the horizontal extent of drawdown was generally similar to the base case simulation, with the exception of the area to the east of the quarry, where it was reduced by up to (approximately) 600 m.

9.0 WATER BALANCE

The purpose of the hydrological assessment is to evaluate the potential implications of quarry operations associated with the Extension Lands on surface water flows in the key surface water receptors. A high-level water balance was completed for the Muskoka River and Sage Creek to quantify water balance changes at the catchment level; changes were estimated at assessments points AP-1 and AP-2, shown on Figure 9. A detailed water balance assessment was completed for the smaller catchment areas within the tributaries of Sage Creek and the Muskoka River, identified as key receivers, to identify changes to the water balance at a smaller scale. Detailed water balance assessments were completed for catchments SC-3, SC-6 and MR-North via assessment points AP-SC3, AP-SC6 and AP-MR North, (see Figure 9). The water balance changes at additional surface water receptors (non-key surface water receptors) identified within the existing Childs Pit/Quarry and Extension Lands (i.e. MR-South, SC-3B and SC-4) were evaluated at the corresponding catchment level. Predicted changes in surplus, infiltration and runoff become less significant as the point of evaluation is moved further downstream within the system. The surface water catchment areas contributing to the point of analysis, estimated quarry capture zones (defined as the areas under the various development scenarios where shallow groundwater would be captured by the quarry based on the hydraulic head distribution predicted by the groundwater flow model) and assumed land uses for all modelling scenarios are provided in Figures 26 to 28 (high-level water balance) and Figures 29 to 31 (detailed water balance).

The calibrated numerical groundwater model was used as the starting point and adjustments were made to the groundwater model to represent the quarry under future conditions. These future conditions are referred to as the forecast scenarios and are described as follows:

- **Scenario 1 – Licensed Childs Pit/Quarry Development**: Development of the existing licensed Childs Pit/Quarry extraction area to the interim quarry floor configuration and existing conditions for the Extension Lands. This scenario represents the basis for evaluation of effects to water balances associated with the subsequent scenarios.
- **Scenario 2 – Full Development**: Development of the existing licensed Childs Pit/Quarry extraction area to the interim quarry floor configuration and development of the Extension Lands to the final quarry floor configuration. Scenario 2 takes into consideration the extraction of the setback reduction areas along the common boundaries between the existing Childs Pit/Quarry and the Extension Lands which represents an area of approximately 1.3 ha.
- **Scenario 3 – Rehabilitation**: Creation of a West Lake to the west of the Hydro easement and an East Lake to the east of the Hydro easement with the lake bottom elevations consistent with interim quarry floor configuration for the licensed Childs Pit/Quarry extraction area and the final quarry floor configuration for the Extension Lands. Where the quarry floor elevations are above the anticipated surface water elevation for the East Lake, these areas would be rehabilitated as an above water terrestrial landform.

The assessment of impact on surface water resources associated with the proposed operational conditions was estimated by comparing Scenario 2 to Scenario 1. Similarly, the impact on surface water resources associated with the proposed rehabilitation was estimated by comparing Scenario 3 to Scenario 1

9.1 Methodology

9.1.1 Model Approach

A water balance analysis was required to conduct an impact assessment under proposed full development (Scenario 2) and proposed rehabilitation (Scenario 3) conditions for the key receptors (Sage Creek and Muskoka River, at the high-level and SC-3, SC-6, and MR-North at the detailed-level) which may experience changes to their annual average water balance as a result of the development of the Extension Lands. The water balance was based on meteorological data from the Meteorological Service of Canada Thornthwaite water budgets (Beatrice Climate Station #6115525 1980 – 2018; refer to Table J-0 in Appendix J), topographic mapping within the delineated sub-catchment areas, land uses, the geology of surficial soils, and predicted changes to the quarry capture zones as a result of the proposed development.

Water budget calculations are based on the following equation:

$$P = S + ET + R + I \qquad [1]$$

Where: P = precipitation
S = change in soil moisture storage
ET = evapotranspiration
R = surface runoff
I = infiltration

Short-term or seasonal changes in soil moisture storage (S) occur as demonstrated by dry conditions in the summer months and relatively saturated conditions in the winter and spring. Long-term changes (e.g., year to year) in soil moisture storage are generally small and assumed to be zero.

Evapotranspiration (ET) refers to water losses from soil surfaces to the atmosphere. The term combines evaporation (i.e., water lost from the soil surface) and transpiration (i.e., water lost from plants and trees) because of the difficulties involved in separating these processes. Potential ET refers to the loss of water from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of ET is typically less than the potential rate under dry conditions (e.g., during the summer months when there is a soil moisture deficit). The mean annual potential ET for the area in question is approximately 560 mm/year and the mean annual precipitation (P) is approximately 1,186 mm/year based on data (Thornthwaite water budget for Beatrice Climate station) provided by Environment Canada (EC).

Annual water surplus is the difference between the annual precipitation (P) and the annual actual ET and represents the total amount of water, the sum of surface runoff (R) and infiltration (I), that would flow from the catchment area on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snowmelt and maximum soil storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use and conceptually represents the difference in water content between the field capacity and the wilting point. The total water surplus is calculated by summing the surplus available from each WHC within the watershed.

9.1.2 Selection of Input Data and Formulation

The water balance analysis (for the site and the full catchments) considered the following:

- WHC were chosen based on Table 3.1 in the MECP Stormwater Management Planning and Design Manual (2003) based on soil type and land use. MNRF and Riverstone wetland mapping (as shown on Figure 2) were reviewed to identify land use and vegetation cover. MNRF wetland mapping was selected to represent perennially ponded water areas. The soil types are identified on the surficial geology map (see Figure 5) based on the Ontario Geological Survey data source (2010), and the soils encountered in the boreholes completed as part of the current investigation (provided in Appendix A):
  - Stone-poor, carbonate-derived silty to sandy till, assumed as soil type B (silt loam):
    - Forest Till/Organics: 400 millimetres (mm)
    - Forest Alluvial: 250 mm
    - Forest Precambrian Bedrock: 10 mm
  - For swamp, marsh, and ponded areas expected to typically have standing water year-round, surplus is estimated as precipitation minus potential evapotranspiration.

- Excavation Area: surplus is estimated using a WHC of 10 mm, which assumes that there are closed depression storage areas (spatially averaged at 10 mm deep), within the quarry floor, that can capture water allowing for evaporation to occur and preventing the water from contributing to the sump.
- Flooded Quarry: surplus is estimated as precipitation minus potential evapotranspiration.
- Rehabilitated Areas: assumed as vegetated, surplus is estimated using a WHC of 10 mm, which assumes that small depressions will be filled with topsoil and the rest of areas will have sufficient topsoil to allow growth of grass by natural seeding. The selected WHC is associated with a depth of topsoil of 40 mm.

Net surplus was estimated by multiplying the estimated monthly surplus (mm/month) for the assumed WHC by the associated drainage area and summing the monthly volumes to provide annual estimates. The estimated monthly surplus is calculated (on a monthly basis) as the difference between precipitation and actual evaporation and changes in soil storage for any given soil type/land use. Surface water runoff is calculated by subtracting Infiltration from the net surplus, as shown in equation [2]:

$$SW\ Runoff = Net\ Surplus - Infiltration \qquad [2]$$

- Infiltration rates were estimated using the MECP Stormwater Management Planning and Design Manual (2003) (Table 3.1). The selected infiltration rates (expressed as a percentage of the surplus) are summarized as follows:
  - Forest Till/Organics: 50%
  - Forest Alluvial: 70%
  - Forest Precambrian Bedrock: 25%
  - Swamp, marsh, and ponded areas expected to typically have standing water year-round, including the flooded quarry area: 0%
  - Excavation Area (within Zone A as per Figure 8): 0%
  - Excavation Area (within Zone B as per Figure 8): 10%
  - Vegetated (rehabilitated areas): 20%
- Infiltration within the surface water catchment subject to analysis is calculated within two distinct areas of evaluation: inside quarry capture zone (and inside surface water catchment) and outside quarry capture zone (and inside surface water catchment). Infiltration within each area of evaluation is further broken down into recharge and interflow according to equation [3]:

$$Infiltration = Recharge + Interflow \qquad [3]$$

- The groundwater inflow into the Childs Pit/Quarry is assumed to contribute to the overall runoff, at the quarry discharge point, as once it enters the sump in the excavation, it will be discharged (pumped) to the environment as surface water. During operations, groundwater inflows were assumed to be pumped off site into MR-North. Differential groundwater inflows resulting from the development of the Extension Lands (Scenario 2 minus Scenario 1) were considered to evaluate water balance changes at AP-MRNorth. Absolute groundwater inflows were considered to evaluate changes in the water balance assessment points AP-1 as it is affected by the approved developments of the Child's Pit/Quarry and proposed development in the Extension Lands..
- The quarry capture zone was delineated as part of the groundwater modelling exercise. The quarry capture zone is defined as the area where shallow groundwater flows towards the quarry, corresponding to the extent where, infiltration intercepted by the water table is captured within the quarry footprint, as opposed to discharged to another surface water feature away from the quarry. Water infiltrated inside the surface water and quarry catchments (interflow to quarry), is assumed to report to the quarry. Water infiltrated elsewhere in the surface water catchment was assumed to contribute to groundwater recharge, or report as interflow to water bodies beyond the extent of the quarry capture zone (interflow to feature).
- The global result of the water balance, referred as 'Total Discharge' is defined according to equations [4] and [5] below, to consider specific volumes affecting the total discharge at given assessment points.
  - For AP-2, AP-SC3, AP-SC6

$$\textit{Total Discharge} = \textit{SW Runoff} + \textit{Interflow (to feature)} + \textit{GW discharge (to feature)} \tag{4}$$

  - For AP-1, AP-MRNorth

$$\begin{aligned}\textit{Total Discharge} = {} & \textit{SW Runoff} + \textit{Infiltration (inside quarry capture zone)} + \\ & \textit{GW discharge (to feature)} + \textit{GW Inflow to Quarry}\end{aligned} \tag{5}$$

The assumptions regarding land uses and modelled groundwater inflows into the Quarry (as per section 8.0), for each scenario considered in this study, are summarized in Table 13. To assess the effects of the proposed extension at AP-MRNorth, the incremental groundwater inflow resulting from the extension was assumed to be the difference between groundwater inflow to the quarry under Scenario 2 minus that under Scenario 1 (180 m^3/d).

Table 13: Summary of Land Use and Quarry Inflows Associated with Water Balance Assessment Scenarios

Scenarios	Land Use		Groundwater Inflow to Quarry (m^3/day)
	Existing Childs Pit/Quarry Licensed Area	Extension Lands	
Scenario 1	Extracted	Existing	1,180
Scenario 2	Extracted	Extracted	1,360
Scenario 3	Rehabilitated	Rehabilitated	330

9.1.3 High-Level Water Balance (Sage Creek and Muskoka River)

The water balance analysis considered the three forecast scenarios (indicated in 8.2.2. to assess changes in the water balance at the existing Childs Pit/Quarry flowing into the Muskoka River and Sage Creek discharge points (indicated as AP-1 and AP-2, respectively, on Figure 9). For each of the forecast scenarios, the model boundaries representing the pit/quarry area were adjusted to reflect the development of the existing Childs Pit/Quarry to the interim quarry floor (Scenario 1), development of the existing Childs Pit/Quarry to the interim quarry floor and full development of Extension Lands (Scenario 2), and rehabilitation (Scenario 3). These are illustrated on Figures 26 through 28, for Scenarios 1 through 3, respectively.

The results of the high-level water balance assessment under the forecast scenarios are presented in Section 9.4.1. The simulated scenarios for each assessment considered the assumptions described in Table 13. A review and discussion of the scenarios, as shown on Figures 26 through 28, is presented in the following paragraphs:

- Scenario 1: considers the development of the existing Childs Pit/Quarry to the interim floor elevations with the Extension Lands consisting of its current land use distribution. Under current conditions, the Extension Lands is composed of forested, water bodies/wetland areas, as shown on Figure 26.
- Scenario 2: most of the existing Childs Pit/Quarry and Extension Lands will be excavated leaving a setback boundary of forested areas as shown on Figure 27. In order to maintain positive drainage to Sage Creek, Zone B (Figure 8) is assumed to be graded towards Sage Creek to minimize impacts to the water balance.
- Scenario 3 Rehabilitation: was also considered in this report to determine the water surplus after excavation operations have ceased and the quarry is rehabilitated. The rehabilitated condition considered most of the existing Childs Pit/Quarry extraction areas filled with water forming the East Lake and the West Lake and a majority of the Extension Lands extraction areas being vegetated and draining, by gravity, to the East Lake (within Zone B) or to Sage Creek (Zone A) or flooded as part of the East Lake. The East Lake is expected to drain by gravity towards the northwest to the existing Childs Pit/Quarry and be directed into the receiving Muskoka River. A border of vegetation (vegetated, natural growth) and forest, defined by the setback boundary, will be sloped and surround the lakes, as shown on Figure 28. The areas within Zone B will be sloped towards Sage Creek to maintain positive drainage during rehabilitation.

The results from the high-level water balance (conducted for the local portion of Muskoka River and Sage Creek within the site), were then scaled up at the larger catchment level to assess impact on the Muskoka River (at assessment point AP-1) and Sage Creek (at assessment point AP-2). MNRF's Ontario Flow Assessment Tool (OFAT) in conjunction with GIS mapping was used to determine the approximate subcatchment areas for AP-1 (148,820 ha) and AP-2 (5,147 ha), and average annual flow. The changes in water balance for each scenario and catchment were combined with OFAT estimated annual flows to provide an estimate of potential changes to annual flows in the Muskoka River (AP-1) and Sage Creek (AP-2) associated with the proposed development.

9.1.4 Detailed Water Balance (SC-3, SC-6 and MR-North)

An additional water balance analysis was completed using Scenarios 1, 2 and 3 to assess changes in the water balance at several points of assessment associated with local features, specifically the SC-3, SC-6, and MR-North drainage catchments (evaluated at AP-SC3, AP-SC6, and AP-MRNorth, respectively, see locations on Figure 9). The results of the water balance assessments are presented in Section 9.3. The simulated scenarios for each assessment considered the assumptions described in Table 13. For each of the forecast scenarios, the model boundaries for the three catchment areas were adjusted to reflect the development of the existing Childs Pit/Quarry to the interim quarry floor (Scenario 1), full development of the existing Childs Pit/Quarry (interim quarry floor) and Extension Lands (Scenario 2), and rehabilitation (Scenario 3). These are illustrated on Figure 29 through 31, for Scenarios 1 through 3, respectively.

The results of the detailed water balance assessment under the forecast scenarios are presented in Section 9.3.2. The simulated scenarios for each assessment considered the assumptions described in Table 13. A review and discussion of the scenarios, as seen in the figures, is presented below.

- Under Scenario 1, the development of the existing Childs Pit/Quarry to the interim floor elevations considers the three catchment areas within the Extension Lands consisting of their current land use distribution. Under current conditions, the Extension Lands containing SC-3, SC-6 and MR-North, are composed of forested, water bodies and wetland areas, as shown on Figure 29.
- Under Scenario 2, the entire area within MR-North, and the majority of area within SC-6 will be excavated leaving a setback boundary of forested areas. A majority of the SC-3 catchment will remain under the current forested land use. For catchments SC-3 and SC-6, a new catchment divide is considered to reflect engineered grading to maintain positive drainage to these features. For catchment MR-North, the analysis included the entire excavation area within the Extension Lands (except for Zone B on Figure 8) as Fowler plans to dewater the quarry through MR-North, as shown on Figure 30.
- Scenario 3 Rehabilitation: considers most of the areas within the Extension Lands becoming vegetated. A border of vegetation (vegetated, natural growth) and forest, defined by the setback boundary, will be sloped and surround the lakes. As per Scenario 2, areas within Zone B (on Figure 8) will be sloped towards Sage Creek to maintain positive drainage during rehabilitation. The new catchment divides engineered during operations for catchments SC-3 and SC-6 will be maintained into rehabilitation, as shown in Figure 31. For catchment MR-North, all the catchment will be sloped towards the flooded area which will ultimately report to the overflow location to the Muskoka River, therefore calculations were not computed for this scenario.

9.1.5 Assumptions

A water balance analysis was completed for the footprint corresponding to the existing Childs Pit/Quarry and Extension Lands for the following three scenarios:

- Scenario 1 was analyzed based on the mapped wetlands and vegetation within the Extension Lands (refer to Figure 26 and 29). The development of the existing Childs Pit/Quarry licenced extraction area to the interim floor elevations (i.e., between 240 m ASL to 300 m ASL) as depicted on Figure 3. This scenario represents the baseline condition for the analysis.
- At full development (Scenario 2), surface water runoff and groundwater collected/intercepted in the quarry sump will be pumped north, via MR-North, to the Muskoka River. Excess water may also be discharged directly to the Muskoka River subject to water handling and water quality controls required by the future MECP Environmental Compliance Approval.

- During rehabilitation (Scenario 3), the vegetated strip on the East portion of Zone A will be sloped towards the flooded area which will ultimately drain to the Muskoka River via the outflow point.
- Recharge was assumed to correspond to 5 mm of the infiltrated water each average year within the quarry catchment where bedrock is within 1 m of ground surface and 165 mm each average year where thicker overburden is located. Areas within the existing Childs Pit/Quarry and Extension Lands are split between the two recharge values, while the majority of the lands outside of the quarry catchment areas reporting to the existing and proposed pit/quarry areas have an average recharge of 165 mm.
- To assess the effects of the proposed extension, the incremental groundwater inflow resulting from the extension was assumed to be the difference between groundwater inflow to the quarry under Scenario 2 minus that under Scenario 1 (180 m^3/d).

9.1.6 Groundwater Inflows

Groundwater inflows were considered in the water balance assessment based on the simulated yearly groundwater inflow, described in Section 8.2.3.1 (see Table 11), for the scenarios considered in the water balance assessment. In all cases, the estimated groundwater inflow into the Childs Pit/Quarry is assumed to report as surface water to the quarry discharge point towards the Muskoka River and Sage Creek Tributaries. The daily groundwater inflow values presented below were calculated based on the yearly groundwater inflow values from the groundwater flow model contributing to the sides and floor of the pit/quarry areas, as provided in Section 8.2.3.1. To assess the effects of the proposed extension, the incremental groundwater inflow resulting from the extension was assumed to be the difference between groundwater inflow to the quarry under Scenario 2 minus that under Scenario 1 (180 m^3/d).

- Scenario 1: Estimated groundwater inflow to existing Childs Pit/Quarry of 1180 m^3/day.
- Scenario 2: Estimated groundwater inflow to the extraction areas of the existing Childs Pit/Quarry and Extension Lands of 1360 m^3/day.
- Scenario 3: Estimated groundwater inflow of 330 m^3/day into the rehabilitated pit/quarry areas.

9.2 Validation

The quarry annual averaged water balance was validated against observed flows for catchment SC-3 and SC-6. The rationale for selecting these stations is that the assessment points (AP-SC3 and AP-SC6) include the total catchment areas and match monitoring stations installed on-site.

The water budget calibration considered the same inputs as those described in Section 9.1.4. The water balance considered Scenario 0, which assumes existing conditions at these catchments. Table 14 below shows annual average total discharge to the features (at AP-SC3 and AP-SC6), which was translated into average flow (L/s). For reference, the range of measured flows at stations SW-3 (associated to AP-SC3) and SW-6 (associated with AP-SC6) are included below (refer to Table 9 for source data).

Table 14: Comparison of Water Balance Results (Annual Average) to Measured Flows During 2019

Element	AP-SC3	AP-SC6
Surface Water Catchment Area (ha)	17.8	27.9
Estimated Surface Water Runoff (m^3/year)	90,600	124,700
Estimated Infiltration within Surface Water Catchment (m^3/year)	34,400	64,300
Estimated Infiltration within Quarry Capture Zone (m^3/year)	0	0
Estimated Recharge outside Quarry Capture Zone (m^3/year)	29,400	31,500
Estimated Interflow outside Quarry Capture Zone (m^3/year) [1]	5,100	35,000
Groundwater Discharge to Surface Water Feature [2]	7,600	22,200
Estimated Average Annual Total Discharge (m^3/year) [3]	103,300	181,900
Estimated Average Annual Flow (L/s) [4]	**3.3**	**5.8**
Measured Minimum Flow (L/s) [5]	0	2.0
Measured Mean Flow (L/s) [5]	**1.0**	**4.0**
Measured Maximum Flow (L/s) [5]	6.0	10.0

Notes:
1. Estimated interflow within surface water catchment assumed to report to the surface water feature.
2. Volumes based on groundwater model presented Table 12.
3. Estimated average annual total discharge according to equation [4]
4. Estimated annual flow excludes daily and seasonal variability which is expected in the surface water feature
5. Measured minimum, mean and maximum flows based on data collected during the ice-free period in 2019.
6. Evaluation area and assessment points depicted in Figure 29.

For SC-3, the results show that the estimated average flow (annual average) is approximately 3.3 L/s which is within the observed range during the ice-free period (negligible to 6.0 L/s with mean value estimated at 1.0 L/s) and in the same order of magnitude as the mean observed flow.

For SC-6, the results show that the estimated average flow (annual average) is approximately 5.8 L/s which is within the observed range during the ice-free period (2.0 L/s to 10 L/s with mean value estimated at 4.0 L/s) and in the same order of magnitude as the mean observed flow.

Another positive observation is that the annual average flow estimated by the water balance is smaller at SC-3 (i.e., 3.3 L/s) than at SC-6 (5.8 L/s). This is consistent with observed mean flows (1.0 L/s for SC-3 and 4.0 L/s for SC-6).

This result from the verification exercise suggests that the water balance methodology is appropriate to use for forecasting changes in the annual average water balance associated with the proposed development.

9.3 Results

9.3.1 High-Level Water Balance Assessment

The water balance analysis assesses the differences in total annual discharge for the following conditions: Scenario 2 compared to Scenario 1; and Scenario 3 compared to Scenario 1. The first water balance analysis focuses on the high-level analysis of drainage areas reporting to points of assessment, indicated in Section 9.1.3, for the Muskoka River at the point of discharge (AP-1) and Sage Creek at the confluence with the Muskoka River (AP-2), respectively.

A summary table of the estimated total annual discharge under Scenarios 1 to 3 is included in Table 15 for AP-1 (Muskoka River Tributary at site boundary) and in Table 16 for AP-2 (Sage Creek at boundary of proposed Extension Lands). The results from the annual average water balance at AP-1 and AP-2 were combined with annual average hydrologic information (from OFAT) for Sage Creek and Muskoka River to estimate changes at the catchment level, which is presented in Table 17. The average annual precipitation and surplus values were averaged over the period of 1980-2018 for all conditions with the annual total discharge developed from a monthly water balance analysis. The detailed results of the monthly water balance analysis are presented in Tables J-1 through J-3 in Appendix J.

Table 15: Water Balance Results (m^3/year) for Point of Assessment AP-1

Point of Assessment	AP-1 (Muskoka River Tributary at Site Boundary)		
Water Balance Variables	**Scenario 1**	**Scenario 2**	**Scenario 3**
Surface Water Catchment Area (ha)	307	308	308
Estimated Surface Water Runoff (m^3/year) [1]	1,807,800	2,022,600	1,775,200
Estimated Infiltration within Surface Water Catchment (m^3/year) [2]	303,000	132,400	222,600
Estimated Infiltration within Quarry Capture Zone (m^3/year) [3]	285,800	115,200	203,100
Estimated Recharge outside of Quarry Capture Zone (m^3/year) [4]	5,000	5,000	5,000
Estimated Interflow outside the Quarry Capture Zone (m^3/year) [5]	12,200	12,200	14,400
Groundwater Discharge to Surface Water Feature (m^3/year) [6]	429,200	497,900	120,500
Estimated Groundwater Inflow into the Pit/Quarry (m^3/year) [7,8]	701,900	690,600	974,200
Estimated Average Annual Total Discharge (m^3/year) [9]	3,224,700	3,355,700	3,106,900
Change in Estimated Annual Total Discharge Compared to Scenario 1 (m^3/year)	-	131,000	-117,800
Percent Change in Estimated Annual Total Discharge Compared to Scenario 1 (%)[10]	-	4	-4

Notes:
1. Runoff calculated as Meteorological Surplus – Infiltration
2. Infiltration calculated as a percentage of the Surplus within Surface Water Catchment
3. Quarry Captured Zone as per definition in Section 9.1.2
4. Recharge based on spatial distribution used in the groundwater modelling exercise (see Section 8.1.6). The recharge value was calculated as a weighted average based on recharge value within the areas subject to evaluation
5. Interflow calculated as Infiltration - Recharge
6. Groundwater Discharge to Surface Water based on the groundwater modelling exercise (see Section 8.2.3)
7. Estimated inflow into pit/quarry calculated as the modelled Daily Inflow into Quarry from the groundwater model (see Section 8.2.3)
8. Groundwater inflow into pit/quarry excavation discharged to the environment as surface water as part of quarry water management strategy.
9. Estimated average annual total discharge calculated as per equation [5]
10. Changes evaluated for the affected area within the property boundary and do not correspond with estimated changes for the entire catchment, Changes at the catchment level are expected to be significantly smaller
11. Analysis limited to area labelled as Muskoka River Tributary as presented in Figures 26 - 28.

Table 16: Water Balance Results (m^3/year) for Point of Assessment AP-2

Point of Assessment	AP-2 (Sage Creek at Boundary of Proposed Extension Lands)		
Water Balance Variables	**Scenario 1**	**Scenario 2**	**Scenario 3**
Surface Water Catchment Area (ha)	91	90	90
Estimated Surface Water Runoff (m^3/year) [1]	434,900	547,100	495,900
Estimated Infiltration within Surface Water Catchment (m^3/year) [2]	192,600	86,800	138,000
Estimated Infiltration within Quarry Capture Zone (m^3/year) [3]	64,500	58,300	108,900
Estimated Recharge outside of Quarry Capture Zone (m^3/year) [4]	52,000	13,800	13,800
Estimated Interflow outside the Quarry Capture Zone (m^3/year) [5]	76,100	14,700	15,400
Groundwater Discharge to Surface Water Feature (m^3/year) [6]	170,500	135,400	143,100
Estimated Groundwater Inflow into the Pit/Quarry (m^3/year) [7,8]	0	0	0
Estimated Average Annual Total Discharge (m^3/year) [9]	681,400	697,300	654,300
Change in Estimated Annual Total Discharge Compared to Scenario 1 (m^3/year)	-	15,900	-27,100
Percent Change in Estimated Annual Total Discharge Compared to Scenario 1 (%)[10]	-	2	-4

Notes:
1. Runoff calculated as Meteorological Surplus – Infiltration
2. Infiltration calculated as a percentage of the Surplus within Surface Water Catchment
3. Quarry Captured Zone as per definition in Section 9.1.2
4. Recharge based on spatial distribution used in the groundwater modelling exercise (see Section 8.1.6). The recharge value was calculated as a weighted average based on recharge value within the areas subject to evaluation
5. Interflow calculated as Infiltration - Recharge
6. Groundwater Discharge to Surface Water based on the groundwater modelling exercise (see Section 8.2.3)
7. Estimated inflow into pit/quarry calculated as the modelled Daily Inflow into Quarry from the groundwater model (see Section 8.2.3)
8. Groundwater inflow into pit/quarry excavation discharged to the environment as surface water as part of quarry water management strategy.
9. Estimated average annual total discharge calculated as per equation [4]
10. Changes evaluated for the affected area within the property boundary and do not correspond with estimated changes the entire catchment, Changes at the catchment level are expected to be significantly smaller
11. Analysis limited to Sage Creek catchment and presented in Figures 26 - 28.

Table 17: Estimated Changes to Annual Average Flows in Muskoka River and Sage Creek

Scenarios (Compared to Existing Flows at the Receiving Watercourses)	Catchment Area of Muskoka River or Sage Creek at Confluence with Point of Assessment (ha)	Catchment Area of Point of Assessment (ha)	Muskoka River or Sage Creek Flow Rate at Point of Assessment (L/s)	Flow Change from Site Discharge Compared to Scenario 1 Conditions (L/s)	Change in Overall Muskoka River or Sage Creek Flow Rate (%)
Muskoka River					
Scenario 2	148,821	308	22,570	4.2	0.02
Scenario 3		308		-3.7	-0.02
Sage Creek					
Scenario 2	5,417	90	820	0.5	0.06
Scenario 3		90		-0.9	-0.11

Under operational conditions for the existing Childs Pit/Quarry and Extension Lands (Scenario 2 compared to Scenario 1), the estimated annual total discharge increases by approximately 131,000 m^3/year (4%) and 15,900 m^3/year (2%) compared to Scenario 1, at the point of assessment AP-1 and AP-2, respectively. These changes are evaluated over the affected areas within the property boundary but do not correspond to estimated changes at the catchment level, which will be significantly smaller. The changes are due to the decrease in evapotranspiration, associated with the change in land use (i.e., from vegetated/forest to exposed bedrock). Under rehabilitated conditions (Scenario 3 compared to Scenario 1), the estimated average annual total discharge is expected to decrease by approximately 117,800 m^3/year (-4%) and 27,100 m^3/year (-4%) compared to Scenario 1. Under the rehabilitation, vegetated lands (natural growth) and forested areas will be located on lands surrounding the lakes, with a large vegetated area located within the Extension Lands (approximately 66% of the total Extension Lands area).

The MNRF's OFAT in conjunction with GIS mapping was used to determine an approximate catchment area for the points of assessment for the Muskoka River at the point of discharge (AP-1) and Sage Creek at the confluence point with the Muskoka River (AP-2). The analysis revealed that during Scenario 2 operations, the 308 ha existing Childs Pit/Quarry catchment contributing to AP-1 represents approximately 0.21% of the Muskoka River subwatershed area (a total of 148,820 ha) and the 90 ha Extension Lands catchment contributing to AP-2 represents approximately 1.7% of the Sage Creek watershed area (a total of 5,417 ha). Under Scenario 2, full development condition, it is suspected that runoff from the existing Childs Pit/Quarry and Extension Lands will report to the receiving watercourses. Runoff from the existing and proposed areas are expected to increase the average flow rates by approximately 0.02% to the Muskoka River subwatershed and 0.06% to Sage Creek watershed areas during full development operations, while the flow rates to the Muskoka River subwatershed and Sage Creek watershed areas are expected to decrease by approximately 0.02% and 0.11% during rehabilitation (see Table 17), respectively.

9.3.2 Detailed Water Balance Assessment

A second detailed water balance analysis focuses on the drainage areas reporting to points of assessment for catchments of SC-3 (AP-SC3), SC-6 (AP-SC6) and MRNorth (AP-MRNorth) indicated in Section 9.1.4, which are the selected tributaries draining within the Extension Lands.

A summary table of the estimated annual total discharge under Scenarios 1 to 3 is included in Table 18 for AP-SC3 (unnamed tributary to Sage Creek), Table 19 for AP-SC6 (unnamed tributary to Sage Creek) and Table 20 for AP-MRNorth (MR-North at boundary of proposed Extension Lands).The annual total discharge was developed from a monthly water balance analysis. The detailed results of the monthly water balance analysis are presented in Tables J-4 through J-6 in Appendix J.

Table 18: Water Balance Results (m^3/year) for Point of Assessment AP-SC3

Point of Assessment	AP-SC3 (Unnamed tributary to Sage Creek)		
Water Balance Variables	Scenario 1	Scenario 2	Scenario 3
Surface Water Catchment Area (ha)	17.5	22.5	22.5
Estimated Surface Water Runoff (m^3/year) [1]	88,800	128,600	120,100
Estimated Infiltration within Surface Water Catchment (m^3/year) [2]	33,800	30,100	38,600
Estimated Infiltration within Quarry Capture Zone (m^3/year) [3]	20,800	9,000	17,400
Estimated Recharge outside of Quarry Capture Zone (m^3/year) [4]	9,400	17,000	17,000
Estimated Interflow outside the Quarry Capture Zone (m^3/year) [5]	3,600	4,100	4,200
Groundwater Discharge to Surface Water Feature (m^3/year) [6]	4,500	100	6,200
Estimated Groundwater Inflow into the Pit/Quarry (m^3/year) [7,8]	0	0	0
Estimated Average Annual Total Discharge (m^3/year) [9]	96,900	132,800	130,500
Change in Estimated Annual Total Discharge Compared to Scenario 1 (m^3/year)	-	35,900	33,600
Percent Change in Estimated Annual Total Discharge Compared to Scenario 1 (%)	-	37	35

Notes:
1. Runoff calculated as Meteorological Surplus – Infiltration
2. Infiltration calculated as a percentage of the Surplus within Surface Water Catchment
3. Quarry Captured Zone as per definition in Section 9.1.2
4. Recharge based on spatial distribution used in the groundwater modelling exercise (see Section8.1.6). The recharge value was calculated as a weighted average based on recharge value within the areas subject to evaluation
5. Interflow calculated as Infiltration - Recharge
6. Groundwater Discharge to Surface Water based on the groundwater modelling exercise (see Section 8.2.3)
7. Estimated inflow into pit/quarry calculated as the modelled Daily Inflow into Quarry from the groundwater model (see Section 8.2.3)
8. Groundwater inflow into pit/quarry excavation discharged to the environment as surface water as part of quarry water management strategy.
9. Estimated average annual total discharge calculated as per equation [4]
10. Analysis limited to area labelled as SC-3 and presented in Figures 29 - 31.

Table 19: Water Balance Results (m^3/year) for Point of Assessment AP-SC6

Point of Assessment	AP-SC6 (Unnamed tributary to Sage Creek)		
Water Balance Variables	**Scenario 1**	**Scenario 2**	**Scenario 3**
Surface Water Catchment Area (ha)	27.9	31.0	31.0
Estimated Surface Water Runoff (m^3/year) [1]	124,700	185,200	167,300
Estimated Infiltration within Surface Water Catchment (m^3/year) [2]	64,300	32,300	50,200
Estimated Infiltration within Quarry Capture Zone (m^3/year) [3]	17,300	18,000	35,700
Estimated Recharge outside of Quarry Capture Zone (m^3/year) [4]	23,100	6,600	6,600
Estimated Interflow outside the Quarry Capture Zone (m^3/year) [5]	23,900	7,700	7,900
Groundwater Discharge to Surface Water Feature (m^3/year) [6]	21,400	11,100	15,400
Estimated Groundwater Inflow into the Pit/Quarry (m^3/year) [7,8]	0	0	0
Estimated Average Annual Total Discharge (m^3/year) [9]	170,000	204,000	190,600
Change in Estimated Annual Total Discharge Compared to Scenario 1 (m^3/year)	-	34,000	20,600
Percent Change in Estimated Annual Total Discharge (%)	-	20	12

Notes:
1. Runoff calculated as Meteorological Surplus – Infiltration
2. Infiltration calculated as a percentage of the Surplus within Surface Water Catchment
3. Quarry Captured Zone as per definition in Section 9.1.2
4. Recharge based on spatial distribution used in the groundwater modelling exercise (see Section 8.1.6). The recharge value was calculated as a weighted average based on recharge value within the areas subject to evaluation
5. Interflow calculated as Infiltration - Recharge
6. Groundwater Discharge to Surface Water based on the groundwater modelling exercise (see Section 8.2.3)
7. Estimated inflow into pit/quarry calculated as the modelled Daily Inflow into Quarry from the groundwater model (see Section 8.2.3)
8. Groundwater inflow into pit/quarry excavation discharged to the environment as surface water as part of quarry water management strategy.
9. Estimated average annual total discharge calculated as per equation [4]
10. Analysis limited to area labelled as SC-6 and presented in Figures 29 - 31.

Table 20: Water Balance Results (m^3/year) for Point of Assessment AP-MRNorth

Point of Assessment	AP-MRNorh (MR-North at Boundary of Proposed Extension Lands)		
Water Balance Variables	**Scenario 1**	**Scenario 2**	**Scenario 3**
Surface Water Catchment Area (ha)	50.7	70.8	NA
Estimated Surface Water Runoff (m^3/year) [1]	219,600	501,200	NA
Estimated Infiltration within Surface Water Catchment (m^3/year) [2]	118,400	0	NA
Estimated Infiltration within Quarry Capture Zone (m^3/year) [3]	118,400	0	NA
Estimated Recharge outside of Quarry Capture Zone (m^3/year) [4]	0	0	NA
Estimated Interflow outside the Quarry Capture Zone (m^3/year) [5]	0	0	NA
Groundwater Discharge to Surface Water Feature (m^3/year) [6]	2,000	0	NA
Estimated Groundwater Inflow into the Pit/Quarry (m^3/year) [7,8]	0	65,700	NA
Estimated Average Annual Total Discharge (m^3/year) [9]	221,600	566,900	NA
Change in Estimated Annual Total Discharge Compared to Scenario 1 (m^3/year)	-	345,300	NA
Percent Change in Estimated Annual Total Discharge (%)	-	156	NA

Notes:
1. Runoff calculated as Meteorological Surplus – Infiltration
2. Infiltration calculated as a percentage of the Surplus within Surface Water Catchment
3. Quarry Captured Zone as per definition in Section 9.1.2
4. Recharge based on spatial distribution used in the groundwater modelling exercise (see Section 8.1.6). The recharge value was calculated as a weighted average based on recharge value within the areas subject to evaluation
5. Interflow calculated as Infiltration - Recharge
6. Groundwater Discharge to Surface Water based on the groundwater modelling exercise (see Section 8.2.3)
7. Estimated inflow into pit/quarry calculated as the modelled Daily Inflow into Quarry from the groundwater model . To assess the effects of the proposed extension, the incremental groundwater inflow resulting from the extension was assumed to be the difference between groundwater inflow to the quarry under Scenario 2 minus that under Scenario 1 (180 m^3/d) (see Section 8.2.3).
8. Groundwater inflow into pit/quarry excavation discharged to the environment as surface water as part of quarry water management strategy.
9. Estimated average annual total discharge calculated as per equation [5]
10. Analysis limited to area labelled as MR-North Tributary and presented in Figures 29 - 31.

Under operational conditions for the existing Childs Pit/Quarry and Extension Lands (Scenario 2 compared to Scenario 1), the estimated annual total discharge increases by approximately 35,900 m^3/year (37%), 34,000 m^3/year (20%) and 345,300 m^3/year (156%) compared to Scenario 1, at the point of assessment AP-SC3, AP-SC6 and AP-MRNorth, respectively. The changes in discharge to SC-3 and SC-6 are due to the decrease in evapotranspiration, associated with the change in land use (i.e., from vegetated/forest to exposed bedrock). The changes in discharge to MR-North are due to the increase in catchment area, change in land use (i.e., from vegetated/forest to exposed bedrock), and associated with the estimated groundwater inflows to the quarry, which are assumed to be pumped out towards MR-North. The portion of MR-North within the existing Childs Pit/Quarry license area is already approved for extraction. The average annual discharge from the

Extension Lands to MR-North will gradually increase to 156%, compared to baseline discharge, as a result of diverting the water captured in the Extension Lands to MR-north, which is a small drainage feature with a relatively small existing catchment area. The effects of this change will be managed through a future ECA, which will require a receiving watercourse assessment to identify suitable discharge rates. The portion of MR-North within the existing Childs Pit/Quarry license area is already approved for extraction and the connectivity of the remaining catchment area within the Extension Lands will be disconnected from the Muskoka River. The surface water from MR-North will drain into the existing Childs Pit/Quarry, be collected in the sump and discharged in accordance with MECP permits.

Under rehabilitation (Scenario 3 compared to Scenario 1), the estimated average annual total discharge is expected to increase by approximately 33,600 m^3/year (35%), 20,600 m^3/year (12%) at the points of assessment AP-SC3 and AP-SC6 compared to Scenario 1. Point of assessment AP-MRNorth was omitted from the assessment because the divide between the existing Childs Pit/Quarry and Extension Lands will not be present, as the East Lake will straddle the boundary. The area within the Extension Lands north of the Zone B boundary will be composed partly of vegetated areas in addition to the East Lake. Under the rehabilitation within the Zone B boundary, catchment areas for points of assessment AP-SC3 and AP-SC6 will be vegetated lands (natural growth) and forested areas will be located on lands surrounding the previous limit of extraction, with lands outside of the limit of extraction being unaltered under their existing condition.

10.0 IMPACT ASSESSMENT

The following section provides an assessment of the potential impacts on surrounding receptors associated with the development of the Childs Pit/Quarry Extension Lands. The primary groundwater receptors in the vicinity of the site are the private wells located within the predicted radius of influence (mostly along Bonnie Lake Road). The main surface water receptors in the vicinity of the site are the Muskoka River and Sage Creek and associated tributaries.

Bonnie Lake is located approximately 1.5 kilometres to the east of the existing Childs Pit/Quarry and the Extension Lands. It is understood that surface water is drawn from Bonnie Lake for the purpose of supplying water to the Bonnie Lake Resort. The development of the existing Childs Pit/Quarry and the Extension Lands does not result in catchment alterations for Bonnie Lake and the simulated extent of the drawdown in the shallow bedrock (see Figure 23) does not extend to Bonnie Lake. As such, there is no mechanism for adversely impacting water levels in Bonnie Lake or the water supply drawn from Bonnie Lake to service the Bonnie Lake Resort, and therefore Bonnie Lake is not discussed in the impact assessment provide below.

10.1 Existing Groundwater Users

10.1.1 Operations

During operations, dewatering of the existing Childs Pit/Quarry and Extension Lands below the groundwater table has the potential to cause a decline in groundwater levels/piezometric levels in adjacent areas. These drawdown/depressurization effects have the potential to lower the groundwater levels in nearby water supply wells. The wells in the vicinity of the site primarily service the residential development along Bonnie Lake Road to the east.

Figure 10 shows the predicted zone of influence in the bedrock (as defined by the 1-m drawdown contour) for the development of the existing Childs Pit/Quarry to the interim floor elevations and the Extension Lands to the final floor elevations (i.e., the development plan depicted on Figure 3). The locations of the 27 properties visited during the private well survey (PW-1 through PW-27) plus additional water supply wells within the predicted zone of influence as provided by the MECP WWIS (filtered for locations having an accuracy code within 300 of the correct location) are also shown on Figure 10. A total of 35 water supply wells are identified within the predicted radius of influence, which include PW-1 through PW-27 plus 8 additional wells from the MECP WWIS.

The supply wells at 6 of the 27 locations visited during the private well survey were identified as being completed in the overburden (PW-2, PW-3, PW-6, PW-23, PW-24 and PW-26). The remaining 21 locations visited during the private well survey have wells completed in the bedrock. Four of the eight additional MECP WWIS wells within the zone of influence are completed in overburden (4209503, 4209502, 7105770 and 7179503) and four are completed in bedrock (7047910, 7211231, 4209825 and 7279477).

10.1.1.1 Overburden Supply Wells

As discussed in Section 7.1, dug wells/shallow drilled wells completed in the overburden obtain their water from the overburden material, and the underlying bedrock does not significantly contribute to the supply capacity of the wells. The water within the overburden wells is expected to be recharge locally, and the water level/supply capacity of these wells are highly dependent on the magnitude and frequency of local precipitation events. Because the water table at the site is within the bedrock, drawdown associated with the development of the existing Childs Pit/Quarry and the Extension Lands will propagate through the bedrock. This drawdown within the low hydraulic conductivity bedrock will not influence the supply capacity of the overburden wells in the vicinity of the site. As such, the overburden wells PW-2, PW-3, PW-6, PW-23, PW-24, PW-26, 4209503, 4209502, 7105770 and 7179503 within the predicted zone of influence shown on Figure 10 are not considered in the water supply impact assessment.

10.1.1.2 Bedrock Supply Wells

For the identified bedrock water supply well locations within the predicted zone of influence, there are no well completion details available for five locations (PW-1, PW-10, PW-11, PW-12 and PW-16). Well completion details are available for the remaining 19 bedrock supply well locations within the predicted zone of influence. For these 19 locations, the available well completion details come from water well records and/or information provided by the well owners as part of the private well survey. Water well records were available for 16 of the 19 locations. These 19 bedrock supply well locations represent a high-quality dataset for use during the completion of the impact assessment for existing groundwater users.

Table K1 in Appendix K provides well completion details for the 19 bedrock water supply wells, as well as the static water level measured during private well survey where available, or the static water level measured at the time of drilling (as per the water well record). The source of the static water level is noted in Column 9 of Table K1. As shown in Column 6 of Table K1, most wells completed in the vicinity of the site are greater than 90 metres deep.

The predicted drawdown (residual drawdown in the case of Scenario 3 – Rehabilitation) as a result of pit/quarry operations for each water supply well under the following development scenarios is also provided in Table K1:

- Scenario 1 – Licensed Childs Pit/Quarry development to the interim quarry floor elevations (Column 10 in Table K1).
- Scenario 2 – Full development of the existing Childs Pit/Quarry to the interim quarry floor elevations and the Extension Land to the final floor elevations (Column 11 in Table K1).
- Scenario 3 – Rehabilitation of the existing Childs Pit/Quarry and Extension Lands (Column 15 of Table K1).

In Table K1 in Appendix K, the static water level (Column 8) and the total depth of the well (Column 6) was used to estimate the available drawdown (Column 13) for each water supply well within the zone of influence (defined by the one-metre drawdown contour on Figure 10). Column 14 in Table K1 presents the predicted remaining available drawdown for each well location following the full development of the existing Childs Pit/Quarry to the interim floor elevations and the Extension Lands to the final floor elevations, and was calculated by subtracting the predicted drawdown under Scenario 2 (Column 11) from the available drawdown (Column 13).

Table 21 below summarizes the predicted available drawdown at the private well locations following full development (Scenario 2).

Table 21: Predicted Available Drawdown Following Full Development (Scenario 2)

Location	Predicted Available Drawdown Following Full Development (Scenario 2)
PW-4	87.9
PW-5	124.8
PW-7	108.7
PW-8	28.8
PW-9	95.7
PW-13	88.3
PW-14	74.6
PW-15	78.4
PW-17	82.7
PW-18	109.5
PW-19	121.5
PW-20	124.0
PW-21	92.9
PW-22	105.8
PW-25	85.7
PW-27	90.1
4209825	106.2
7047910	104.1
7211231	113.8
7279477	53.9

As shown in Table 21, due to the significant depth of most wells in the vicinity of the site, and the minimal predicted drawdown (i.e., 10 metres of drawdown or less), the predicted available drawdown following full development (Scenario 2) is greater than 50 m for all locations except PW-8. Well interference at water supply wells having greater than 50 m of available drawdown remaining is not predicted.

The remaining available drawdown at PW-8 is predicted to be 28.8 m. As part of the private well survey, a data logger was installed at PW-8 to monitor changes in groundwater levels for approximately six weeks between February 25, 2020 and April 6, 2020. The results of the groundwater level monitoring at PW-8 are provided on Figure G2 in Appendix G. As shown on Figure G2, the typical available drawdown required for domestic supply at PW-8 is 1.2 m or less, and the maximum decline in the groundwater observed during the 6-week monitoring period was 1.5 m. Based on the available data, well interference is not predicted at PW-8 as a result of the proposed full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands.

10.1.1.3 Summary

Based on the above assessment, interference with water supply wells as a result of the proposed full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands is not predicted. As discussed in Section 12, additional monitoring wells are being proposed between the site and the private wells located on Bonnie Lake Road. The proposed groundwater level monitoring program will permit the collection of long-term groundwater level data as the existing Childs Pit/Quarry and Extension Lands develop. These data will show the actual changes in groundwater levels within the monitoring wells completed around the extraction areas as the quarry expands laterally and vertically and can be used to further assess the propagation of the drawdown cone. In the unlikely event that complaints are received regarding interference to water wells in the vicinity of the site, the complaints response plan discussed in Section 11 would be implemented.

10.1.2 Rehabilitation

Following the completion of site operations, the dewatering system will be turned off, and the quarry will be allowed to flood back. The elevation of the water level within the flooded quarry will be controlled by the low points around the perimeter of the extraction areas. Based on a review of the available elevation data, flood back will result in the creation of a West Lake to the west of the Hydro easement with a lake level of approximately 290 m ASL and an East Lake to the east of the Hydro easement with a lake level of approximately 295 m ASL.

As shown in Table K1 in Appendix K, the predicted available drawdown following rehabilitation (Column 16) is equal to or greater than the predicted available drawdown during the full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands (Column 14). As such, interference with water supply wells following rehabilitation is not predicted.

10.2 Surface Water Features

This section provides an analysis of the data, in the context of the potential water resources impacts associated with the development of the Extension Lands, with respect to the identified receptors in the vicinity of the site. Based on the assessment of hydrogeological and hydrological conditions within the vicinity of the site and comparison of the modelled conditions for Scenarios 1, 2 and 3, the following conclusions were drawn:

1) Modelled shallow groundwater quarry capture zones associated with the development of the licensed Childs Pit/Quarry do not extend into Sage Creek or Muskoka River, but do extend partially into the catchment areas reporting to SC-3 and SC-6 and fully under the MR-North catchment;

2) All features evaluated in this report (SC-3, SC-6, MR-North) are expected to still contain water under the proposed development of the Extension Lands; and

3) Effects to annual average discharge to Sage Creek (less than 1.1% change) and Muskoka River (less than 0.2%) are considered negligible.

From a surface water perspective, the quarry development at the site and the subsequent rehabilitation has the potential to affect the identified receptors mainly via land use changes, surface water drainage alterations (mainly catchment area and land use changes) and quarry water management (e.g., quarry dewatering). If un-managed, these changes have the potential to affect the receptor flow regime (base flow and storm flow/flooding), channel erosion and water quality.

The potential surface water receptors in the vicinity of the site that could be affected include the:

- Muskoka River
- Sage Creek
- SC-3
- SC-6
- MR-North

The following text describes the changes that are anticipated to occur in the downstream receiving drainage features during the proposed operations (Scenario 2) and rehabilitation (Scenario 3) stages of the site.

10.2.1 Drainage Pattern

As part of the proposed development, the change in catchment areas during operations are approximately +1 ha for Muskoka River, -1 ha for Sage Creek, +20 ha for MR-North (at the AP-MRNorth point of assessment), +5 ha for SC-3, and +3 ha for SC-6. The changes to drainage patterns for surface water features are as follows:

- Muskoka River and MR-North: Extraction on Zone A (Figure 8) will capture site runoff that would have drained mainly towards MR-North and eventually to the Muskoka River. Under operations, water from the excavation area within Zone A will be pumped to MR-North to limit water loss in the feature. Under rehabilitation, Zone A footprint will be partially flooded and partially vegetated and draining towards flooded areas, with outlet towards the Muskoka River. As a result of the proposed rehabilitation, water will be lost from the MR-North feature but will still report to the Muskoka River via the outflow point.
- Sage Creek, SC-3 and SC-6: Extraction on Zone B (Figure 8) will capture site runoff that would have drained mainly towards Sage Creek via a series of small un-named tributaries. Under operations, water will be directed towards Sage Creek by providing positive grading towards the creek. Furthermore, a portion of the water captured within Zone B will be collected and appropriately directed via passive drainage to SC-3 and SC-6 to minimize loss of water contribution on these features. Under rehabilitation, the drainage pattern will remain as per operations to ensure that sufficient water contribution is maintained.

Therefore, the drainage patterns will not be significantly affected at Sage Creek, Muskoka River, MR-North, SC-3 and SC-6 as a result of the development of the Extension Lands; runoff will continue to drain towards these features during operations. Only the drainage pattern of MR-North will be affected under the rehabilitation phase as water will be directed to the Muskoka River via the rehabilitated existing quarry licensed area, rather than contributing to this feature as it occurs during existing and operational conditions. It is worth noting that MR-North ultimately contributes to the Muskoka River under existing conditions and therefore, the loss of drainage experienced by MR-North will cause local effects at the feature level but is not expected to affect the Muskoka River hydrology.

10.2.2 Average Annual Stream Flow

During the operational period for the existing Childs Pit/Quarry and Extension Lands (Scenario 2), a reduction in evapotranspiration and a corresponding increase in the amount of surface water runoff collected within the proposed extraction areas is expected to occur. During the same period, groundwater inflow and direct precipitation will be collected in the quarry sump and discharged to MR-North. During rehabilitation (Scenario 3), an increase in the evaporation and a corresponding decrease in the amount of surface water runoff collected within the proposed flooded lake areas and ultimately reporting to the Muskoka River is expected to occur. For the

Sage Creek and its tributaries (SC-3 and SC-6), evaporation and associated runoff is expected to be similar to existing conditions. Table 22 below compiles the water balance calculations (Section 9.3) to assess the change in flow in the key receiving drainage features.

Table 22: Estimated Changes in Net Surplus and Total Discharge in Comparison with the Scenario 1

Scenarios (Compared to Scenario 1)	Total Discharge Volume (m^3/year)	Difference in Discharge (%)	Averaged Annual Flow (l/s)
Muskoka River (AP-1)			
Scenario 1	3,224,700	--[1]	102.3 (20,570)[2]
Scenario 2	3,355,700	4 (0.02)[2]	106.4 (20,574)[2]
Scenario 3	3,106,900	-4 (-0.02)[2]	98.5 (20,566)[2]
Sage Creek (AP-2)			
Scenario 1	681,400	--[1]	21.6 (820)[3]
Scenario 2	697,300	2 (0.06)[3]	22.1 (821)[3]
Scenario 3	654,300	-4 (-0.11)[3]	20.7 (819)[3]
MR-North (AP-MRNorth)			
Scenario 1	221,600	--[1]	7.0
Scenario 2	566,900	156[4]	10.9
Scenario 3	NA[5]	NA[5]	NA[5]
SC-3 (AP-SC3)			
Scenario 1	96,900	--[1]	3.1
Scenario 2	132,800	37	4.2
Scenario 3	130,500	35	4.1
SC-6 (AP-SC6)			
Scenario 1	170,000	--[1]	5.4
Scenario 2	204,000	20	6.5
Scenario 3	190,600	12	6.0

Notes:

1. Scenario 1 represented the reference to calculate the percent change
2. Estimated annual flows and change at the Muskoka River catchment level under the assumption that hydrologic conditions extracted from OFAT correspond with Scenario 1
3. Estimated annual flows and difference change at the Muskoka River catchment level under the assumption that hydrologic conditions extracted from OFAT correspond with Scenario 1
4. Estimated increase refers to average annual discharge. Actual instantaneous pump rates will be subject to MECP approval and will be designed to be compatible with the range of baseline flow rates in the receiving watercourse. Results consider incremental changes corresponding to area within the Extension Lands.
5. Scenario not evaluated

During the operational stage (Scenario 2), an increase in average annual total discharge volume of approximately 156 percent (at AP-MRNorth) and approximately 0.02 percent at the Muskoka River is expected compared to Scenario 1, which is a result of: (1) increase of drainage area reporting to the quarry discharge point (applicable to MR-North only); (2) change in land uses leading to decreased evapotranspiration and increased runoff; (3) reduction of the overall infiltration associated with modifications in the land uses (i.e., removal of vegetation); and, (4) the interception of groundwater flow which becomes runoff.

The effects of this increased average annual discharge to MR-North will be managed through a future ECA, which will require a receiving watercourse assessment to identify suitable discharge rates. Instantaneous pump rates will be selected within the range of flows naturally experienced by MR North under baseline conditions to minimize the risk of channel erosion and negative effects on aquatic habitat. If quarry discharge rates, in excess of the suitable range of flows in MR-North are necessary, Fowler will apply to discharge the excess quarry sump water directly to the Muskoka River following treatment (settling) and confirmation of compatible water quality. Any such, modifications will be subject to review and approval under applicable laws and regulations (e.g. Section 53 of the Ontario Water Resources Act).

During the operational stage (Scenario 2), average annual discharge is expected to increase from approximately 3.1 L/s (Scenario 1) to approximately 4.2 L/s at AP-SC3 and from approximately 5.4 L/s (Scenario 1) to approximately 6.5 L/s at AP-SC6. These changes are a result of: (1) change in land uses leading to decreased evapotranspiration and increased runoff; and, (2) reduction of the overall infiltration associated with modifications in the land uses (i.e., removal of vegetation).

During rehabilitation (Scenario 3), a decrease in average annual total discharge volume of approximately 0.02 percent at the Muskoka River and approximately 0.11 percent at Sage Creek are expected as a result of increased evapotranspiration rate, and decrease in infiltration over the quarried area as the existing Childs Pit/Quarry and Extension Lands will be allowed to fill with water to create a lake.

During rehabilitation (Scenario 3), an increase in average annual discharge, from approximately 3.1 L/s (Scenario1) to approximately 4.1 L/s is expected in SC-3 (at AP-SC3) and an increase in average annual discharge, from approximately 5.4 L/s (Scenario 1) to approximately 6.0 L/s is expected at SC-6 as a result of land uses changes.

The estimated changes in overall average annual flow volume to the Muskoka River, Sage Creek, SC-3 and SC-6 during proposed operational (Scenario 2) and rehabilitation (Scenario 3) phases are not expected to significantly change flows and water levels. For MR-North, the incremental surface flow will be managed in the quarry water management system during operational conditions. Actual rates of discharge to MR-North will be subject to review and approval under a future ECA to be obtained from the MECP. Based on calculations and visual observations in the field, it is expected that there will be no change to the form or function of the receiving features in comparison to current conditions, except where approved by relevant legislation as part of ongoing development of the existing licensed area or proposed Extension Lands.

10.2.3 Water Quality

Water quality results at the monitoring locations have typically met the PWQO, with the exception of a few parameters (i.e., aluminum, iron and pH) which are found to generally exceed guidelines in all parts of the system, unaffected by the current operations. Based on a review of the water quality data, negative impacts in the downstream receiving watercourse associated with discharge from the quarry are not anticipated.

For areas within Zone B (i.e., sloped towards Sage Creek), which will not be reporting to the quarry sump, additional controls will be put in place where appropriate to ensure water quality is suitable prior to discharge to environment. These controls will include treatment for total suspend solids and will be designed and applied for approval under relevant legislation (e.g., the *Ontario Water Resources Act*) prior to commencing extraction.

10.2.4 Flooding

While the site is operational, the areas associated with Zone A of the existing Childs Pit/Quarry and Extension Lands will act as a large extended detention pond during storms due to the collection of water in the sump and the lower pump rate from the sump, which will affect areas draining to the Muskoka River. For the portion of the site that is sloped to drain to Sage Creek by gravity (Zone B), additional controls will be put in place, where appropriate, to ensure appropriate control of peak flows during storm events. These controls will be designed and applied for approval under relevant legislation (e.g., the *Ontario Water Resources Act*) prior to commencing extraction.

During rehabilitation, the outlet from the flooded quarry will serve to reduce storm flows associated with Zone A of the development. Peak flows are expected to approximate pre-development conditions following rehabilitation in Zone B given the vegetated cover and engineered slopes built during operations. In addition, some of the water management features built during operations may be left in place as part of the rehabilitation phase and subject to the approvals under relevant legislation (e.g., the *Ontario Water Resources Act*).

In conclusion, flooding issues within the receiving watercourses are not anticipated given the integrated mitigation considered by Fowler during the operational and rehabilitation phases.

10.2.5 Stream Erosion

Operation of the existing Childs Pit/Quarry and Extension Lands are not expected to contribute to erosion problems in the receiving watercourses because detention of drainage in the quarry sump and controlled pumped discharge rates will be used to manage peak flows associated with storm events. The operation of a quarry typically reduces downstream erosion potential due to attenuation of large storm flows within the quarry and resultant downstream decreased peak flows. For the portion of the site that is sloped towards Sage Creek (Zone B), additional controls will be put in place, where appropriate to manage discharge and minimize the risk of un-natural stream erosion in the receiving environment.

10.2.6 Summary

The quarry development at the site and subsequent rehabilitation have the potential to affect the identified receptors mainly via land use changes, surface water drainage alterations and the quarry water management (e.g., quarry dewatering). Active quarry water management, stormwater management controls and Best Management Practices (BMP) in compliance with the required regulations and directives (e.g., the Ontario Water Resources Act), and a robust monitoring program will minimize adverse effects of the proposed Extension Lands on the key surface water receptors evaluated as part of this assessment.

11.0 COMPLAINTS RESPONSE PROGRAM

Based on the results of the groundwater modelling and the review of local water supply wells, it is concluded that water well interference complaints attributable to the development of the existing Childs Pit/Quarry or the Extension Lands are unlikely. Water well interference complaints will be responded to considering the collected monitoring data and under the *Complaints Response Program* described below.

A comprehensive complaints response program has been developed for the purpose of responding to well interference complaints from local water supply well users. Each complaint will be dealt with on a case-by-case basis. When a complaint is received by Fowler, a representative of Fowler or their agent will visit the site to make an initial assessment within three days of receiving the complaint. This will include a well/system inspection (where accessible) by a licensed pump maintenance contractor to determine the groundwater level, pump depth setting and condition of the well system. The available groundwater level data from the existing on-site monitoring well network will be reviewed by a licensed professional hydrogeologist/engineer to develop an estimate of the potential groundwater level drawdown at the potentially affected well that is the subject of the complaint response. The information obtained by the contractor from the well/well system inspection and the review of the available groundwater level data will be used by the professional hydrogeologist/engineer to prepare an opinion on the likelihood that the well interference complaint is attributable to quarry dewatering.

If it is concluded that the well interference complaint is most likely attributable to quarry dewatering activities at the site and the water supply is at risk, then a temporary supply will immediately be arranged and a water supply restoration program will be implemented. The decision as to whether to proceed with the water supply restoration program will be based on a review of groundwater level information by the professional hydrogeologist/engineer and well construction and performance information from the licensed pump maintenance contractor as noted above.

The water supply restoration program consists of the following measures which are applicable for local water supply wells where the operation of the water supply wells may have been compromised by quarry excavation or, based on the analysis of all monitoring data, are assessed to likely be compromised in the near future:

- Well System Rehabilitation – The well system could be rehabilitated by replacement or lowering of pumps, pump lines flushing, well deepening, etc. to improve performance. Where water is unavailable in the shallow bedrock and a well in deeper bedrock is being considered, a water sample(s) would be taken from the existing well for chemical, physical and bacteriological analyses prior to deepening the well to provide a basis of comparison. If the groundwater in the deeper bedrock is found to be of acceptable quality by the homeowner, either directly from the well or with treatment, it will be developed as the domestic supply. Any modifications to a well would be conducted in accordance with *Ontario Regulation 903*.
- Well Replacement or Additional Well(s) – The well could be replaced or augmented with a new well(s) that could be located further from the quarry excavation. The feasibility of well replacement would be based on a test drilling program that could include more than one test well. Where water is unavailable in the shallow bedrock and a well in deeper bedrock (compared to the original water supply well) is being considered, a water sample(s) would be taken from the existing well for chemical, physical and bacteriological analyses to provide a basis of comparison. If the groundwater in the deeper bedrock is found to be of acceptable quality by the homeowner, either directly from the well or with treatment, it will be developed as the domestic supply. Construction of a new well(s) would be conducted in accordance with *Ontario Regulation 903*.
- Trickle Wells and Storage – Where feasible, the existing well(s) could be converted to a low yield pumping system, or installation of an additional well(s), along with non-pressurized water storage to augment water supplies, if required.
- Water Treatment Considerations – Appropriate water treatment will be incorporated into any restored water supply as discussed above.

Fowler would be responsible for all costs associated with the water supply restoration program. It is important to note that water supply restoration activities undertaken to address an adverse effect would be done so in consultation with the affected property owner in order to ensure a mutually agreeable solution is implemented.

12.0 MONITORING PROGRAMS

Site-specific groundwater and surface water monitoring recommendations have been developed to measure and evaluate the actual effects on potential receptors associated with long-term development of the existing Childs Pit/Quarry and/or the Extension Lands, and to allow for a comparison of the actual effects measured during the monitoring program and those predicted as part of the impact assessment provided Section 10. The groundwater and surface water monitoring programs are discussed in the following sections.

Ecological monitoring recommendations are presented in the Level 1 and Level 2 Natural Environment Report (RiverStone, 2020).

If the results of the monitoring program indicate the potential for adverse impact to groundwater users or surface water features, then appropriate enhanced monitoring and/or mitigative actions would be developed.

12.1 Proposed Groundwater Level Monitoring Program

The proposed groundwater level monitoring program would include existing on-site monitoring wells, as well as a new monitoring well location.

12.1.1 Existing Monitoring Wells

The existing on-site monitoring wells to be included in the monthly groundwater level monitoring program are listed below:

- DDH15-1A and DDH15-1B
- DDH15-2A and DDH15-2B
- DDH15-3A and DDH15-3B
- BH18-4A, BH18-4B and BH18-4C
- TW12-1

The locations of the above existing monitoring wells are shown on Figure 10. Based on the locations of BH18-4 and TW12-1, these wells will be removed as part of quarry operations. These monitoring locations would not be replaced. The remaining existing monitoring well locations are not within the proposed extraction areas at the site. These wells would be replaced if damaged during site development.

12.1.2 Proposed Monitoring Well

Table 23 includes a description of the additional monitoring well location proposed for inclusion in the groundwater level monitoring program as well as the rationale for inclusion and timing for well installation. The proposed monitoring well location is shown on Figure 10.

Table 23: Proposed Groundwater Monitoring Well

Location	Description of Installation	Rationale for Inclusion and Timing for Installation
1	Multilevel monitoring wells located within the eastern setback of the existing Childs Pit/Quarry. Monitoring wells to be installed in the shallow bedrock (above 303 m ASL) and deeper bedrock.	Long-term monitoring location to assess changes in groundwater levels in the bedrock between the site and private wells located along Bonnie Lake Road. This location would be installed prior to extraction below the water table within the existing Childs Pit/Quarry.

Once proposed monitoring well location 1 is installed, there will be adequate coverage around the perimeter of the site providing an opportunity to gather groundwater level data between the on-site excavation and the surrounding water supply wells during operations. The frequency for measuring groundwater levels and reviewing the collected data would be established as part of the Permit to Take Water (PTTW) application for site dewatering.

The groundwater level monitoring data would be used to assess groundwater level drawdown in bedrock in response to progressive quarry development and would be compared to the drawdown predicted by the groundwater flow model. The groundwater level monitoring program would be reassessed on an on-going basis to determine if changes to the monitoring program should be considered.

12.2 Proposed Surface Water Monitoring Program

12.2.1 Operational Period

12.2.1.1 Existing Monitoring Surface Water Stations

Based on the assessment reported on herein, we do not expect adverse effects on the surrounding surface water features; however, this monitoring program is designed to identify any potential effects early enough to allow for mitigative actions. Table 24 includes a description of the monitoring locations proposed for inclusion in the surface water monitoring program as well as the rationale for inclusion. The locations of the proposed monitoring locations are shown on Figure 9.

Table 24: Proposed Surface Water Monitoring Stations

Location	Description of Installation	Rational for Inclusion
Muskoka River Tributary	Surface water monitoring station located in MR-North, immediately upstream from the discharge to Muskoka River (corresponding with AP-1). Monitoring station to be installed in the watercourse.	Long-term monitoring location to assess changes in surface water level and flows in Muskoka River tributary MR-North.
Sage Creek	Surface water monitoring station located in Sage Creek immediately upstream from discharge to Muskoka River (corresponding with AP-2). Monitoring station to be installed in the watercourse.	Long-term monitoring location to assess changes in surface water level and flows in Sage Creek.
SC-3	Surface water monitoring station located in Sage Creek tributary SC-3, at the property boundary. Monitoring station to be installed in the watercourse.	Long-term monitoring location to assess changes in surface water level and flows in Sage Creek tributary SC-3.
SC-6	Surface water monitoring station located in Sage Creek tributary SC-6, at the property boundary. Monitoring station to be installed in the watercourse.	Long-term monitoring location to assess changes in surface water level and flows in Sage Creek tributary SC-6.

The monitoring program would consist of staff gauge stations and data loggers during ice-free conditions at each of the aforementioned monitoring stations.

12.2.2 Monitoring Frequency and Data Review

Monitor the quarry discharge as well as flows and water levels at the stations identified above. Surface water levels will be measured at the monitoring locations every hour using data loggers. Flows and water levels will be manually measured in-situ on a monthly basis during the ice-free period. Potential mitigation options, if required, may include changes in the pumping schedule to the extent feasible.

12.3 Instruments Prescribing Monitoring Program

Prior to the start of water taking and/or water discharge at the existing Childs Pit/Quarry and/or the Extension Lands, a PTTW and an Environmental Compliance Approval for Industrial Sewage Work (ECA) would be obtained for the site. The applications for the PTTW and ECA would include the appropriate portions of the proposed monitoring programs described above. Because the PTTW and ECA for the site will address water taking and discharge from the existing Childs Pit/Quarry and the Extension Lands, it makes sense to have the applicable components of the monitoring program (groundwater level monitoring, surface water monitoring and ecological monitoring) prescribed under these instruments, as opposed to having different portions of the monitoring program included on the separate quarry licenses.

13.0 SUMMARY AND CONCLUSIONS

Fowler is applying for a Category 1, Class A license (Pit Below Water) and a Category 2, Class A license (Quarry Below Water) under the ARA, and a Town of Bracebridge Zoning By-law Amendment under the *Planning Act* to permit an extension to their existing Childs Pit/Quarry operation (Extension Lands). The proposed Extension Lands are located directly to the south of the existing licensed area. The area proposed to be licensed under the *ARA* is 163.1 ha and the proposed extraction area is 143.2 ha. The licensing of the Extension Lands would also include a setback reduction along the common boundaries with the existing licensed area. This setback reduction covers an area of 1.3 ha. The proposed final quarry floor base elevation for the Extension Lands is variable and ranges between 270 m ASL and 320 m ASL.

The existing licensed area and area of extraction under the current MNRF license for the Childs Pit/Quarry are 234.7 ha and 202.0 ha, respectively. The existing Childs Pit/Quarry is currently licensed to be operated in a series of phases and lifts with final approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). These approved final floor elevations for the existing Childs Pit/Quarry are substantially lower than the lowest proposed floor elevation for the Extension Lands which has been established at a minimum (lowest) floor elevation of 270 m ASL.

Given that Fowler proposes to operate both the existing Childs Pit/Quarry and the Extension Lands simultaneously in a phased approach with consistent floor elevations between the two properties, the impact assessment presented in this report does not consider full extraction on the existing Childs Pit/Quarry property down to the currently approved floor elevations of 190 m ASL (west of Hydro easement) and 195 m ASL (east of Hydro easement). The impact assessment presented in this report considers **interim quarry floor elevations** for the existing Childs Pit/Quarry which are similar to the proposed **final floor elevations** for the Extension Lands.

Based on published mapping, the vast majority of the existing Childs Pit/Quarry property is underlain by thick ice-contact stratified deposits. Along the eastern limits of the existing Childs Pit/Quarry property, the area is underlain by shallow or exposed bedrock. The Extension Lands are characterized by the presence of shallow or exposed bedrock with limited overburden cover. Within the study area, the bedrock surface is uneven, which can result in localized thicker deposits of overburden in the troughs between bedrock highs. The overburden thickness at the on-site boreholes varies between 0.15 m and over 30.2 m.

Based on published mapping and field observations, the majority of the existing Childs Pit/Quarry property drains to the Muskoka River overland and/or via two un-named tributaries which flow nominally northwest. Under baseline conditions, part of the area within the Extension Lands drains to Sage Creek via several small intermittent drainage features and one small perennial tributary, which flow nominally southward, while the remainder of the extension lands drain north onto the existing quarry license. During operation, the northern part of the area within the Extension Lands will drain to the Muskoka River (i.e., Phase A) with the remainder continuing to drain to Sage Creek (i.e., Phase B).

Based on drilling completed at the site, the upper bedrock unit is a grey gneiss. The bedrock at the site has minimal primary porosities (i.e., natural volume of void space), and primary permeability close to zero. Groundwater flow within such bedrock is through secondary porosity from fractures that have developed. Based on bedrock core logged as part of the current investigation, there was slightly more weathering observed in the upper portion of the bedrock at two of the three cored boreholes.

The measured hydraulic conductivity in the bedrock at the site varies between 8×10^{-12} m/s and 4×10^{-7} m/s and the geometric mean was estimated to be 1×10^{-8} m/s. Based on a review of the available data, hydraulic conductivity at the site is not correlated with elevation. Overall, the bedrock is interpreted to be massive, with no preferred fracture direction.

Based on available water level data, the water table at the site is interpreted to be within the shallow bedrock between 1 m to 4 m below the bedrock surface. During wet portions of the year, because of the significant contrast in hydraulic conductivity between the overburden deposits and the underlying bedrock, it is expected that water would be found at the overburden/bedrock interface (i.e., perched on top of the lower hydraulic conductivity bedrock). The measured hydraulic gradients in the vicinity of the site are typically downward (i.e., recharging conditions). Local surface water features and seasonally wet areas in the vicinity of the site are not interpreted to be supported by significant groundwater discharge. For the site conceptual model, the local water features are interpreted to be primarily surface water fed with limited groundwater input.

The wells in the vicinity of the site primarily service the residential development to the east of the site located along Bonnie Lake Road. Based on the results of the groundwater modelling and the review of local water supply wells, it is concluded that interference with water supply wells as a result of the proposed full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands (final floor elevations) is not predicted. An additional monitoring well location is being proposed between the existing Childs Pit/Quarry and the water supply wells located on Bonnie Lake Road. The proposed groundwater level monitoring program will permit the collection of long-term groundwater level data as the existing Childs Pit/Quarry and Extension Lands develop. These data will show the actual changes in groundwater levels within the monitoring wells completed around the extraction areas as the quarry expands laterally and vertically and can be used to further assess the propagation of the drawdown cone. In the unlikely event that complaints are received regarding interference to water wells in the vicinity of the site, the complaints response plan would be implemented.

Watercourses within the existing Childs Pit/Quarry property and Extension Lands were identified based on published mapping, field observations and surveys completed by Riverstone. Some of these watercourses were classified as key surface water receptors (i.e., MR-North, SC-3 and SC-6) because of their potential to be changed as a result of the development of the Extension Lands and/or their environmental relevance and changes to the water balance were evaluated in detail. Other watercourses identified within the existing Childs Pit/Quarry property and Extension Lands, which were not classified as key surface water receivers (i.e., MR-South, SC-3B and SC-4) were evaluated at the catchment level.

The existing Childs Pit/Quarry and Extension Lands are located within two catchment areas (i.e., Sage Creek and Muskoka River). During operations, water will be managed to minimize potential changes to the water balance as part of Fowler's integrated mitigation approach. The vast majority of areas currently draining to the Muskoka River, will be controlled by a quarry sump and will remain draining to the Muskoka River. The vast majority of areas currently draining to Sage Creek, will remain sloped towards Sage Creek rather than reporting to the quarry sump and additional controls will be put in place to ensure water quality is suitable prior to discharge to environment.

Based on the results of the water balance analysis, drainage patterns will not be significantly affected as a result of the proposed full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands (final floor elevations); runoff will continue to drain towards these features during operations. Only the drainage pattern of MR-North will be affected under the rehabilitation phase as water will be directed to the Muskoka River via the rehabilitated existing quarry licensed area, rather than contributing to this feature as it occurs during existing and operational conditions. MR-North ultimately contributes to the Muskoka River under approved existing conditions and therefore, the loss of drainage experienced by MR-North will cause local effects at the feature level but is not expected to affect the Muskoka River hydrology.

Based on the results of the water balance analysis, the estimated changes in overall average annual flow volume to the Muskoka River, Sage Creek, SC-3 and SC-6 during proposed operational and rehabilitation phases are not expected to significantly change flows and water levels. For MR-North, the incremental surface flow will be managed in the quarry water management system during operational conditions. Based on calculations and visual observations in the field, it is expected that there will be no change to the form or function of the receiving features in comparison to current conditions, except where approved by relevant legislation as part of ongoing development of the existing licensed area or proposed extension.

Based on the results of the water quality monitoring program, water quality in the system generally meets the Provincial Water Quality Objectives (PWQO), with the exception of a few parameters (i.e., aluminum, iron and pH) which are found to generally exceed guidelines in all parts of the system under existing conditions. Based on a review of the water quality data, negative impacts in the downstream receiving watercourse associated with discharge from the quarry are not anticipated as the exceedances are consistent with natural conditions in the area and are not related to the existing extraction operations. In addition, detention times at the quarry sump and additional control measures applied to areas which do not report to the quarry sump (i.e., areas within Zone B sloped towards Sage Creek) will ensure water quality is suitable prior to discharge to environment.

Operations associated with the proposed full development of the existing Childs Pit/Quarry (interim floor elevations) and the Extension Lands (final floor elevations) are not expected to contribute to erosion and/or flooding problems in the receiving watercourses because detention of drainage in the quarry sump and controlled pumped discharge rates will be used to manage peak flows associated with storm events. For the portion of the site that is sloped towards Sage Creek (Zone B), additional controls will be put in place, where appropriate to manage discharge and minimize the risk of un-natural stream erosion in the receiving environment.

Overall, based on the results of this hydrogeological and hydrological investigation for the Extension Lands, the proposed additional quarry development will protect sensitive surface water and sensitive groundwater receptors during the operational period and under rehabilitated conditions.

14.0 RECOMMENDATIONS

Based on the results of the hydrogeological and hydrological assessments of the existing Childs Pit/Quarry and the Extension Lands, the following recommendations are provided for inclusion on the site plans:

a) Prior to the start of water taking and/or water discharge at the existing Childs Pit/Quarry and/or the Extension Lands, a Permit to Take Water (PTTW) and an Environmental Compliance Approval for Industrial Sewage Work (ECA) shall be obtained and the Licensee is required to operate in compliance with these approval instruments, including the associated monitoring and reporting. The proposed groundwater and surface water monitoring programs in Sections 12.2 and 12.2, respectively, shall be considered for inclusion in these instruments.

b) The Licensee shall implement the Complaints Response Program, outlined in Section 11.0, in the event of a water well interference complaint.

15.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of Fowler Construction Company Limited. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the property at the time of the work. Any use which a third party makes of this report, or any reliance on, or decisions to be made based of it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements or inaccuracies contained in the reports as a result of omissions, misinterpretation or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The assessment of environmental conditions and possible hazards at this site has been made using the results of physical measurements from a number of locations. The site conditions between testing locations have been inferred based on conditions observed at the testing locations. Actual conditions may deviate from the inferred values.

The groundwater level lowering, and groundwater inflow/seepage estimates developed from the groundwater model described in this report are considered to represent reasonable "theoretical" estimates based on the available data. There is uncertainty inherently associated with the (subsequent) forecasts by the groundwater model, stemming from limitations in the available subsurface information and can be related to variability in the bedrock properties (e.g., hydraulic conductivity, porosity, etc.) or uncertainties with the conceptual model (e.g., groundwater-surface water interactions, location of flow boundaries, recharge rates, continuity in aquitards, direction of regional groundwater flow, etc.). It is the intention of Golder Associates Ltd. that the model results be used as a screening tool to predict groundwater inflow/seepage rates and groundwater level lowering for the purposes of this license application process, and not for any other purposes.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

16.0 CLOSURE

We trust the information presented in this report meets your requirements. Should you have any questions or concerns, please contact the undersigned.

Golder Associates Ltd.

Kevin MacKenzie, M.Sc., P.Eng.
Water Resources Engineer/Principal

Kris Marentette, M.Sc., P.Geo.
Senior Hydrogeologist, Principal

Prepared by:

Marta Lopez-Egea, Water Resources Specialist
Nicholas Bishop, Geological Engineer/Groundwater Modeller
Jaime Oxtobee, Hydrogeologist/Associate
Kevin MacKenzie, Water Resources Engineer/Principal
Kris Marentette, Hydrogeologist/Principal

JPAO/ML/NB/KMM/KAM/sg
https://golderassociates.sharepoint.com/sites/26644g/deliverables/hydrogeology reporting/1895639-r-rev 0 - childs pit_quarry hydrogeological and hydrological assessments.docx

17.0 REFERENCES

Anderson, M.P., and W.W. Woessner, 1992. Applied Groundwater Modelling: Simulation of Flow and Advective Transport. Academic Press Inc. San Diego.

Chapman, L.J. and Putnam, D.F., 1984. Physiography of the Southern Ontario, 3rd Edition. Ontario Geological Survey, Special Volume 2.

Diersch, H-J,. 2009. Finite Element Modeling of Flow, Mass and Heat Transport in Porous and Fractured Media. Springer-Verlag Berlin Heidelberg.

Freeze, R.A. and Cherry, J.A., 1979. *Groundwater*. Prentice–Hall Inc., Englewood Cliffs, 604 pp.

Golder Associates Ltd., 2016. Summary of Overburden Drilling Program, Fowler Construction Company Limited, Childs Pit/Quarry, Bracebridge, Ontario.

Harden Environmental Services Ltd., 2012. Draft Level 2 Hydrogeological Investigation, Childs Pit/Quarry Expansion, Bracebridge, Ontario.

Hazen, A., 1892. Some Physical Properties of Sands and Gravels, with Special References to Their Use in Filtration. 24th Annual Rep., Massachusetts State Board of Health, Pub. Doc. No. 34, 539-556.

Henson, B.L., Brodribb, K.E. and Riley, J.L., 2005. Great Lakes Conservation Blueprint for Terrestrial Biodiversity Volume 2: Ecodistrict Summaries, 344 pp.

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground-Water Observations, Bull. No. 36, *Waterways Exper. Sta. Corps of Engrs*, U.S. Army, Vicksburg, Mississippi, pp. 1-50

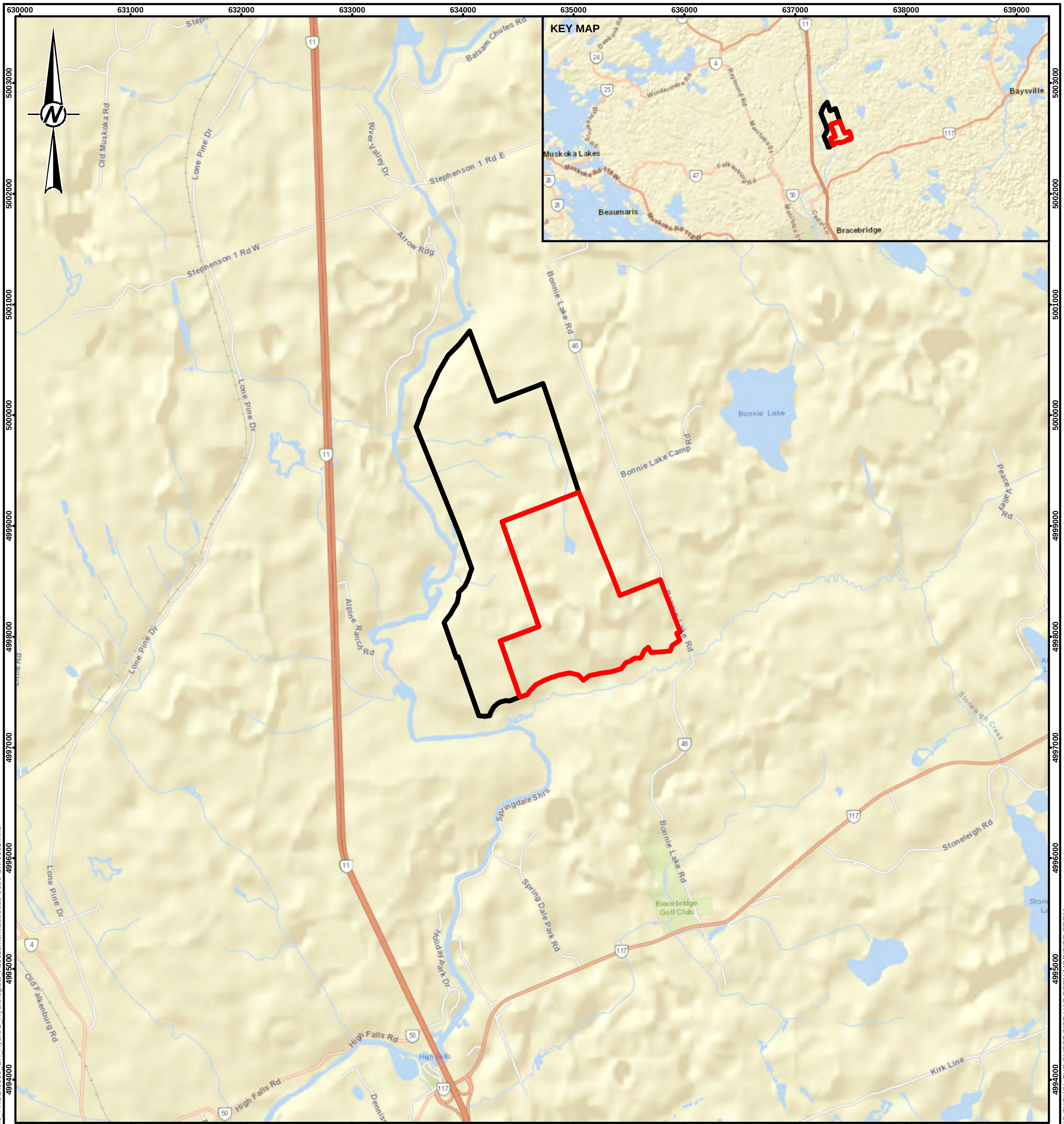
Ministry of Natural Resources and Forestry, 2015. South Central Ontario Orthophotography Project (SCOOP) 2013 Digital Elevation Model.

Ministry of Natural Resources and Forestry, Ontario Power Generation (OPG), Orillia Power Generation Corporation, Bracebridge Generation Ltd., Algonquin Power Fund (Canada) Inc., 2018. Final Plan Report - Muskoka River - Water Management Plan.

Ministry of the Environment (2003). Stormwater Management Planning and Design Manual.

Reid, R. and B. Bergsma., 1994. Natural History Evaluation of Muskoka – Final Report of the Muskoka Heritage Areas Program, Bracebridge: District of Muskoka, Ontario.

RiverStone, 2020. Natural Environment Level 1 & 2 Assessment, Childs Pit/Quarry, Town of Bracebridge, Fowler Construction Company Limited. June 2020.



LEGEND

PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY

EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY

0 500 1,000 2,000

1:50,000 METRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
KEY PLAN

CONSULTANT

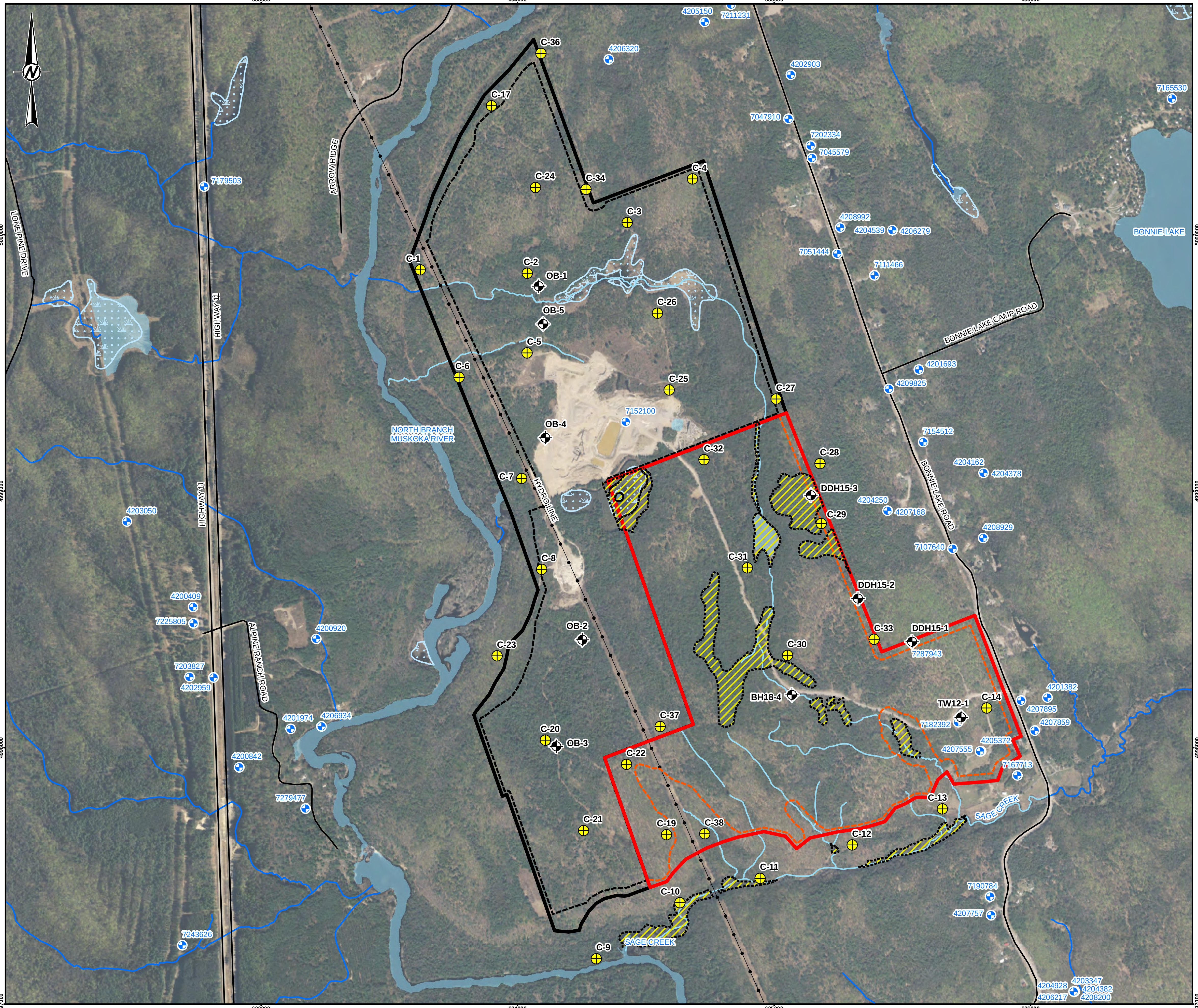
GOLDER

YYYY-MM-DD	2020-05-04
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

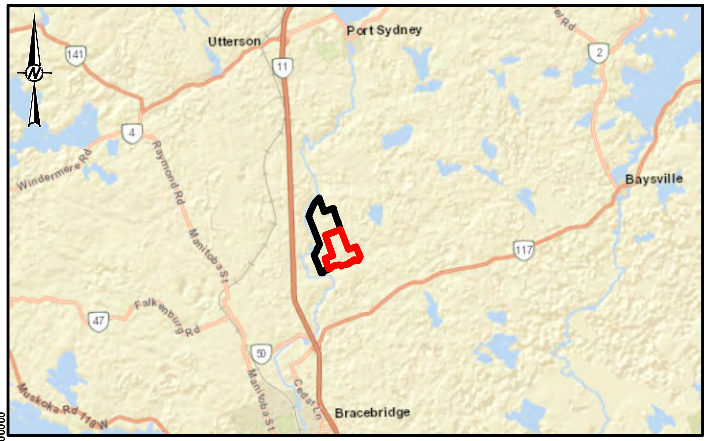
PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0009_CH_HydroG_Hydrological_Assessment\1895639-0009-CH-0001.mxd



KEY MAP



SCALE 1:350,000

LEGEND

- MONITORING WELL LOCATION
- CONE PROBE LOCATION
- WATER WELL LOCATION (AS PER MECP WWIS)
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- ROADWAY
- HYDRO LINE
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- WETLAND
- EXTENSION LANDS AND SAGE CREEK WETLAND FEATURES (AS MAPPED BY RIVERSTONE, 2020)
- WATERBODY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
4. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 150 300 600

1:15,000 METRES

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

SITE PLAN

CONSULTANT

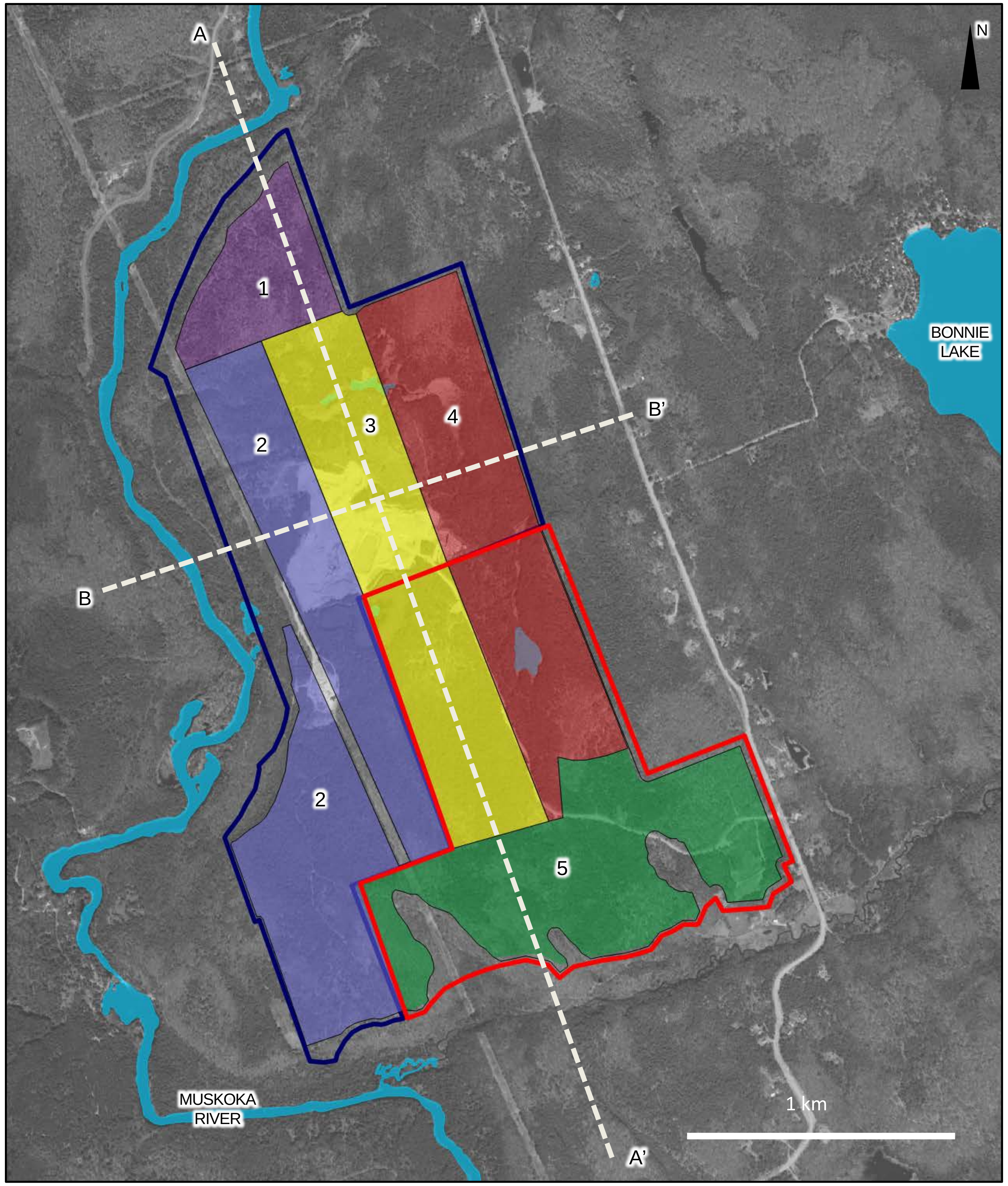
GOLDER

YYYY-MM-DD	2020-06-18
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

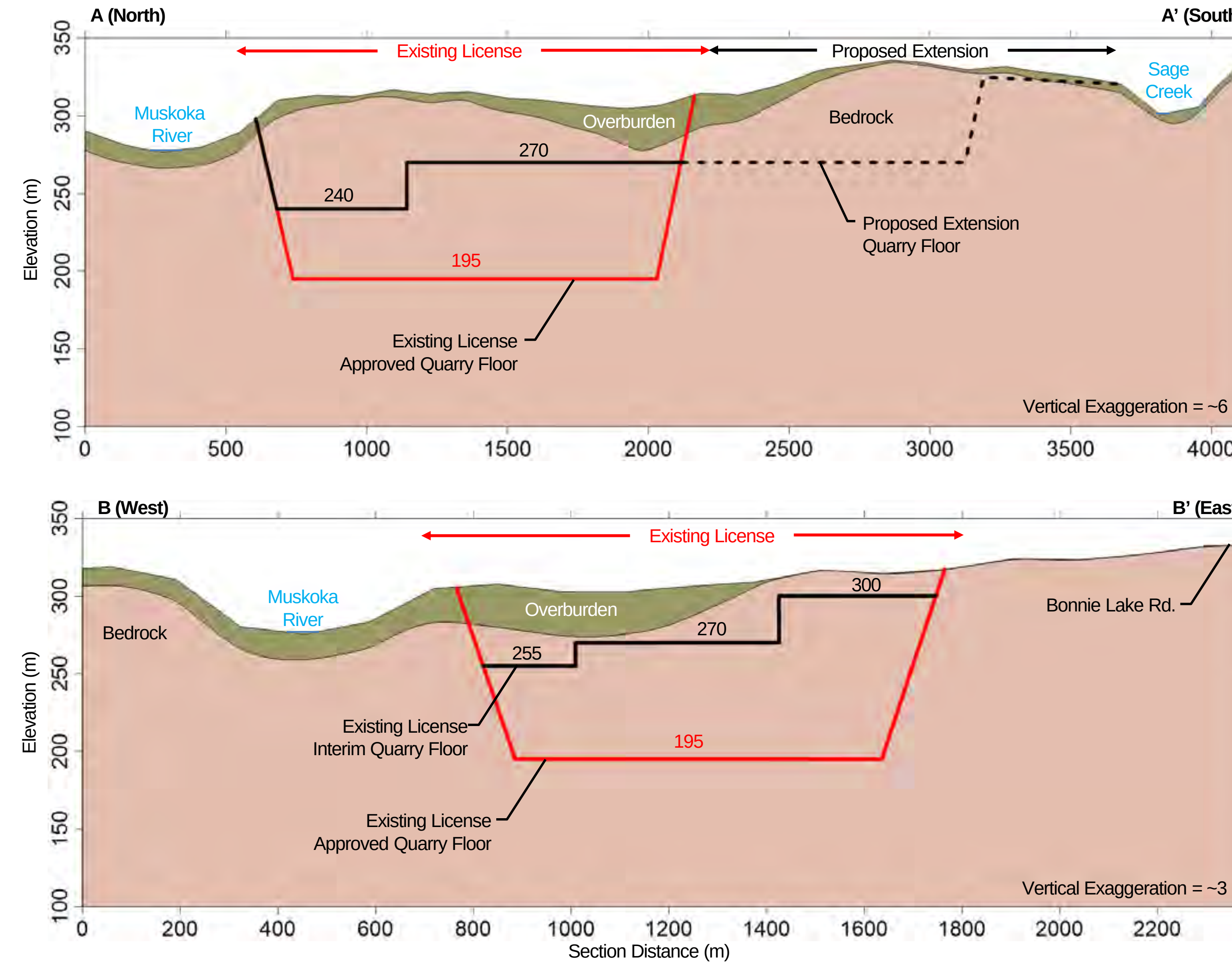
PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Plan View – Childs Pit/Quarry Licensed Areas and Quarry Floor Elevations Used in Impact Assessment



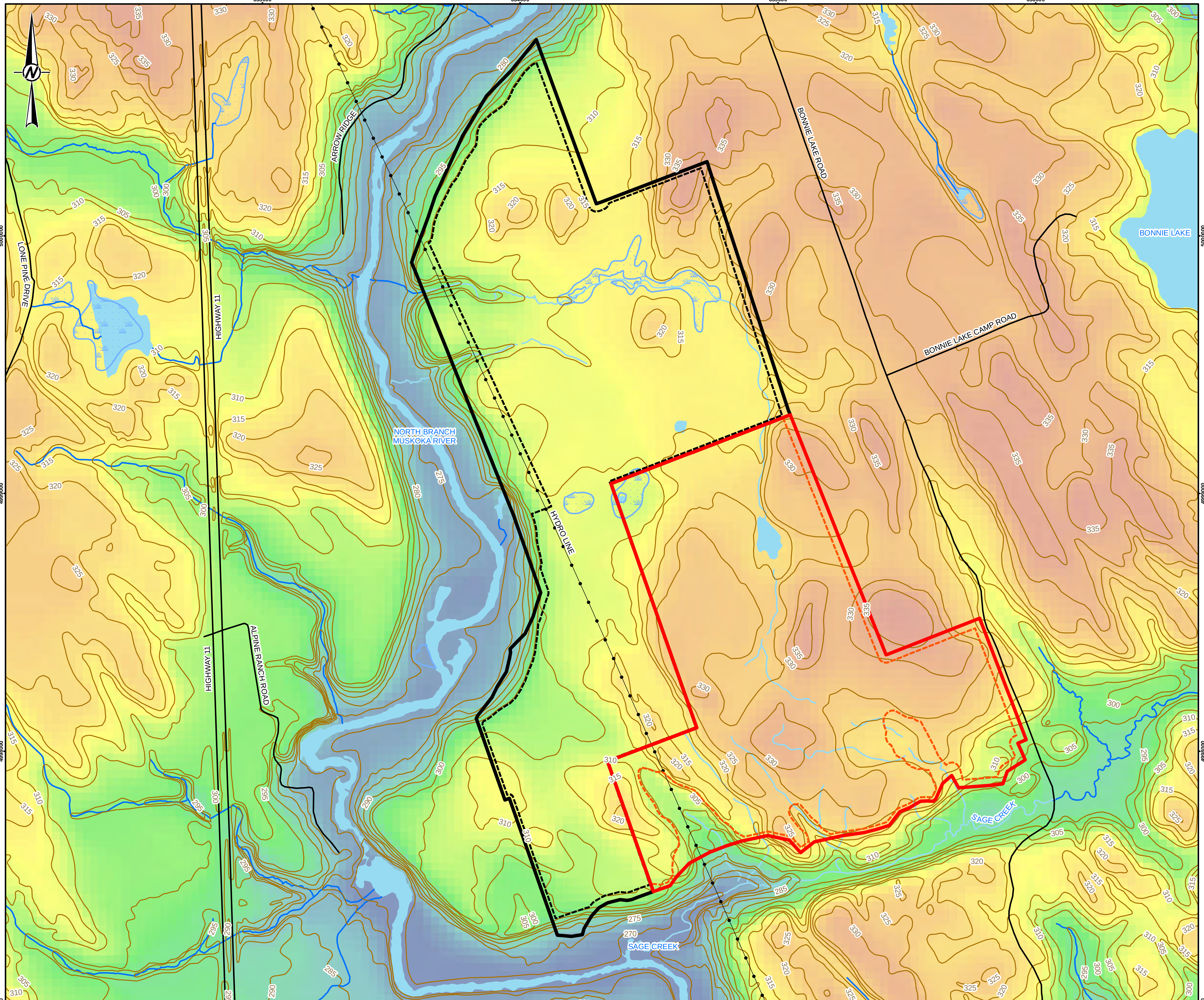
Cross-Sections



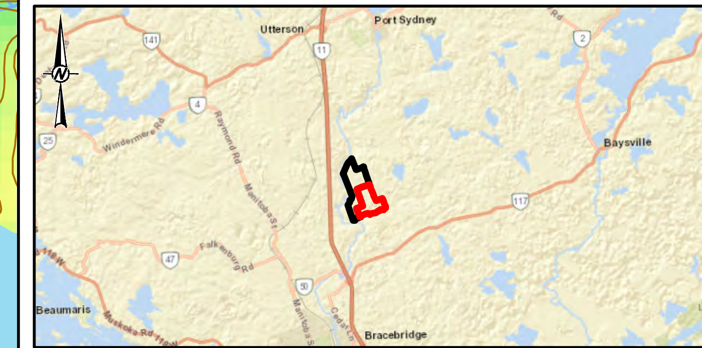
LEGEND (PLAN VIEW IMAGE)

- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Existing Childs Pit/Quarry Licensed Boundary
- 1 Area Extracted to Floor Elevation 240 m ASL
- 2 Area Extracted to Floor Elevation 255 m ASL
- 3 Area Extracted to Floor Elevation 270 m ASL
- 4 Area Extracted to Floor Elevation 300 m ASL
- 5 Area Extracted to Floor Elevation min. 310 m ASL

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED
PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM
TITLE	EXISTING CHILDS PIT/QUARRY AND EXTENSION LANDS DEVELOPMENT PLAN
PROJECT No.	1895639
CONTROL	0009
Rev.	A
FIGURE	3



KEY MAP



SCALE 1:425,000

LEGEND

- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- ROADWAY
- HYDRO LINE
- TOPOGRAPHIC CONTOUR, 5 METRES
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- WETLAND
- WATERBODY

ELEVATION (m)

High : 338 m

Low : 269 m

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
4. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 150 300 600

1:15,000 METRES

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

TOPOGRAPHY

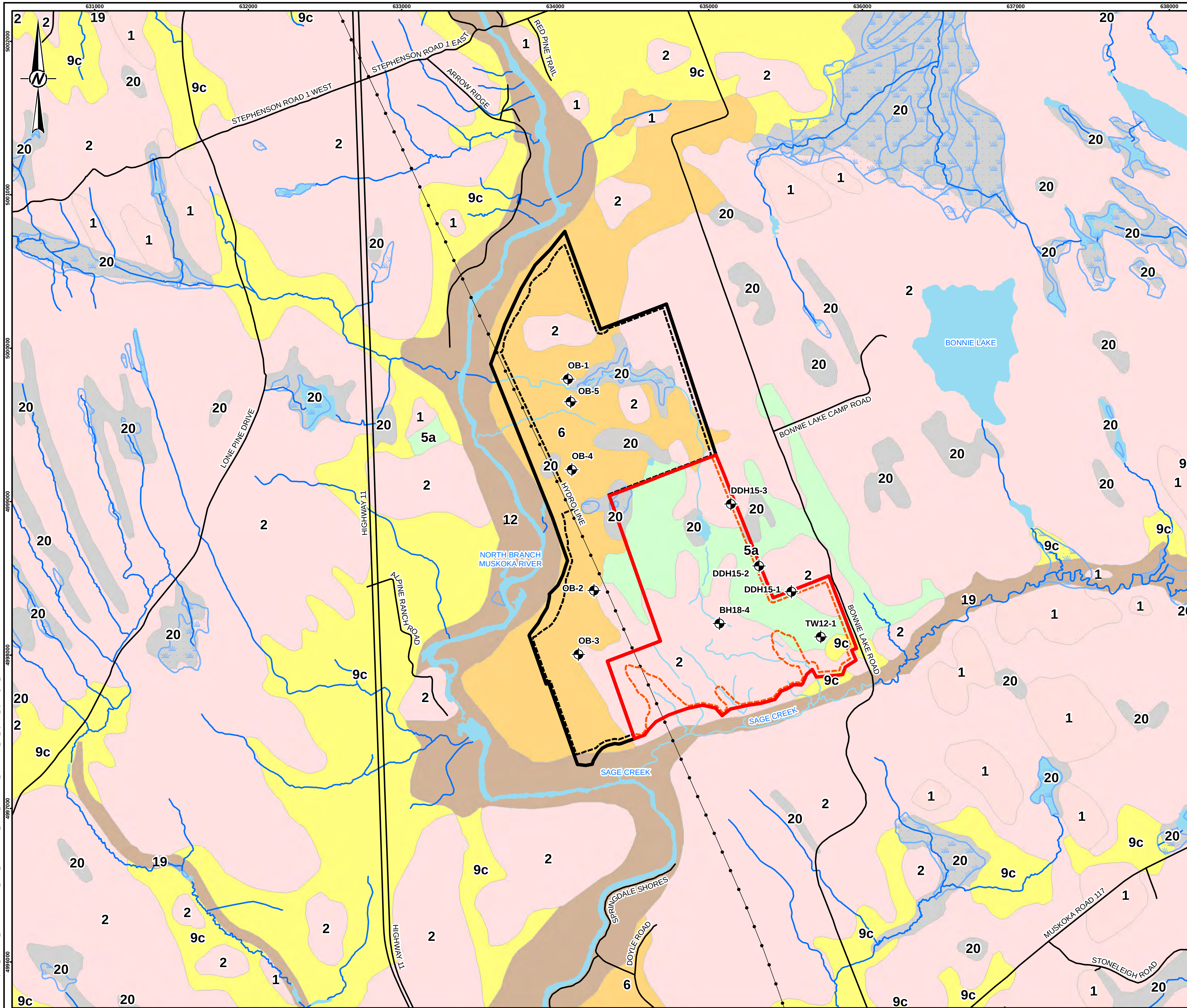
CONSULTANT

GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:



LEGEND

- MONITORING WELL LOCATION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- ROADWAY
- HYDRO LINE
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- WETLAND
- WATERBODY

OGS SURFICIAL GEOLOGY

1. **PRECAMBRIAN BEDROCK**
2. **BEDROCK-DRIFT COMPLEX IN PRECAMBRIAN TERRAIN:**

5a. **TILL:** SILTY SAND TO SAND-TEXTURED TILL ON PRECAMBRIAN TERRAIN

6. **ICE-CONTACT STRATIFIED DEPOSITS:** SAND AND GRAVEL MINOR, SILT, CLAY AND TILL

9c. **COARSE-TEXTURED GLACIOLACUSTRINE DEPOSITS:** SAND, GRAVEL, MINOR SILT AND CLAY; FORESHORE AND BASINAL DEPOSITS

12. **OLDER ALLUVIAL DEPOSITS:** CLAY, SILT, SAND, GRAVEL, MAY CONTAIN ORGANIC REMAINS

19. **MODERN ALLUVIAL DEPOSITS:** DAY, SILT, SAND, GRAVEL, MAY CONTAIN ORGANIC REMAINS

20. **ORGANIC DEPOSITS:** PEAT, MUCK, MARL

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV3.
2. SHAPFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
3. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 250 500 1,000
1:25,000 METRES

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

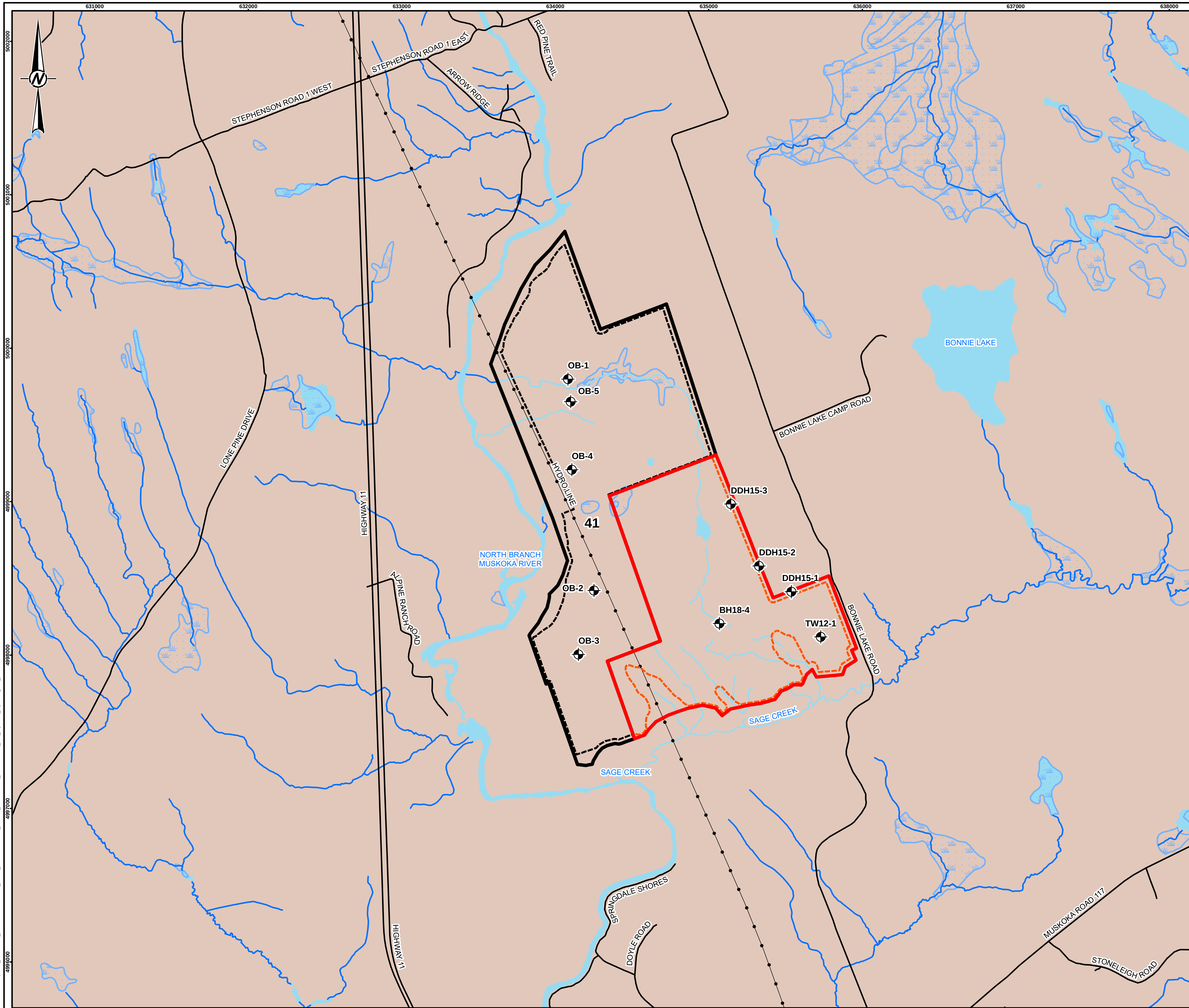
TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



LEGEND

- MONITORING WELL LOCATION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- ROADWAY
- HYDRO LINE
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- WETLAND
- WATERBODY
- 41 MIGMATITIC ROCKS AND GNEISSES OF UNCERTAIN PROTOLITH. COMMONLY LAYERED BIOTITE GNEISSES AND MIGMATITES; LOCALLY INCLUDES QUARTZOFELDSPATHIC GNEISSES, ORTHOGNEISSES, PARAGNEISSES.

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. ONTARIO GEOLOGICAL SURVEY 2011. 1:250 000 SCALE BEDROCK GEOLOGY OF ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE–DATA 126 - REVISION 1
2. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
3. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 250 500 1,000
1:25,000 METRES

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
BEDROCK GEOLOGY

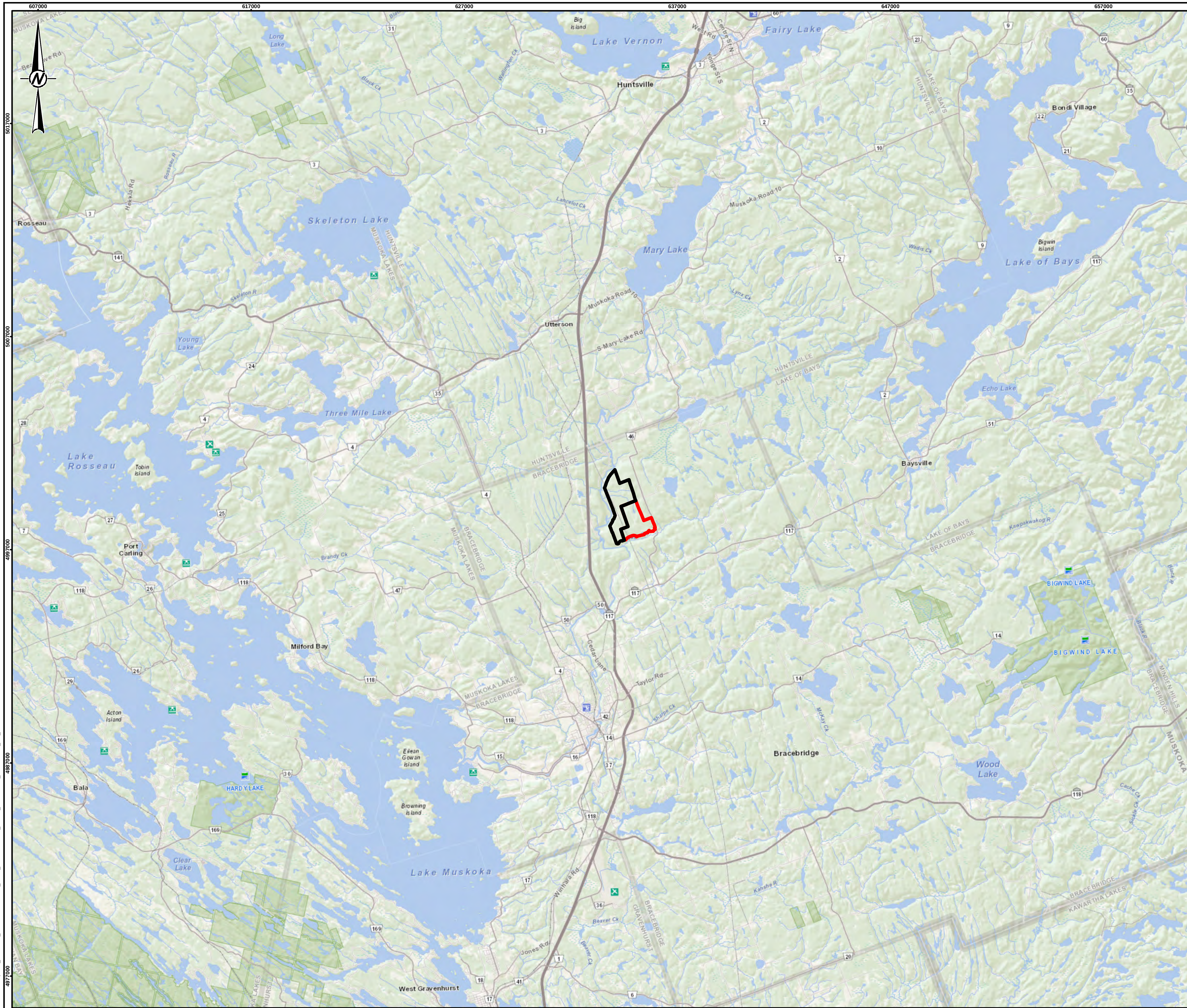
CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0009_CH_HydroG_Hydrological_Assessment\1895639-0009-CH-0006.mxd



LEGEND

EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY

PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
2. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 2,000 4,000 8,000

1:180,000 METRES

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

REGIONAL HYDROLOGY

CONSULTANT

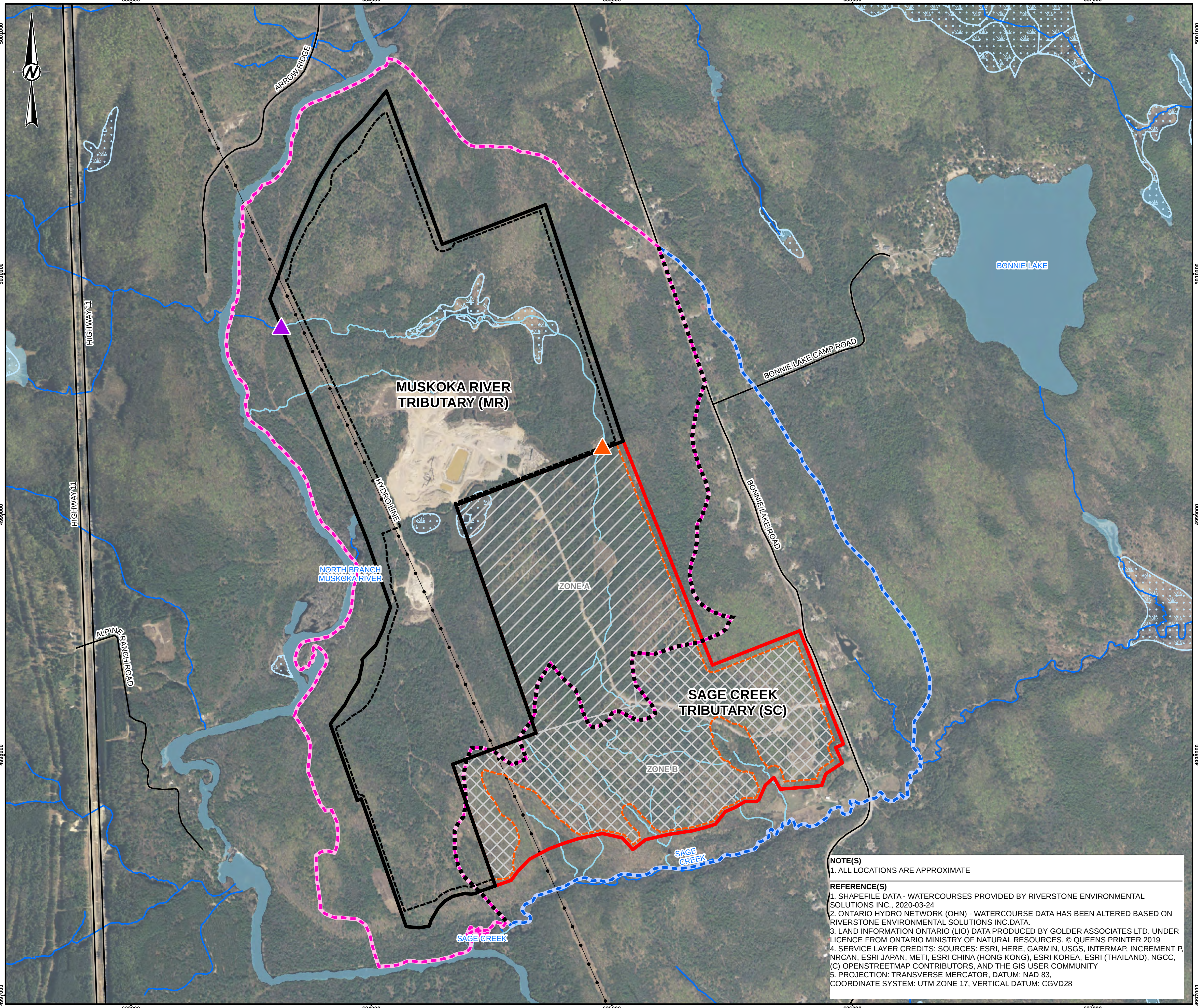
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

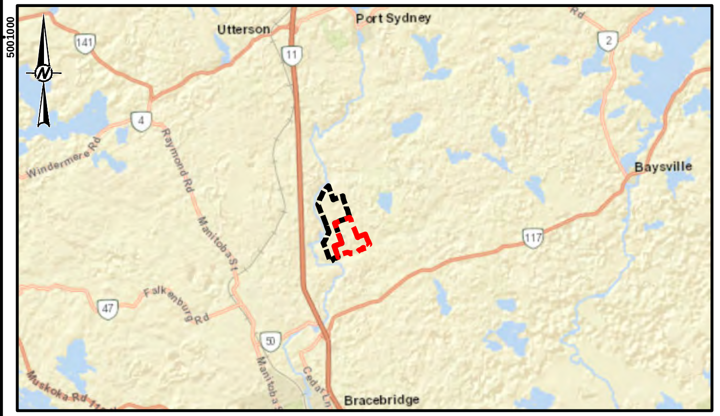
Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0008_CH_WaterBalance\1895639-0008-CH-0007.mxd



NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. SHAPEFILE DATA - WATERCOURSES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
4. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- QUARRY DRAINAGE POINT DURING OPERATIONS
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- ZONE A
- ZONE B
- ROADWAY
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- HYDRO LINE
- WETLAND
- OPEN WATER

0 150 300 600
1:16,000 METRES

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

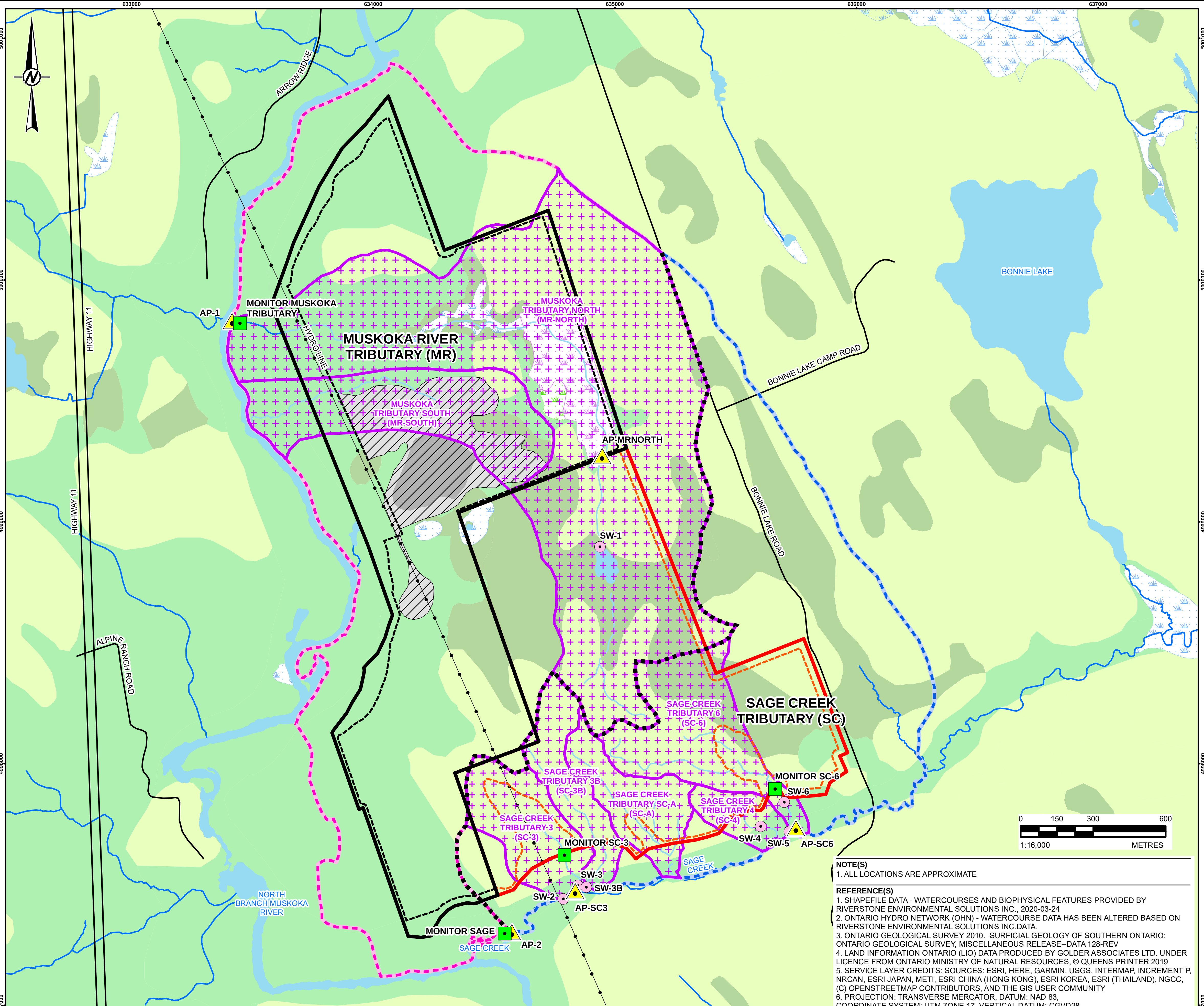
TITLE
CATCHMENT BOUNDARIES AND PROPOSED EXPANSION LANDS

CONSULTANT
GOLDER

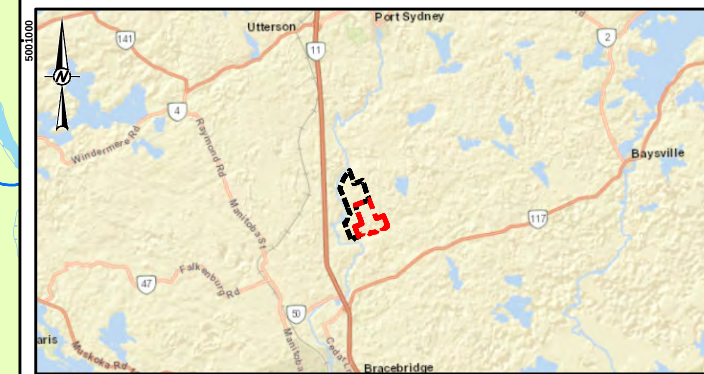
YYYY-MM-DD	2020-06-18
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	**8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0



KEY MAP



SCALE 1:380,000

LEGEND

- POINTS OF ASSESSMENT
- APPROXIMATE SURFACE WATER MONITORING STATIONS
- PROPOSED MONITORING LOCATIONS DURING OPERATIONS
- ROADWAY
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- HYDRO LINE
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- TRIBUTARY
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- Existing Childs Pit/Quarry License Boundary
- Existing Childs Pit/Quarry Limit of Extraction
- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Proposed Childs Pit/Quarry Extension Lands Limit of Extraction
- CURRENT PROCESSING AREA
- CURRENT SAND & GRAVEL PIT OPERATION

LAND USE

- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

BIOPHYSICAL FEATURES (RIVERSTONE, MARCH 24, 2020)

- G224: MINERAL RICH CONIFER SWAMP
- G134S: MINERAL THICKET SWAMP

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
EXISTING SURFACE WATER FEATURES, KEY SURFACE WATER RECEPTORS, ASSESSMENT POINTS (AP), AND SURFACE WATER MONITORING STATIONS

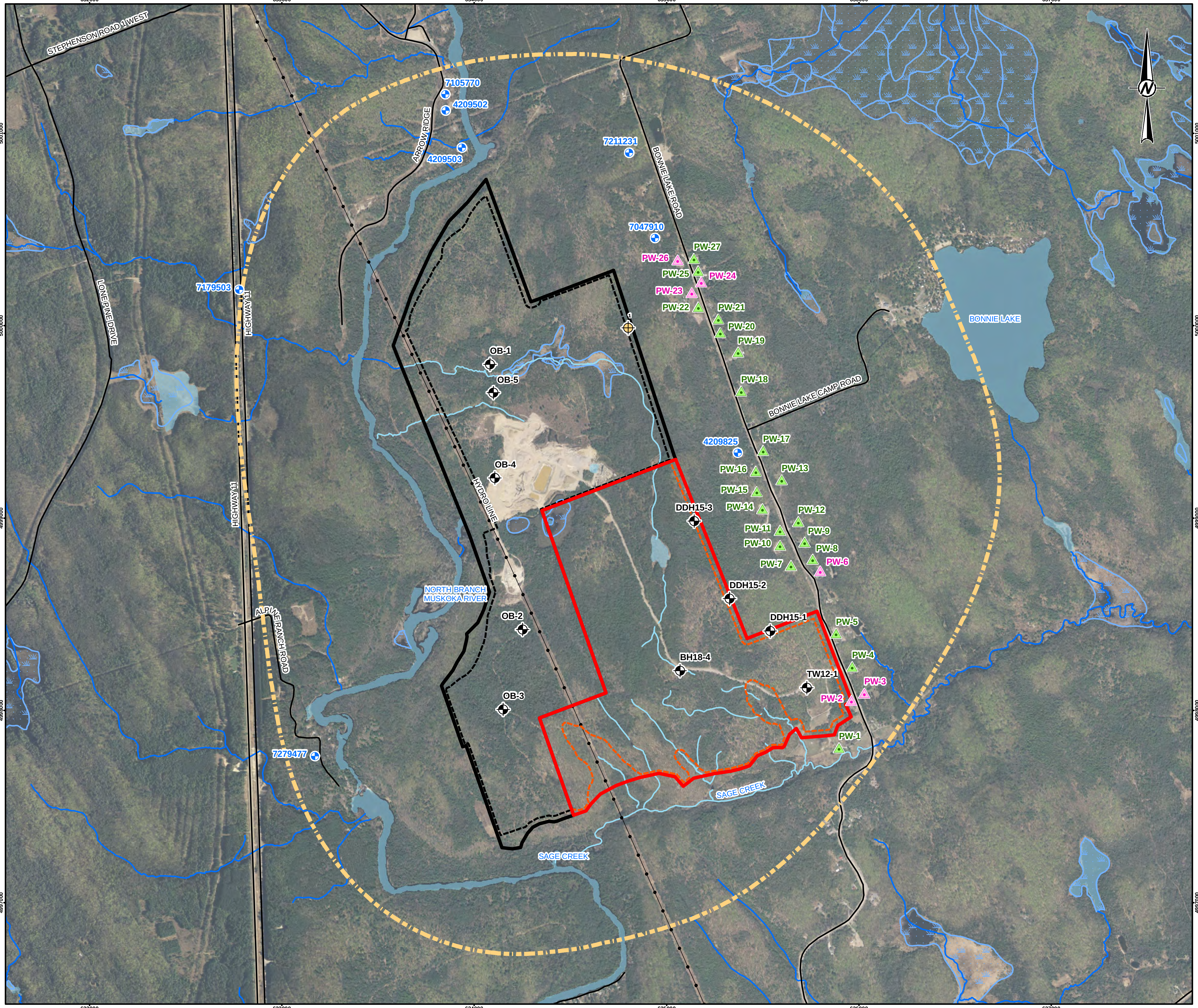
CONSULTANT

GOLDER

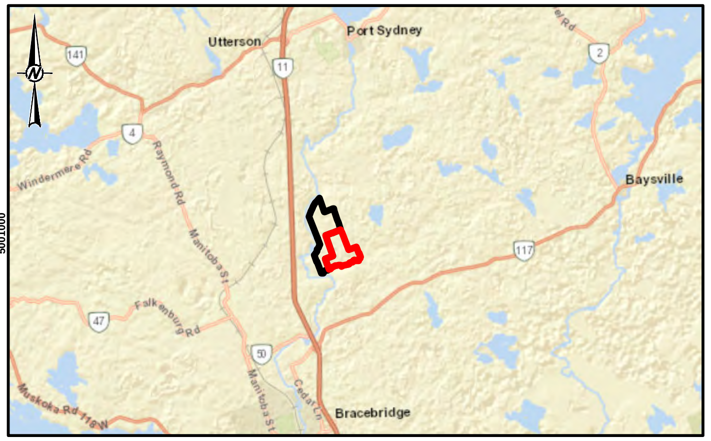
YYYY-MM-DD	2020-05-13
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



KEY MAP



SCALE 1:350,000

LEGEND

- PROPOSED MONITORING WELL LOCATION
- MONITORING WELL LOCATION
- WATER WELL RECORD LOCATION NOT VISITED DURING WELL SURVEY
- BEDROCK PRIVATE WELL LOCATION VISITED DURING WELL SURVEY
- OVERBURDEN PRIVATE WELL LOCATION VISITED DURING WELL SURVEY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- ROADWAY
- HYDRO LINE
- ZONE OF INFLUENCE (BASED ON 1-m DRAWDOWN CONTOUR FOR THE DEEP BEDROCK SHOWN ON FIGURE 23)
- WATERCOURSE (RIVERSTONE, MARCH 24, 2020)
- WATERCOURSE
- WETLAND
- WATERBODY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
4. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
5. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

0 200 400 800

1:20,000 METRES

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

PRIVATE WELL LOCATIONS, PREDICTED ZONE OF INFLUENCE AND PROPOSED MONITORING WELL LOCATIONS

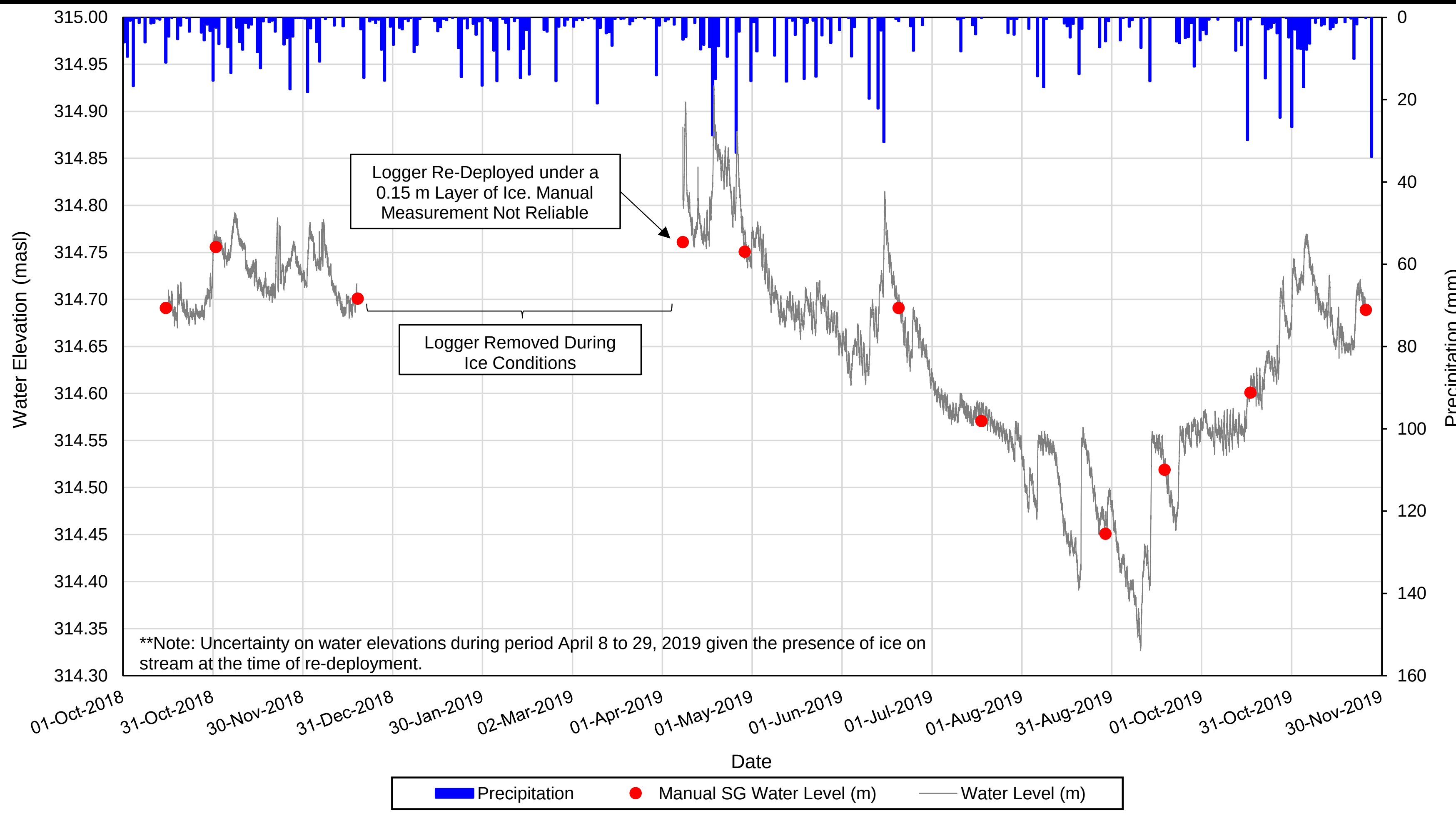
CONSULTANT

GOLDER

YYYY-MM-DD	2020-06-03
DESIGNED	----
PREPARED	BR
REVIEWED	JPAO
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0009	0	10

Continuous Water Level Hydrograph at SW1	Figure 11

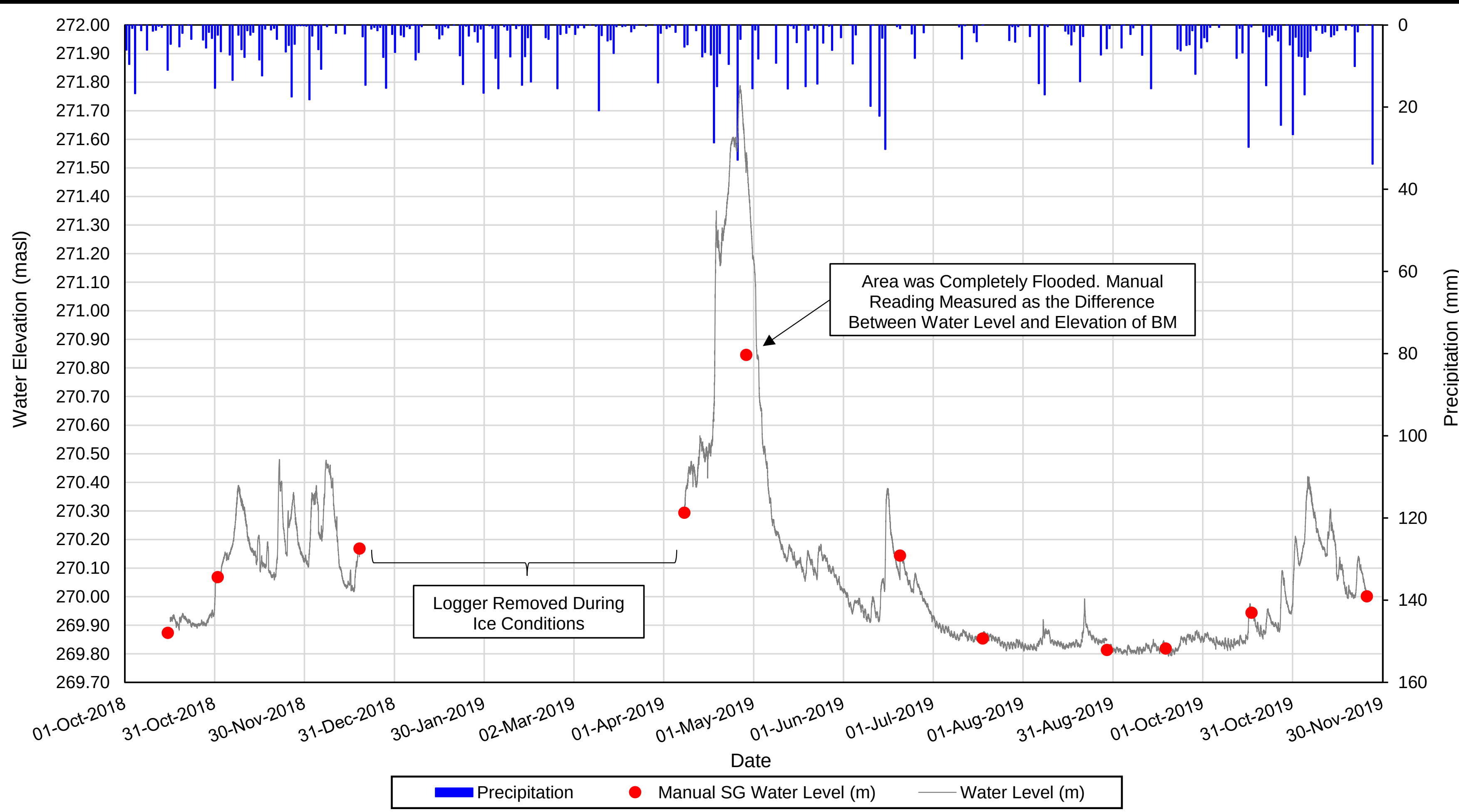


DATE: April 2020
PROJECT: 1895639

GOLDER

CAD: NP
CHK: MLE

Continuous Water Level Hydrograph at SW2	Figure 12



DATE: April 2020

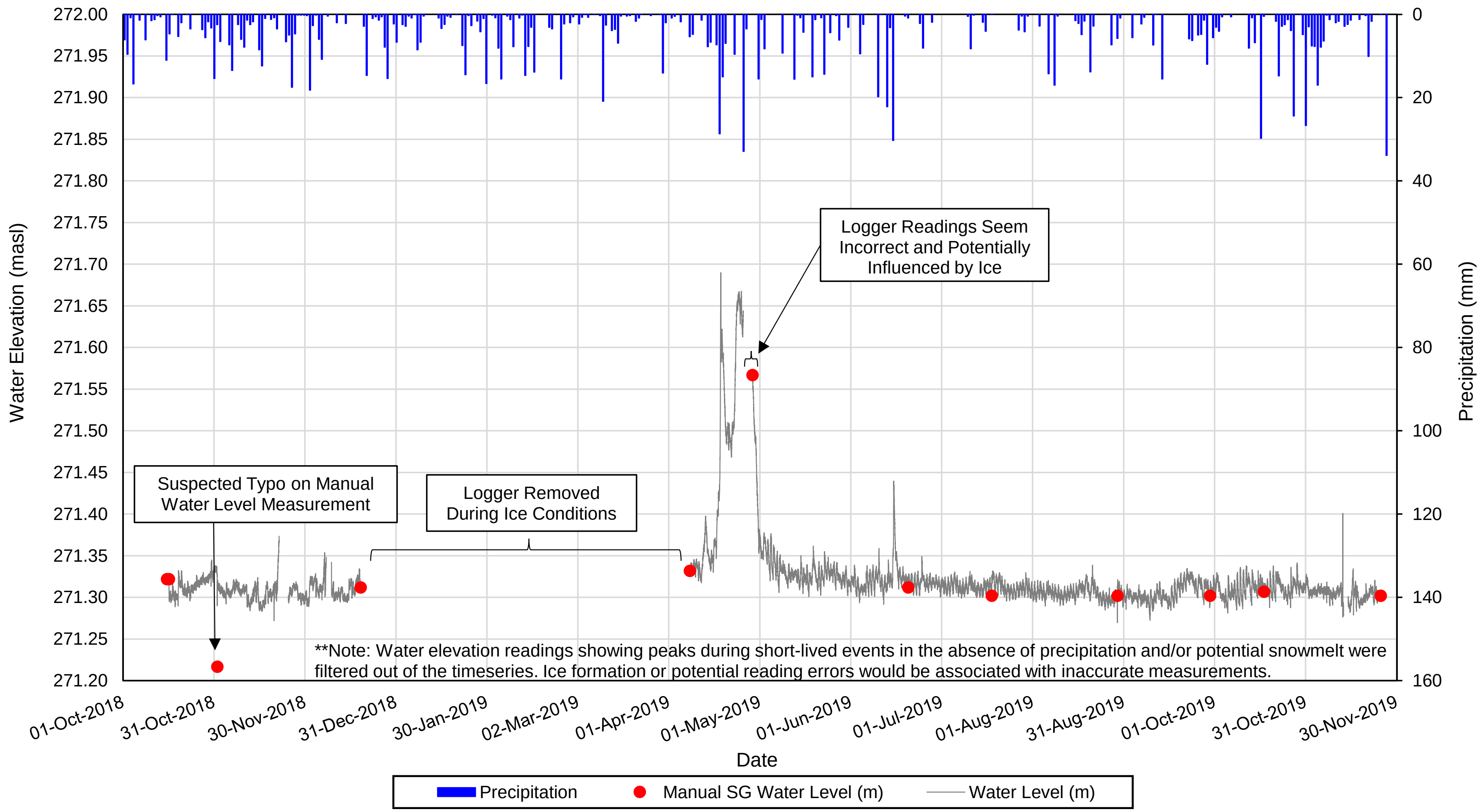
PROJECT: 1895639

GOLDER

CAD: NP

CHK: MKL

Continuous Water Level Hydrograph at SW3 | **Figure 13**

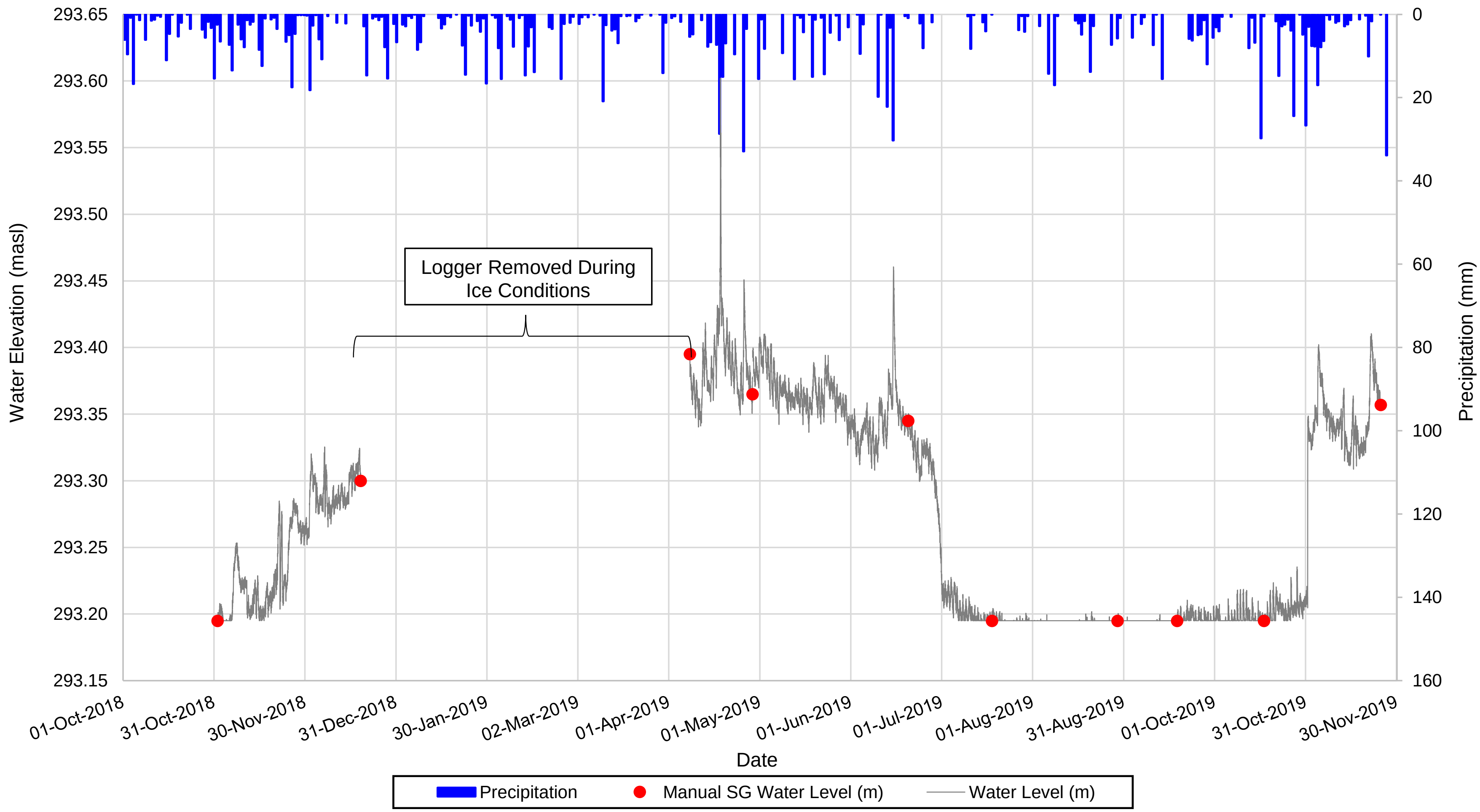


DATE: April 2020
PROJECT: 1895639

GOLDER

CAD: NP
CHK: MKL

Continuous Water Level Hydrograph at SW4	Figure 14

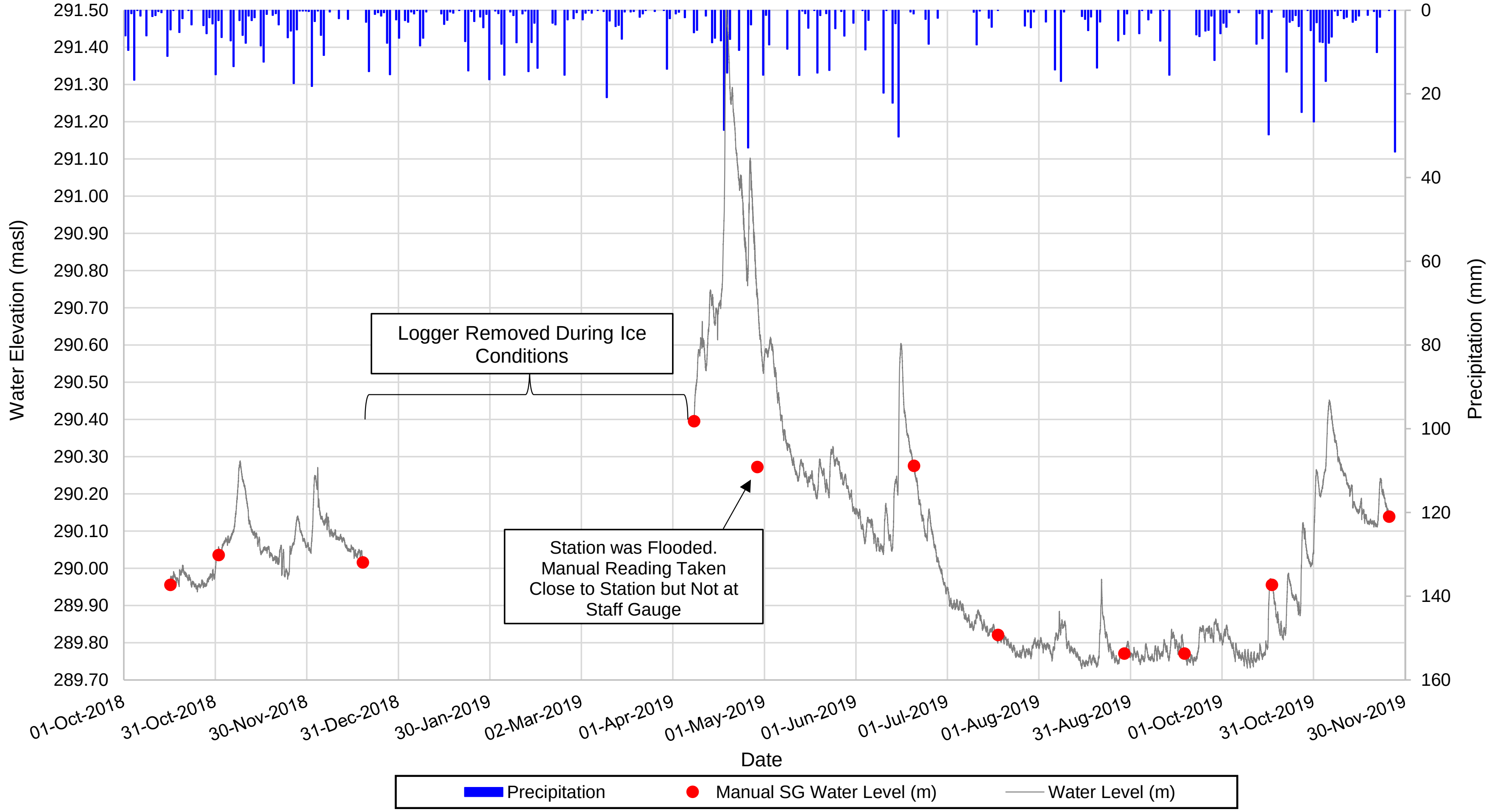


DATE: April 2020
PROJECT: 1895639

GOLDER

CAD: NP
CHK: MKL

Continuous Water Level Hydrograph at SW5 | **Figure 15**



DATE: April 2020

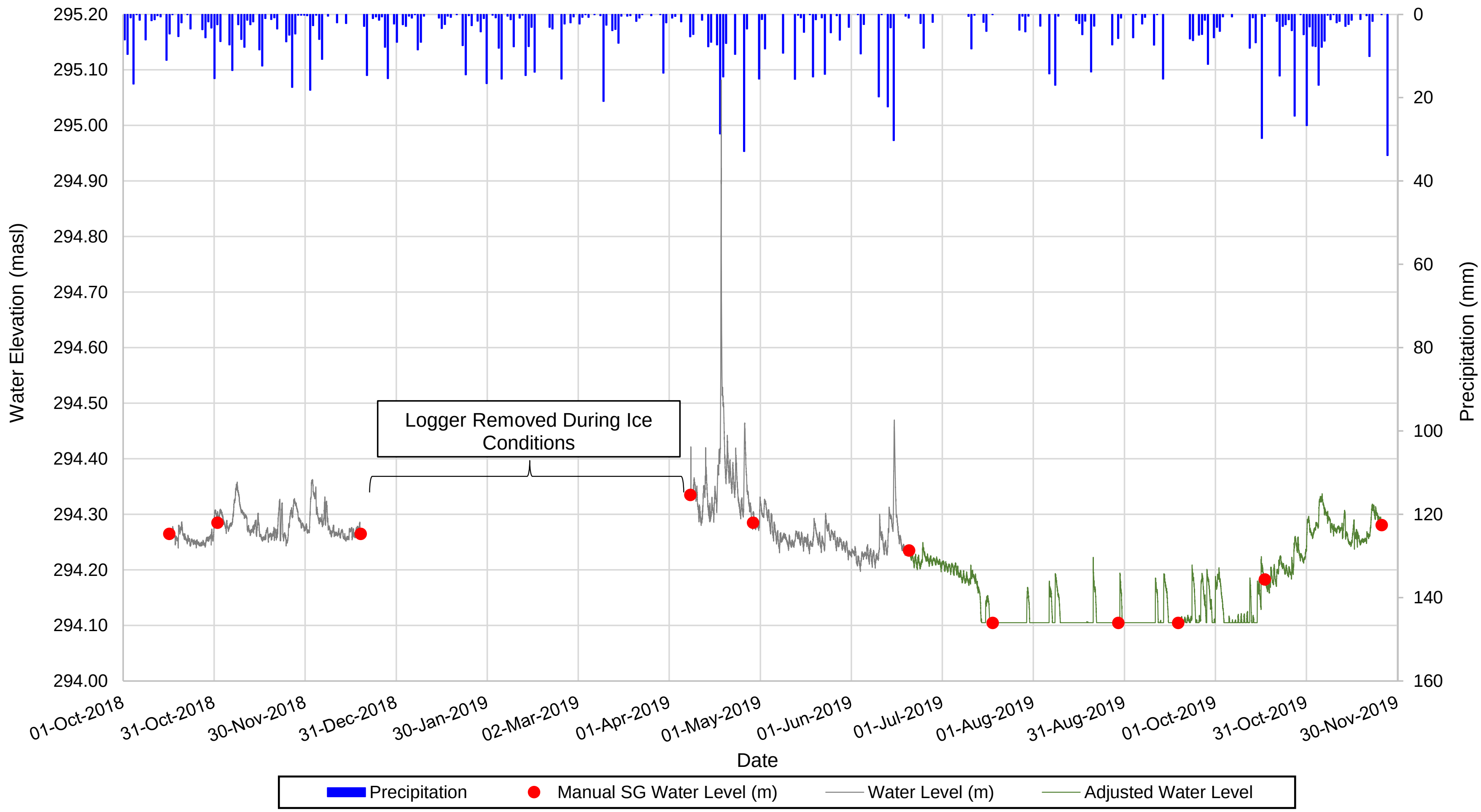
PROJECT: 1895639

GOLDER

CAD: NP

CHK: MKL

Continuous Water Level Hydrograph at SW6	Figure 16



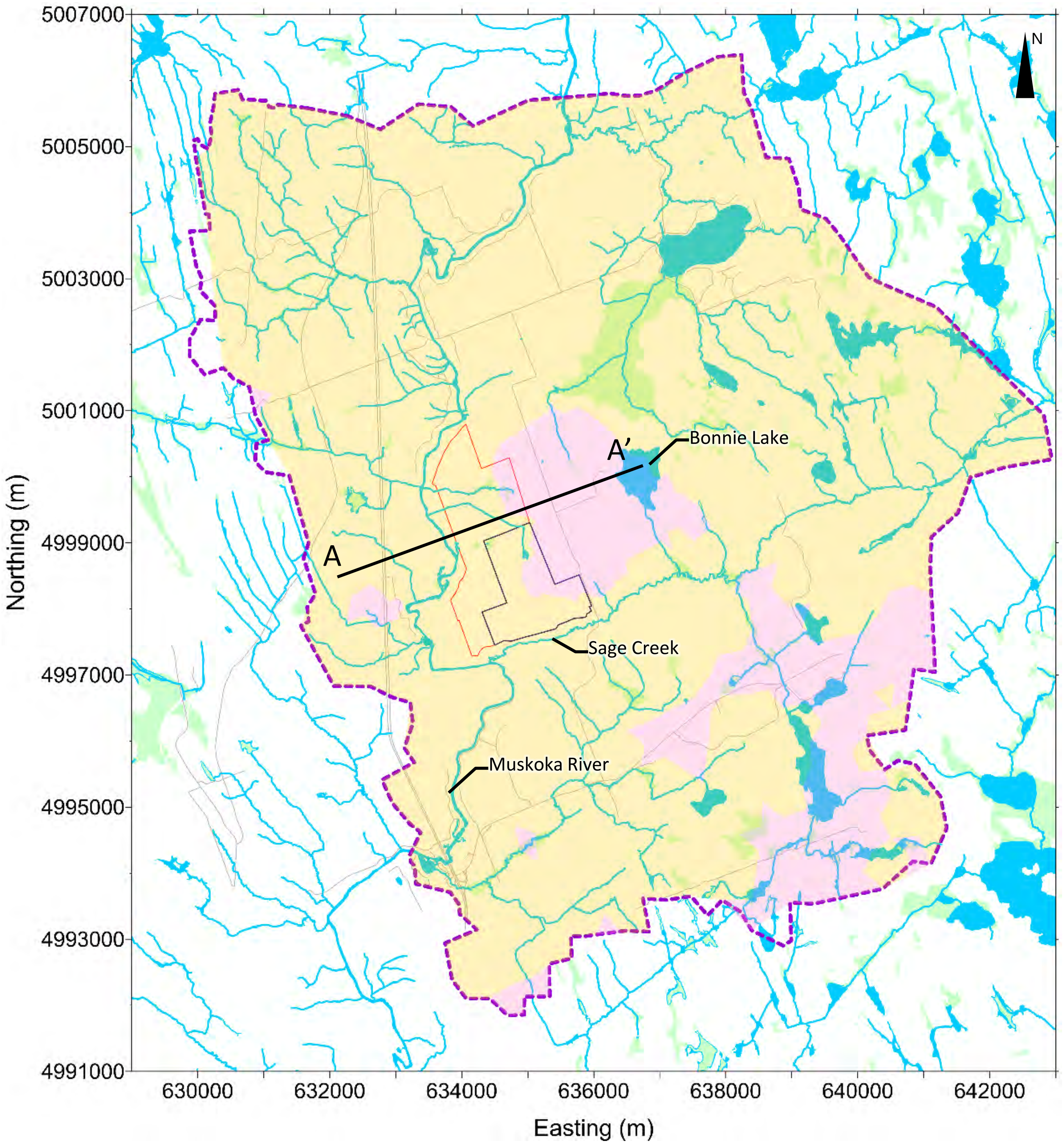
DATE: April 2020

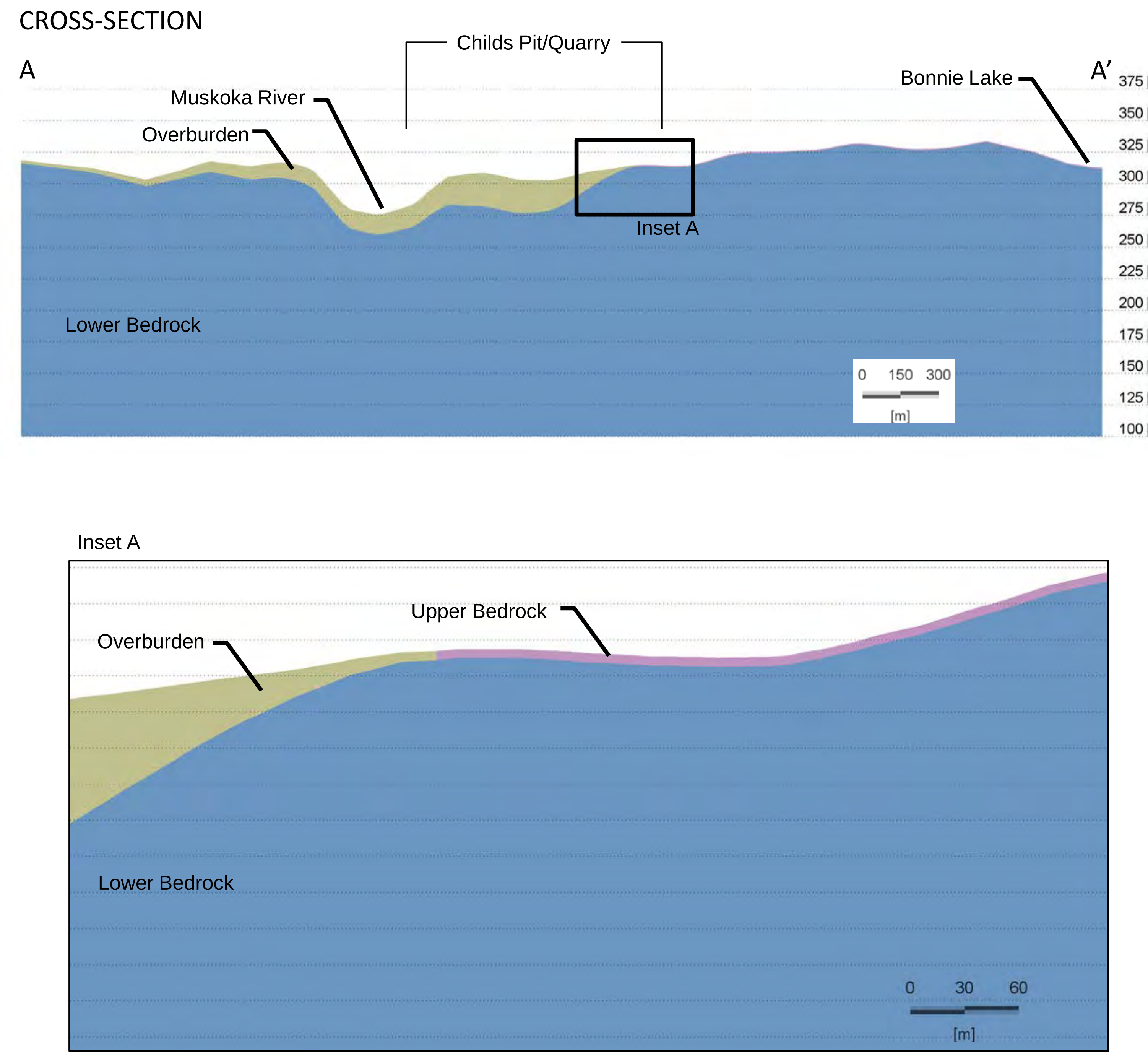
PROJECT: 1895639

GOLDER

CAD: NP

CHK: MKL





LEGEND

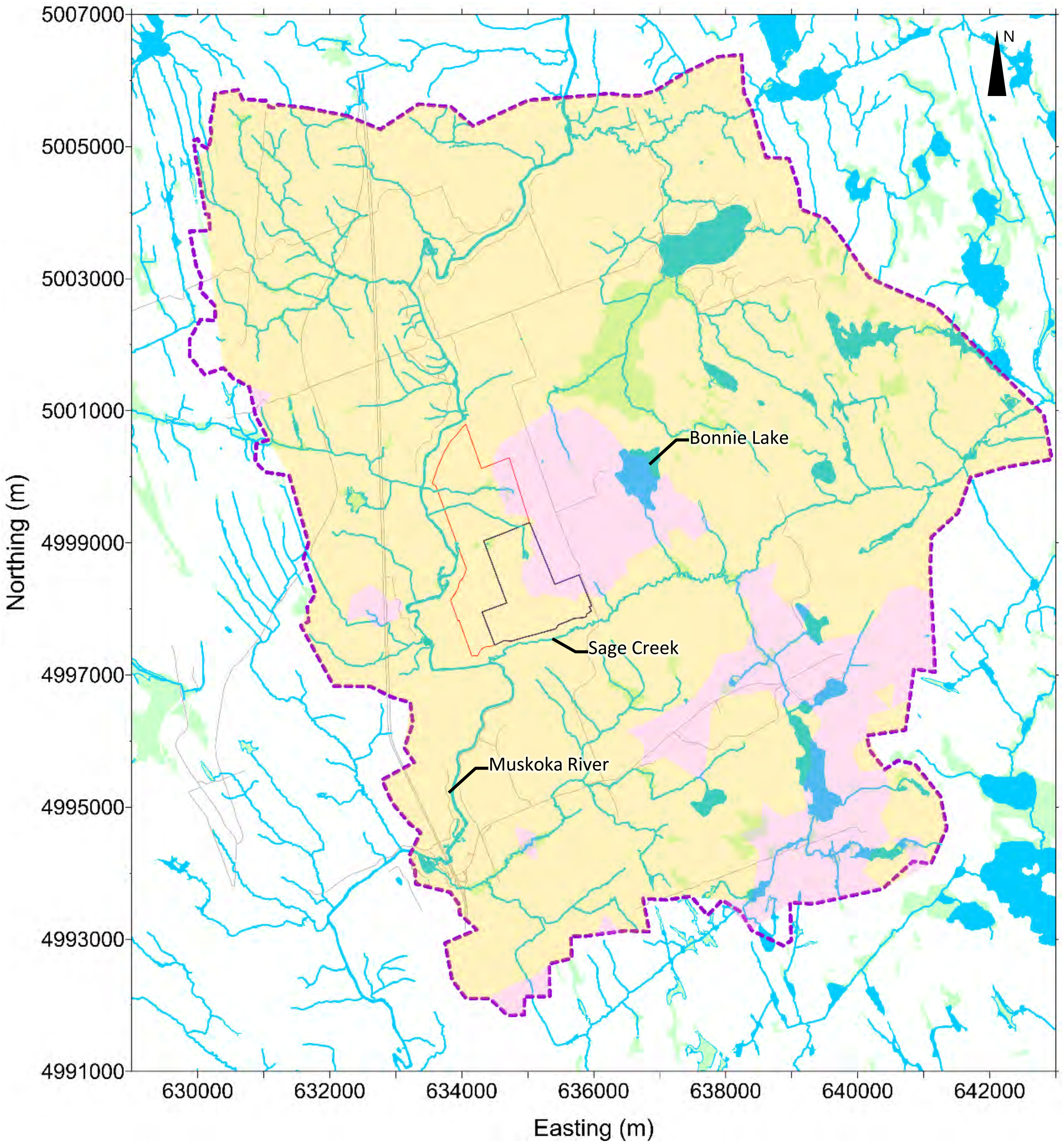
- Groundwater Model Boundary
- Overburden (K = 8E-6 m/s; Layers 1 and 2)
- Bedrock (K = 1E-7 m/s; Layers 1 and 2)
- Bedrock (K = 1E-8 m/s; Layers 3 - 19)
- Existing Childs Pit/Quarry Licensed Boundary
- Proposed Childs Pit/Quarry Extension Lands License Boundary

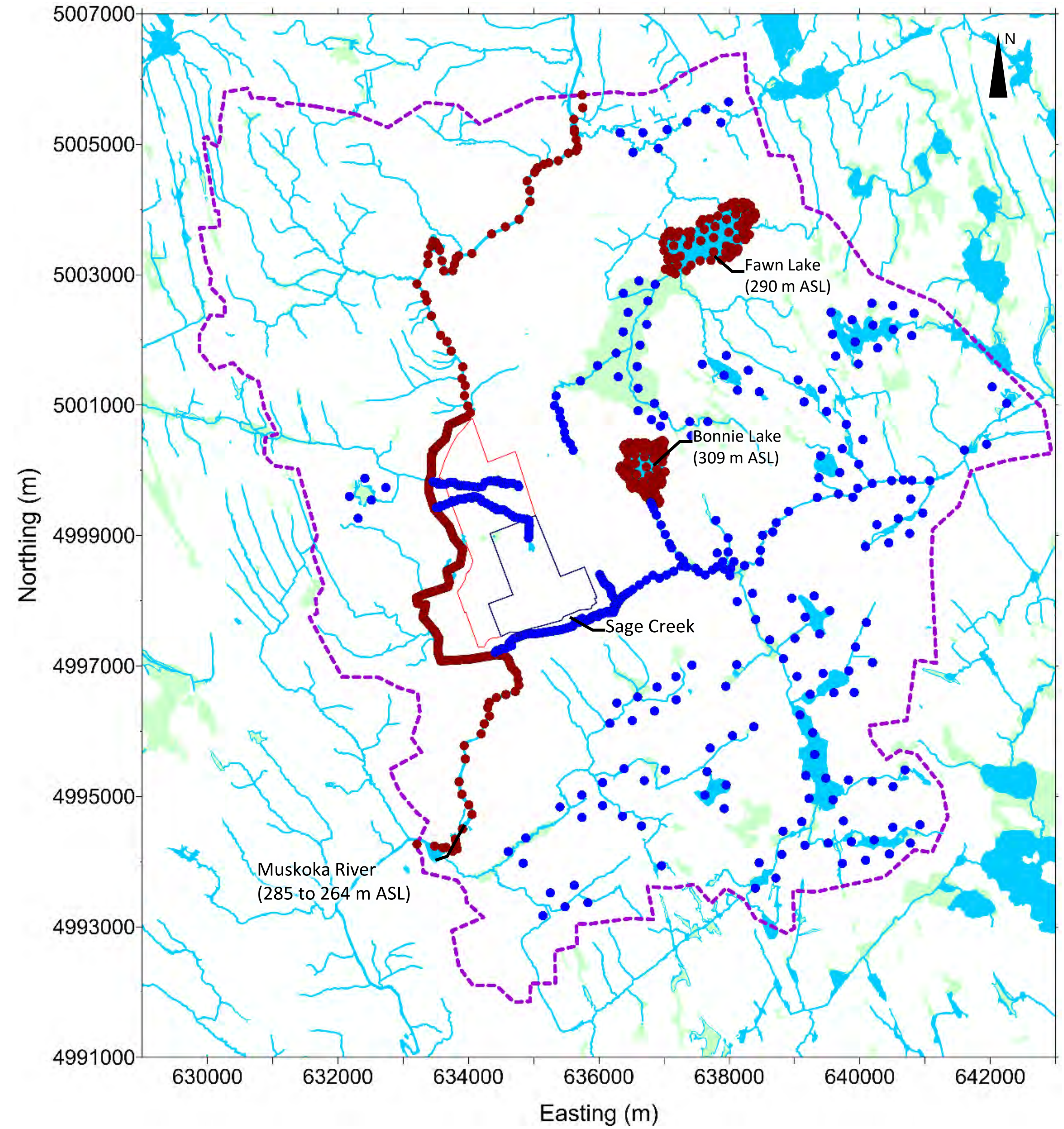
Notes:
1. "K" refers to hydraulic conductivity
2. Vertical exaggeration on cross-section images is 5x

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED	PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER	TITLE	HYDROSTRATIGRAPHIC UNITS AND MATERIAL PROPERTIES

YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM

PROJECT No.	CONTROL	Rev.	FIGURE
1895639	0009	A	17



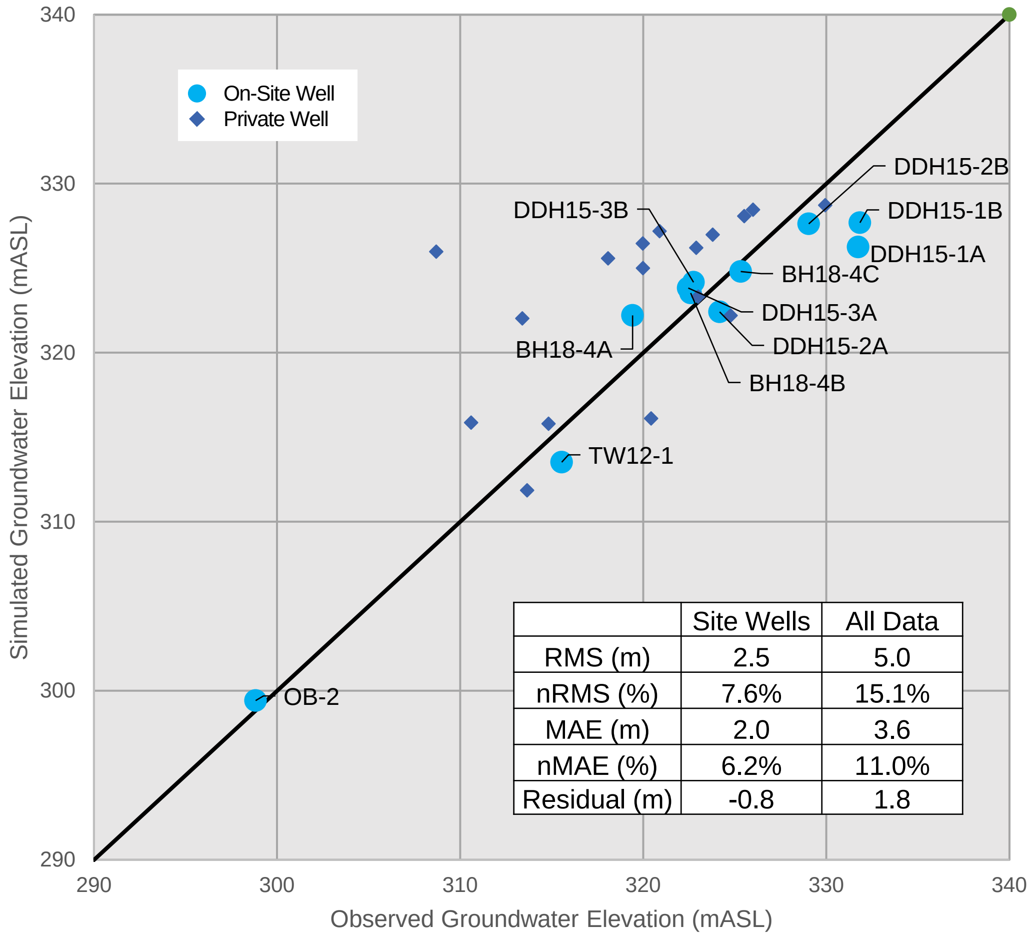


LEGEND

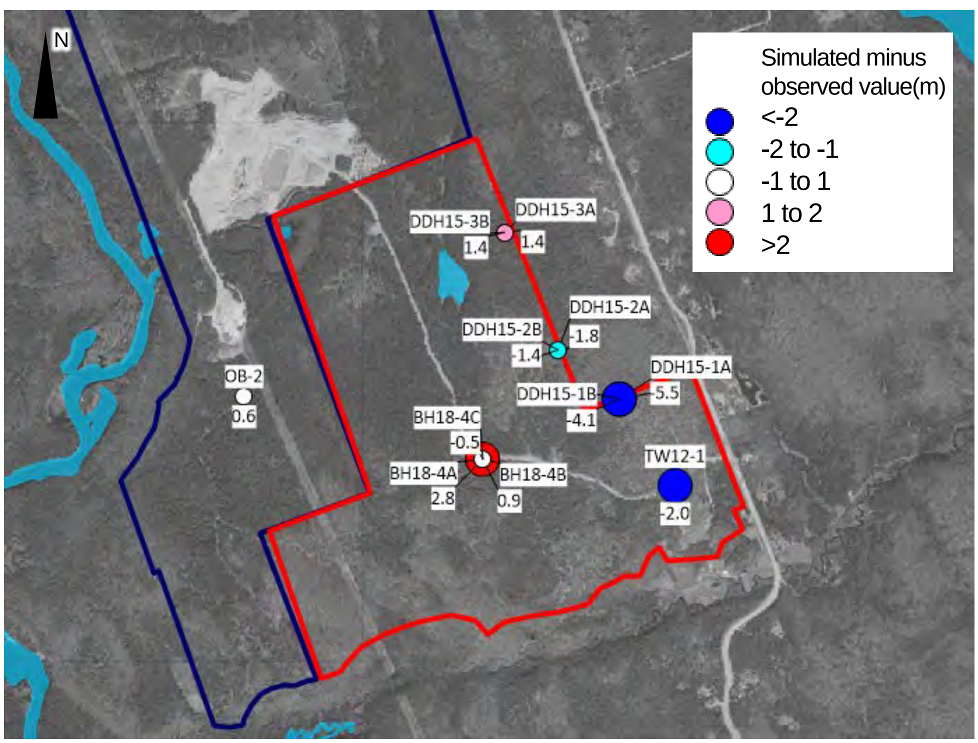
- Groundwater Model Boundary
- Overburden (Recharge = 165 mm/y)
- Bedrock (Recharge = 5 mm/yr)
- Constant Head Boundary
- Seepage Boundary
- Existing Childs Pit/Quarry Licensed Boundary
- Proposed Childs Pit/Quarry Extension Lands License Boundary

Notes:
1. Model boundaries specified at the upper surface of the model (model slice 1), as defined by topography.

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED	PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER	TITLE	GROUNDWATER MODEL RECHARGE AND FLOW BOUNDARIES
YYYY-MM-DD	2020-04-26	PROJECT No.	1895639
PREPARED	NB	CONTROL	0009
DESIGN	NB	Rev.	A
REVIEW	JO	FIGURE	18
APPROVED	KM		



	Site Wells	All Data
RMS (m)	2.5	5.0
nRMS (%)	7.6%	15.1%
MAE (m)	2.0	3.6
nMAE (%)	6.2%	11.0%
Residual (m)	-0.8	1.8



CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION

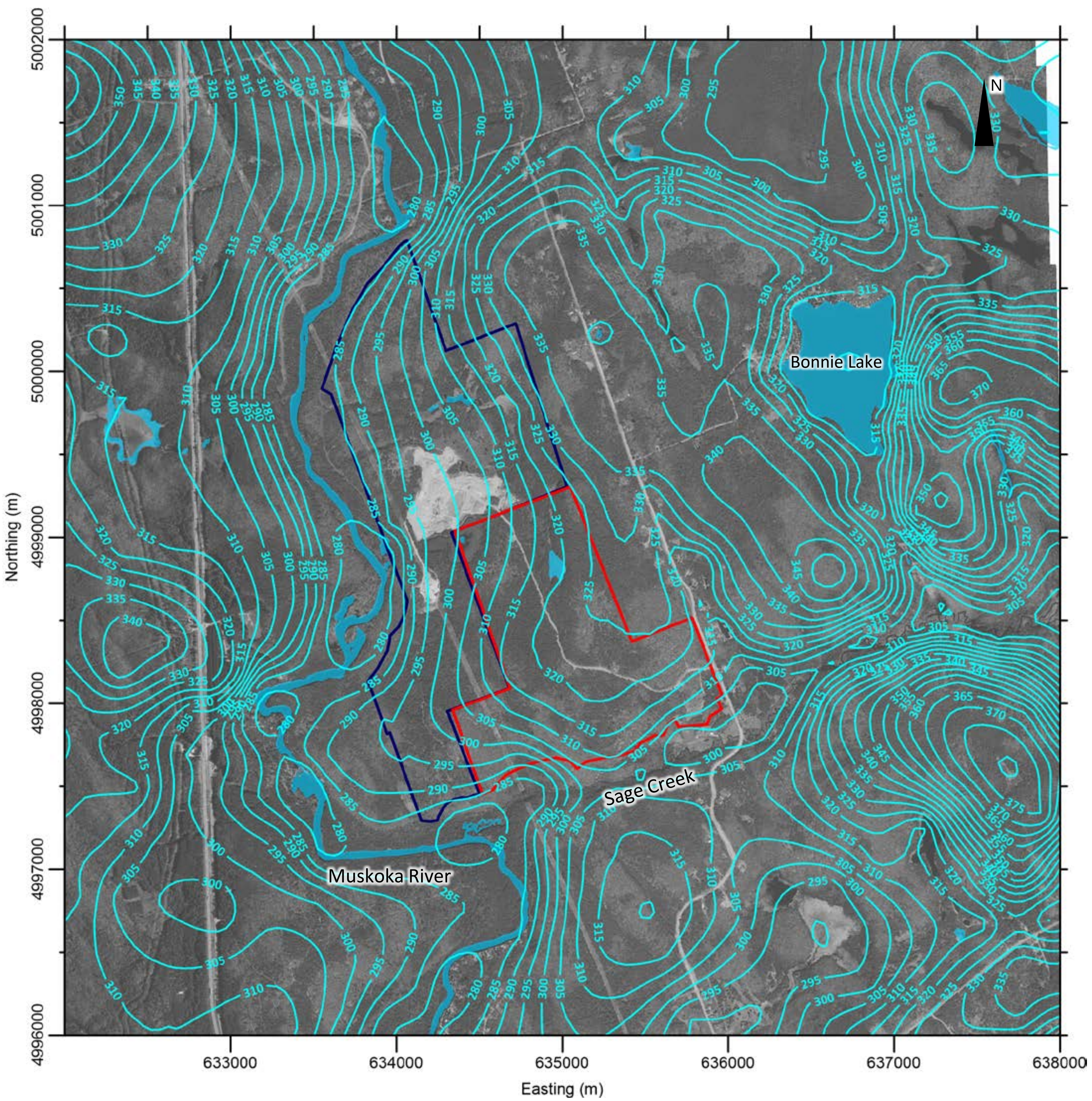
CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM

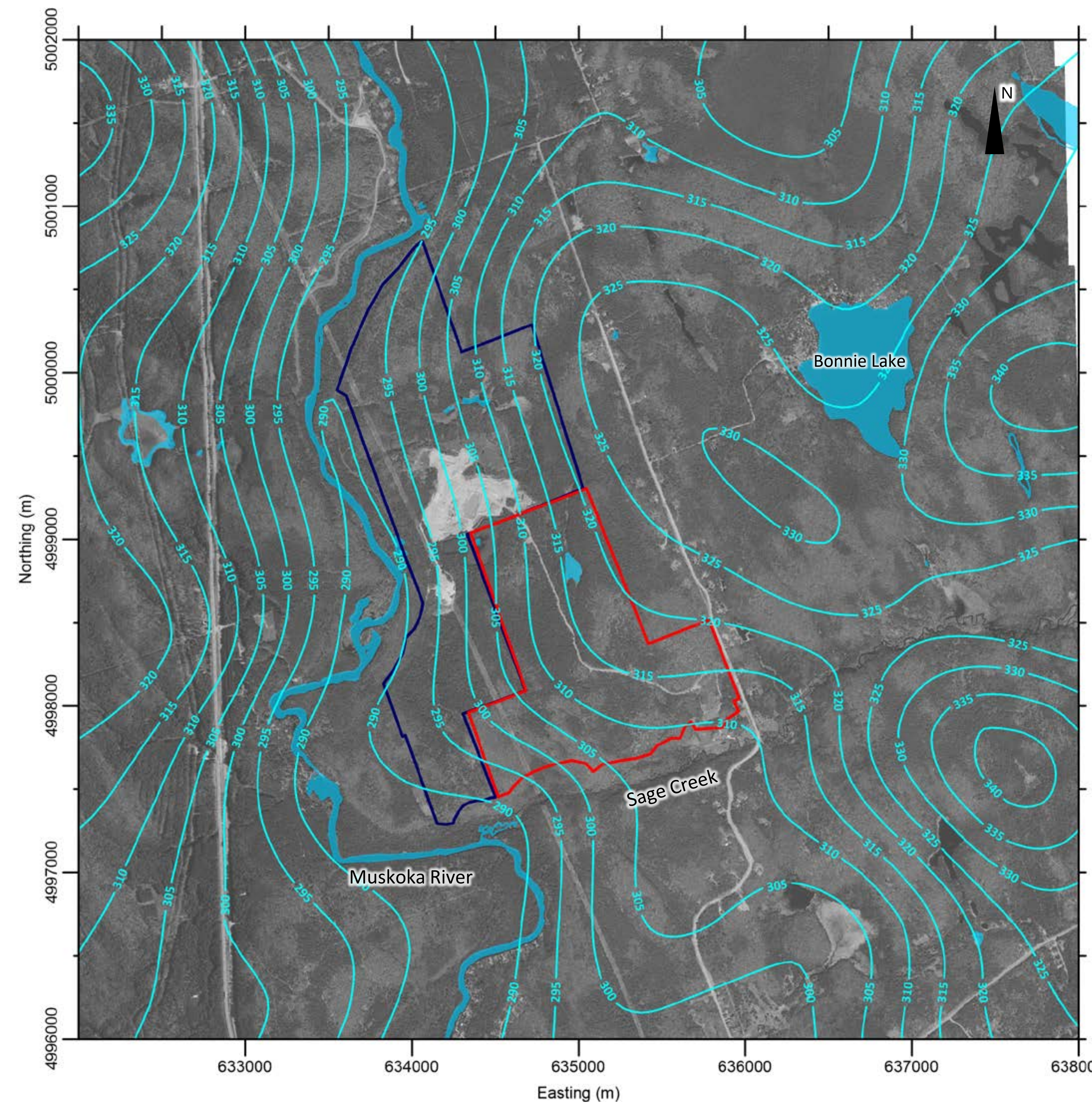
TITLE
GROUNDWATER MODEL CALIBRATION

PROJECT No.	CONTROL	Rev.	FIGURE
1895639	0009	A	19

GROUNDWATER ELEVATIONS IN SHALLOW BEDROCK (NUMERICAL MODEL SLICE 7)



GROUNDWATER ELEVATIONS IN DEEP BEDROCK (NUMERICAL MODEL SLICE 14)



LEGEND

- Simulated groundwater elevation (m ASL)
- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Existing Childs Pit/Quarry Licensed Boundary

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED
PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM
TITLE	SIMULATED GROUNDWATER ELEVATIONS IN SHALLOW AND DEEP BEDROCK
PROJECT No.	1895639
CONTROL	0009
Rev.	A
FIGURE	20

SCENARIO 1 – LICENSED CHILDS PIT/QUARRY DEVELOPMENT

SCENARIO 2 – FULL DEVELOPMENT

SCENARIO 3 – REHABILITATION

LEGEND

- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Existing Childs Pit/Quarry Licensed Boundary
- 1 Area Extracted to Floor Elevation 240 m ASL
- 2 Area Extracted to Floor Elevation 255 m ASL
- 3 Area Extracted to Floor Elevation 270 m ASL
- 4 Area Extracted to Floor Elevation 300 m ASL
- 5 Area Extracted to Floor Elevation min. 310 m ASL
- Rehabilitation Area - Lake
- Rehabilitation Area – Above Water Terrestrial Land Form

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

CONSULTANT
GOLDER

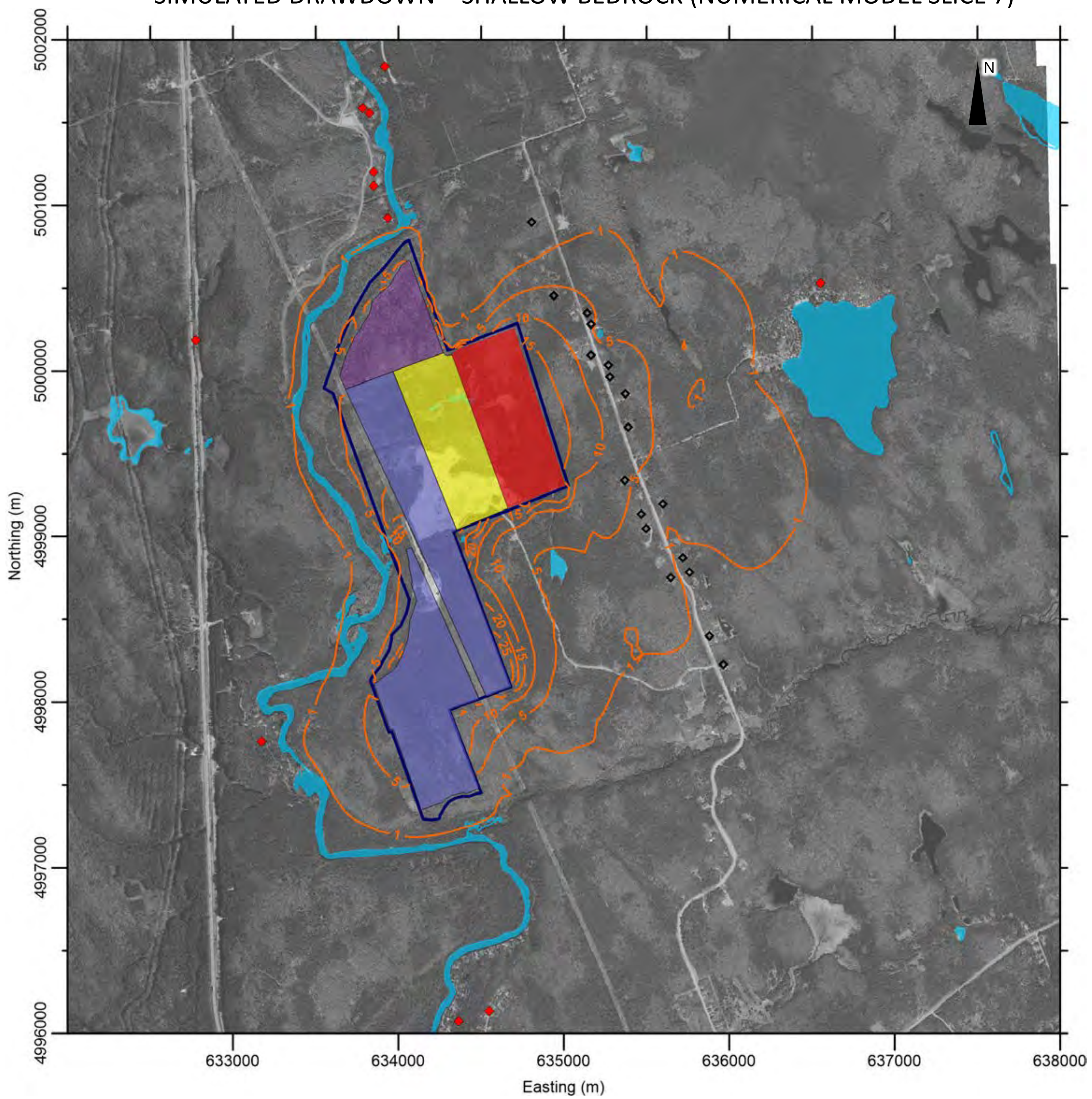
YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION

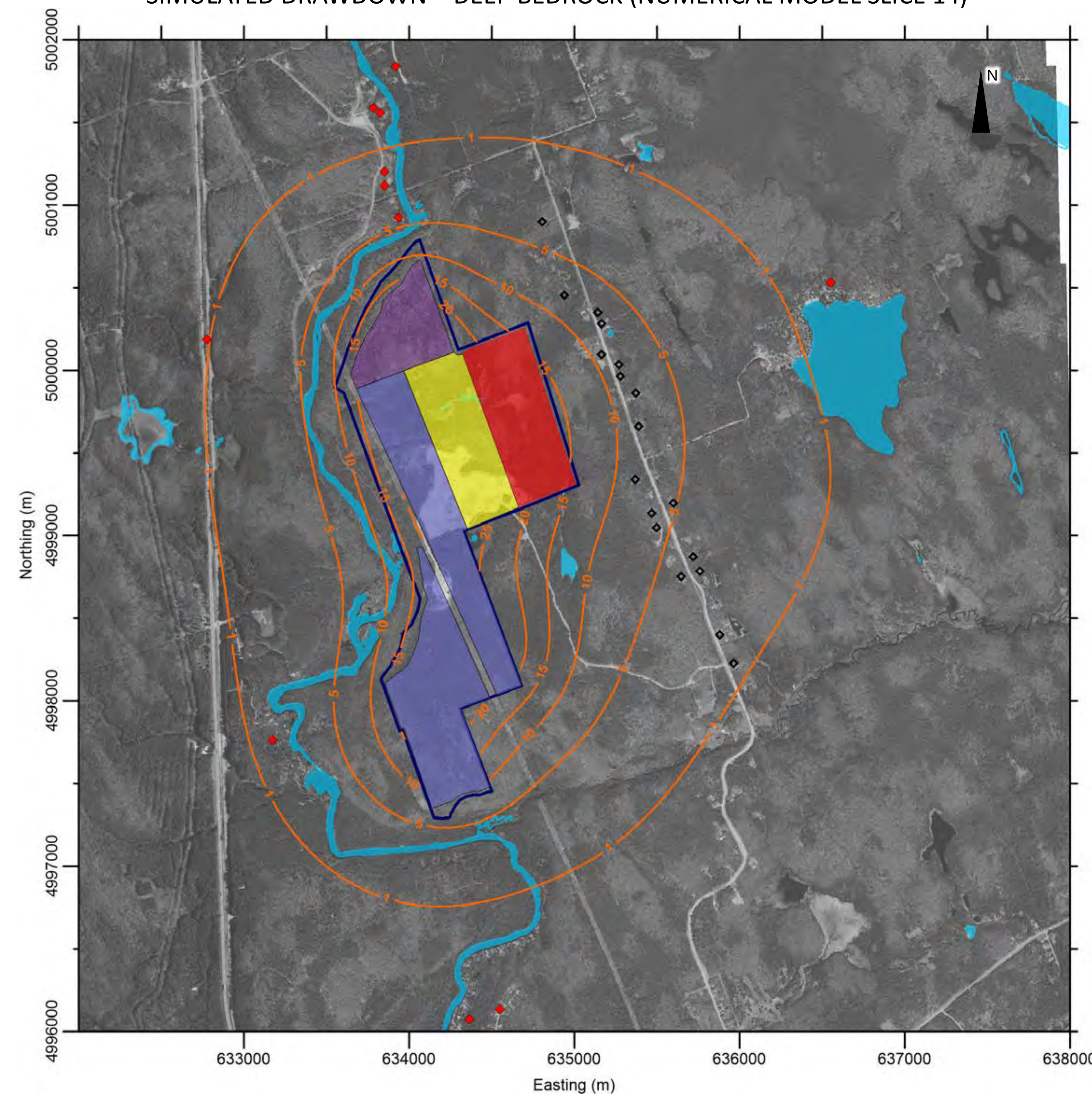
TITLE
ILLUSTRATION OF MODEL SCENARIOS

PROJECT No.	CONTROL	Rev.	FIGURE
1895639	0009	A	21

SIMULATED DRAWDOWN – SHALLOW BEDROCK (NUMERICAL MODEL SLICE 7)



SIMULATED DRAWDOWN – DEEP BEDROCK (NUMERICAL MODEL SLICE 14)



LEGEND

- Existing Childs Pit/Quarry Licensed Boundary
- Simulated groundwater drawdown (m)
- Groundwater well location (private well survey)
- Groundwater well location (WWIS)
- 1 Area Extracted to Floor Elevation 240 m ASL
- 2 Area Extracted to Floor Elevation 255 m ASL
- 3 Area Extracted to Floor Elevation 270 m ASL
- 4 Area Extracted to Floor Elevation 300 m ASL

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION

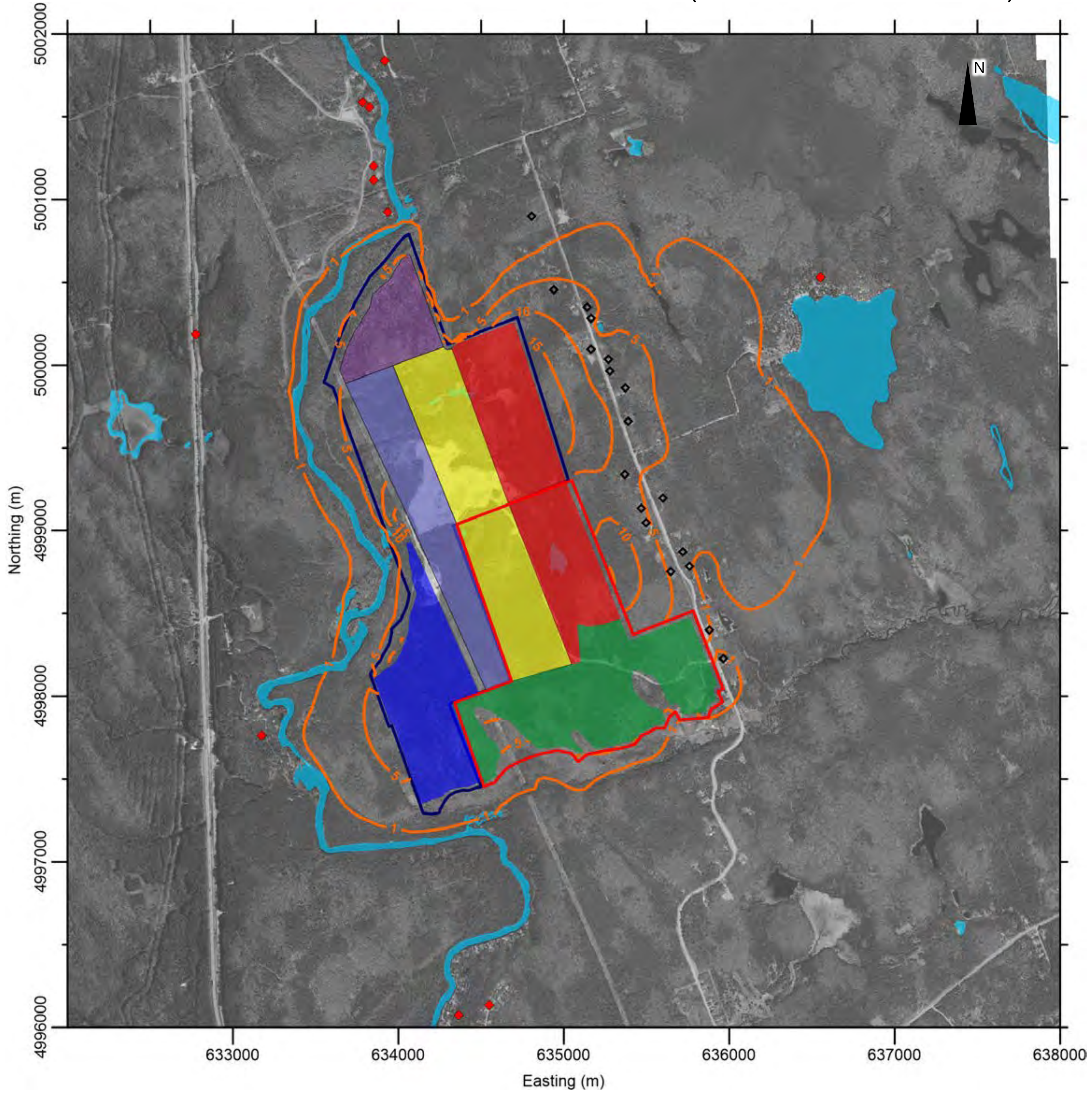
CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM

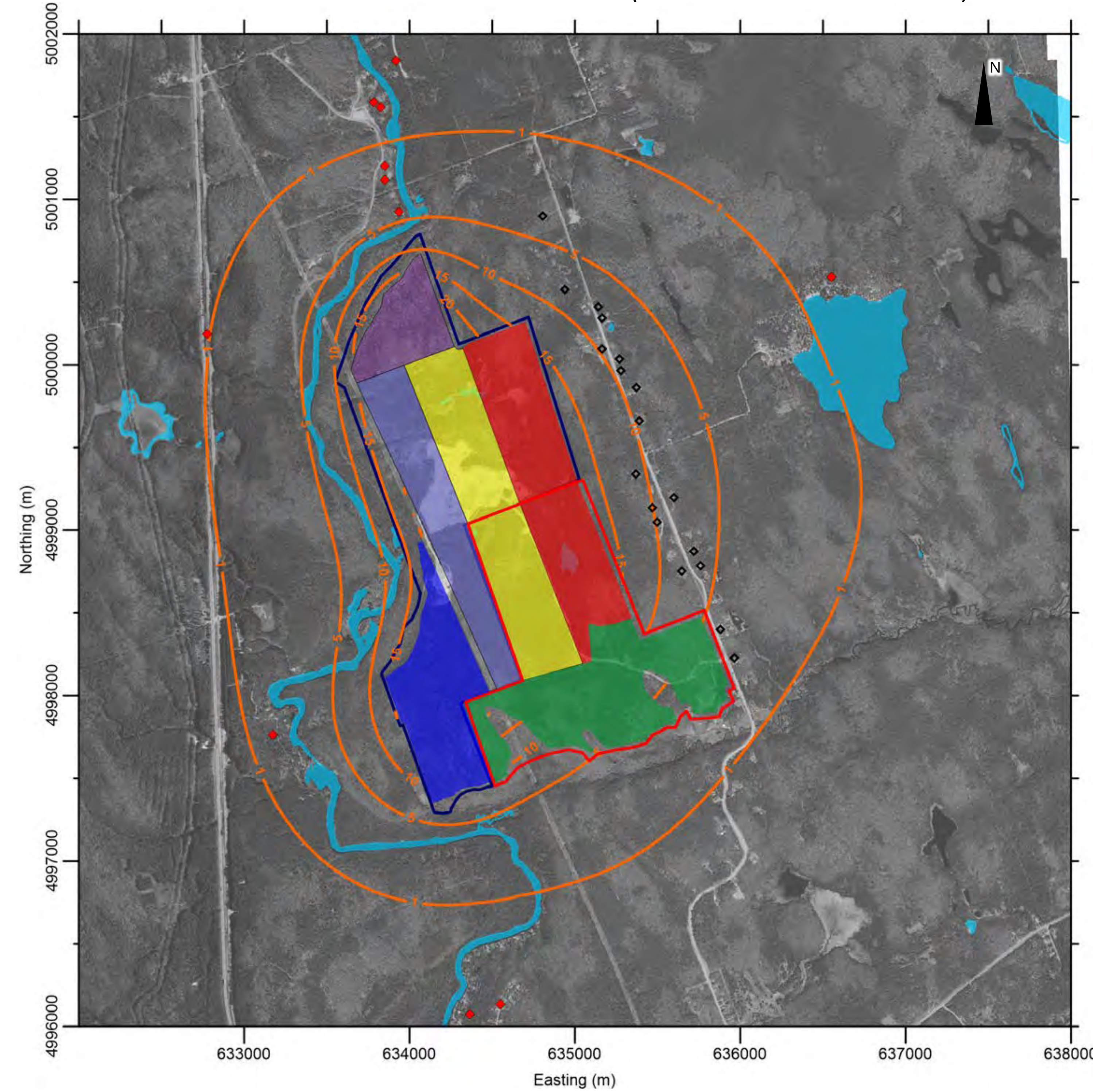
TITLE
SIMULATED GROUNDWATER DRAWDOWN – SCENARIO 1 (LICENSED CHILD'S PIT/QUARRY DEVELOPMENT)

PROJECT No.	CONTROL	Rev.	FIGURE
1895639	0009	A	22

SIMULATED DRAWDOWN – SHALLOW BEDROCK (NUMERICAL MODEL SLICE 7)



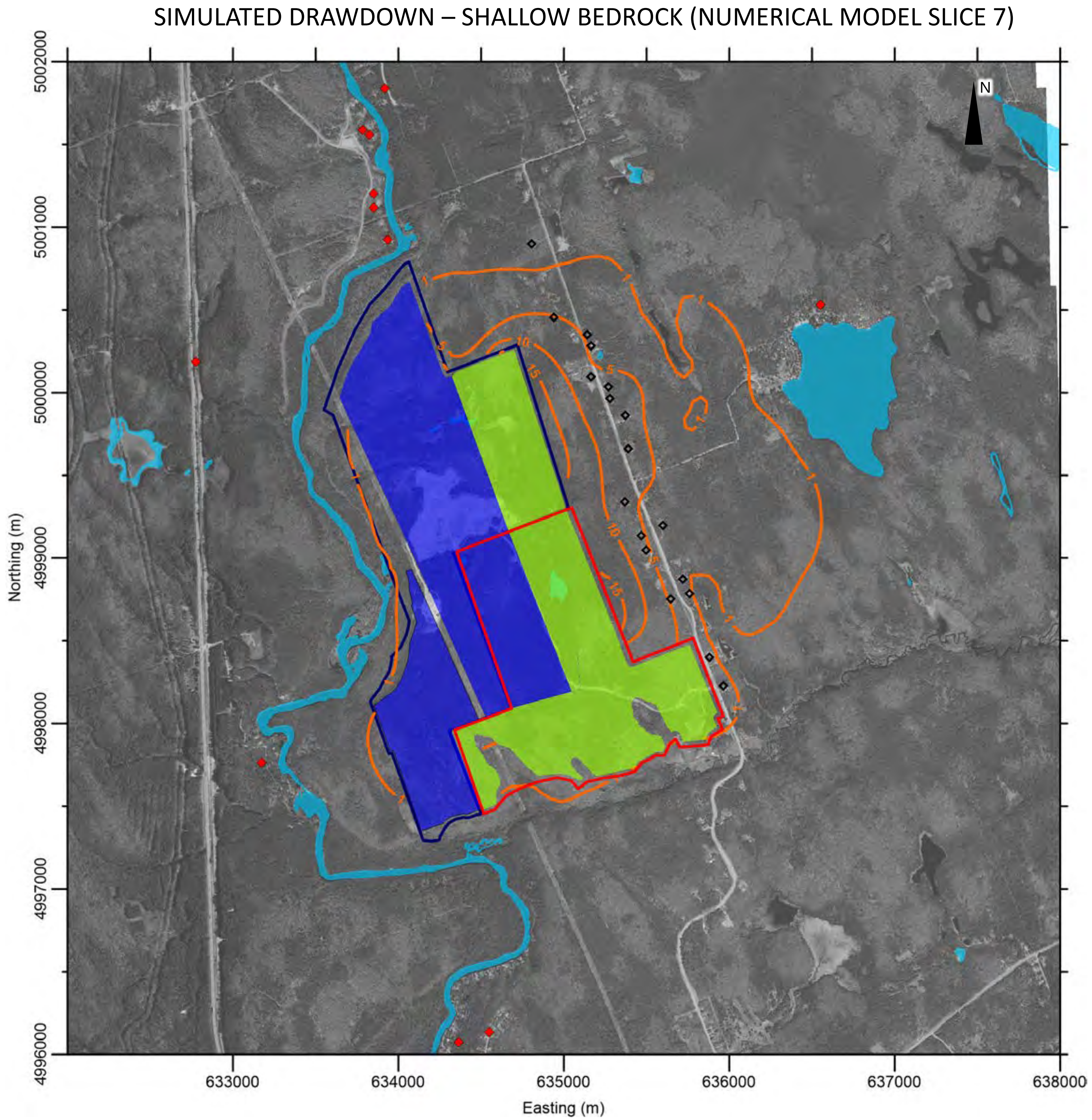
SIMULATED DRAWDOWN – DEEP BEDROCK (NUMERICAL MODEL SLICE 14)

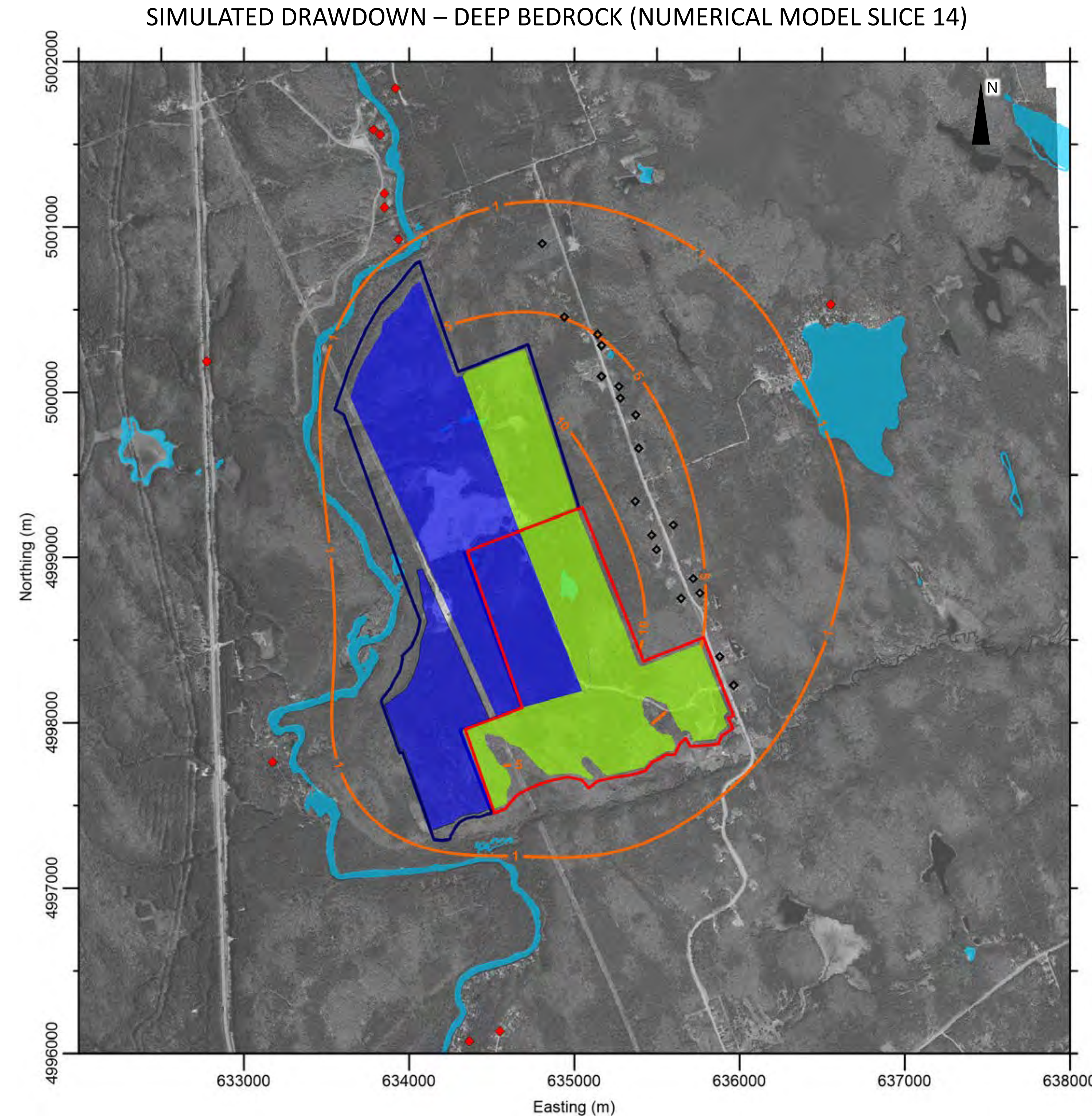


LEGEND

- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Existing Childs Pit/Quarry Licensed Boundary
- Simulated groundwater drawdown (m)
- Groundwater well location (private well survey)
- Groundwater well location (WWIS)
- 1 Area Extracted to Floor Elevation 240 m ASL
- 2 Area Extracted to Floor Elevation 255 m ASL
- 3 Area Extracted to Floor Elevation 270 m ASL
- 4 Area Extracted to Floor Elevation 300 m ASL
- 5 Area Extracted to Floor Elevation min. 310 m ASL

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED
PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM
TITLE	SIMULATED GROUNDWATER DRAWDOWN – SCENARIO 2 (FULL DEVELOPMENT)
PROJECT No.	1895639
CONTROL	0009
Rev.	A
FIGURE	23

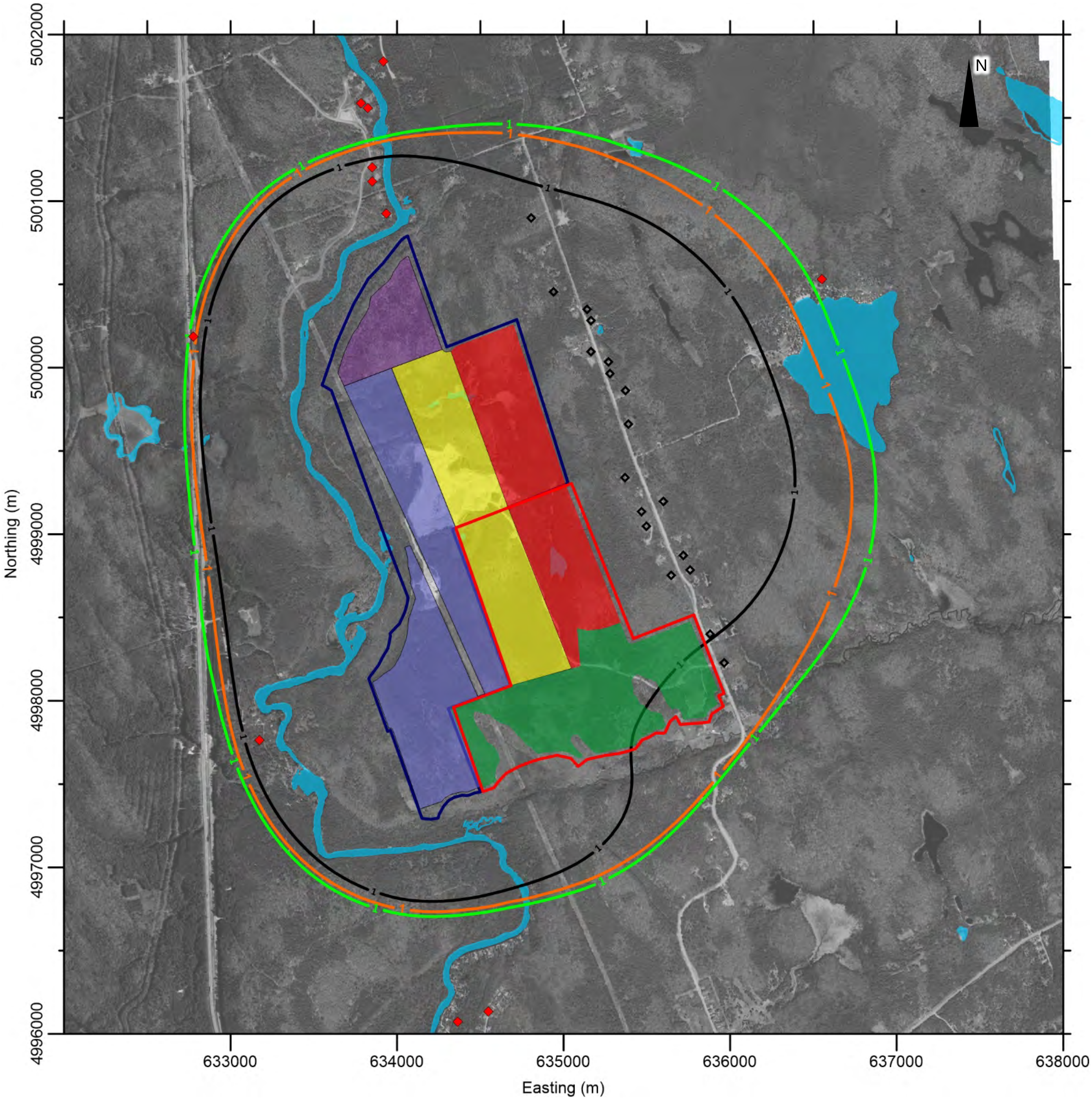




LEGEND

- Proposed Childs Pit/Quarry Extension Lands License Boundary
- Existing Childs Pit/Quarry Licensed Boundary
- Simulated groundwater drawdown (m)
- Groundwater well location (private well survey)
- Groundwater well location (WWIS)
- Rehabilitation Area - Lake
- Rehabilitation Area – Terrain

CLIENT	FOWLER CONSTRUCTION COMPANY LIMITED
PROJECT	HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM
TITLE	SIMULATED GROUNDWATER DRAWDOWN – SCENARIO 3 (REHABILITATION)
PROJECT No.	1895639
CONTROL	0009
Rev.	A
FIGURE	24



Proposed Childs Pit/Quarry Extension Lands License Boundary

Existing Childs Pit/Quarry Licensed Boundary

Simulated groundwater drawdown – Base Case (m)

Simulated groundwater drawdown – Sensitivity Run 1 -5x Bedrock K (m)

Simulated groundwater drawdown – Sensitivity Run 2 –Reduced Recharge (m)

Groundwater well location (private well survey)

Groundwater well location (WWIS)

1 Area Extracted to Floor Elevation 240 m ASL

2 Area Extracted to Floor Elevation 255 m ASL

3 Area Extracted to Floor Elevation 270 m ASL

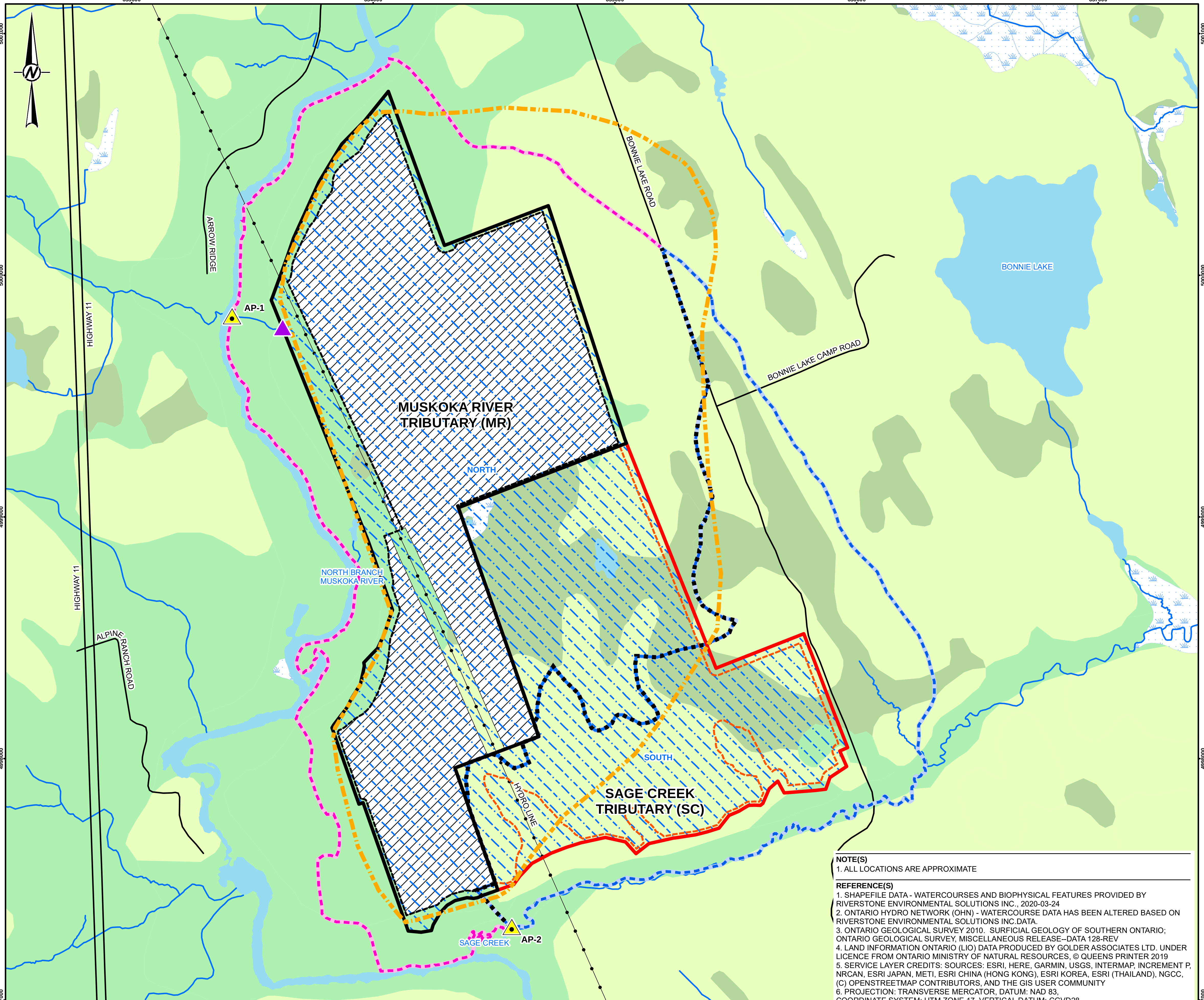
4 Area Extracted to Floor Elevation 300 m ASL

5 Area Extracted to Floor Elevation min. 310 m ASL

CLIENT FOWLER CONSTRUCTION COMPANY LIMITED	PROJECT HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS – PROPOSED CHILDS PIT/QUARRY EXTENSION
CONSULTANT GOLDER	TITLE RESULTS OF GROUNDWATER MODEL SENSITIVITY SIMULATIONS

YYYY-MM-DD	2020-04-26
PREPARED	NB
DESIGN	NB
REVIEW	JO
APPROVED	KM

PROJECT No.	CONTROL	Rev.	FIGURE
1895639	0009	A	25



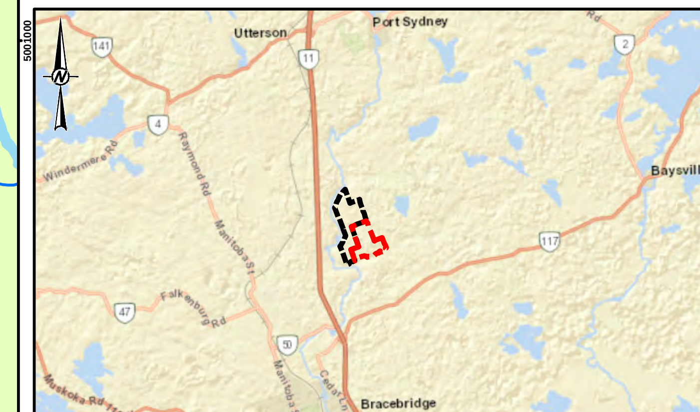
NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 1
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600
1:16,000 METRES

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
WATER BALANCE - SCENARIO 1 (LICENSED CHILDS PIT/QUARRY DEVELOPMENT) - SAGE CREEK AND MUSKOKA RIVER

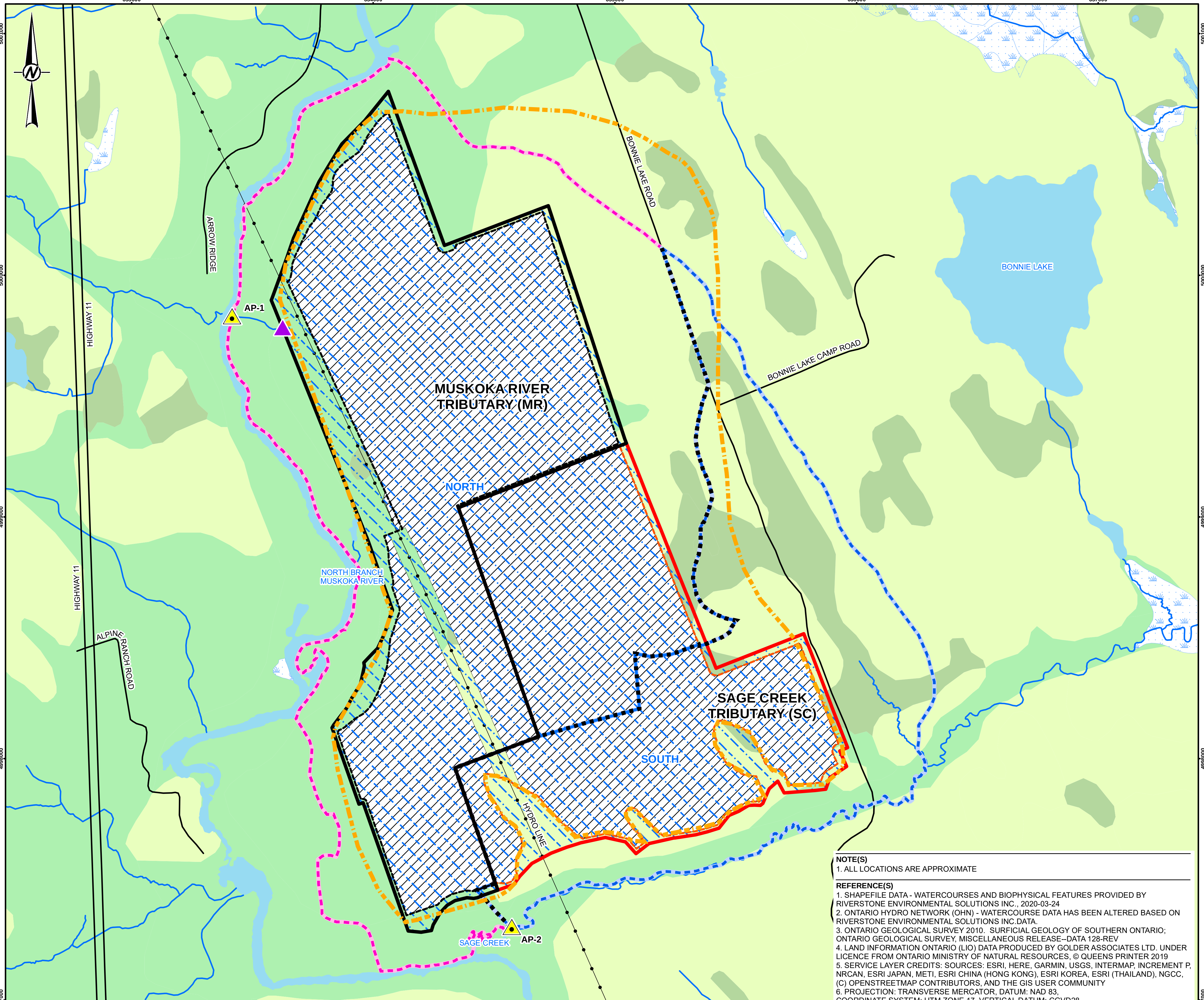
CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

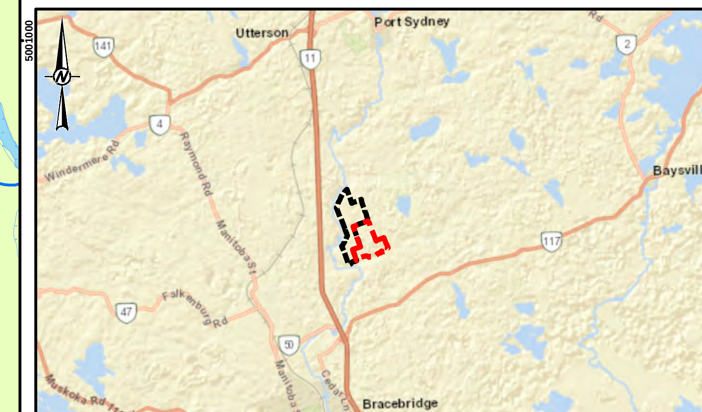
PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	26

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0008_CH_WaterBalance\1895639-0008-CH-0026.mxd



KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 2
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600
1:16,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

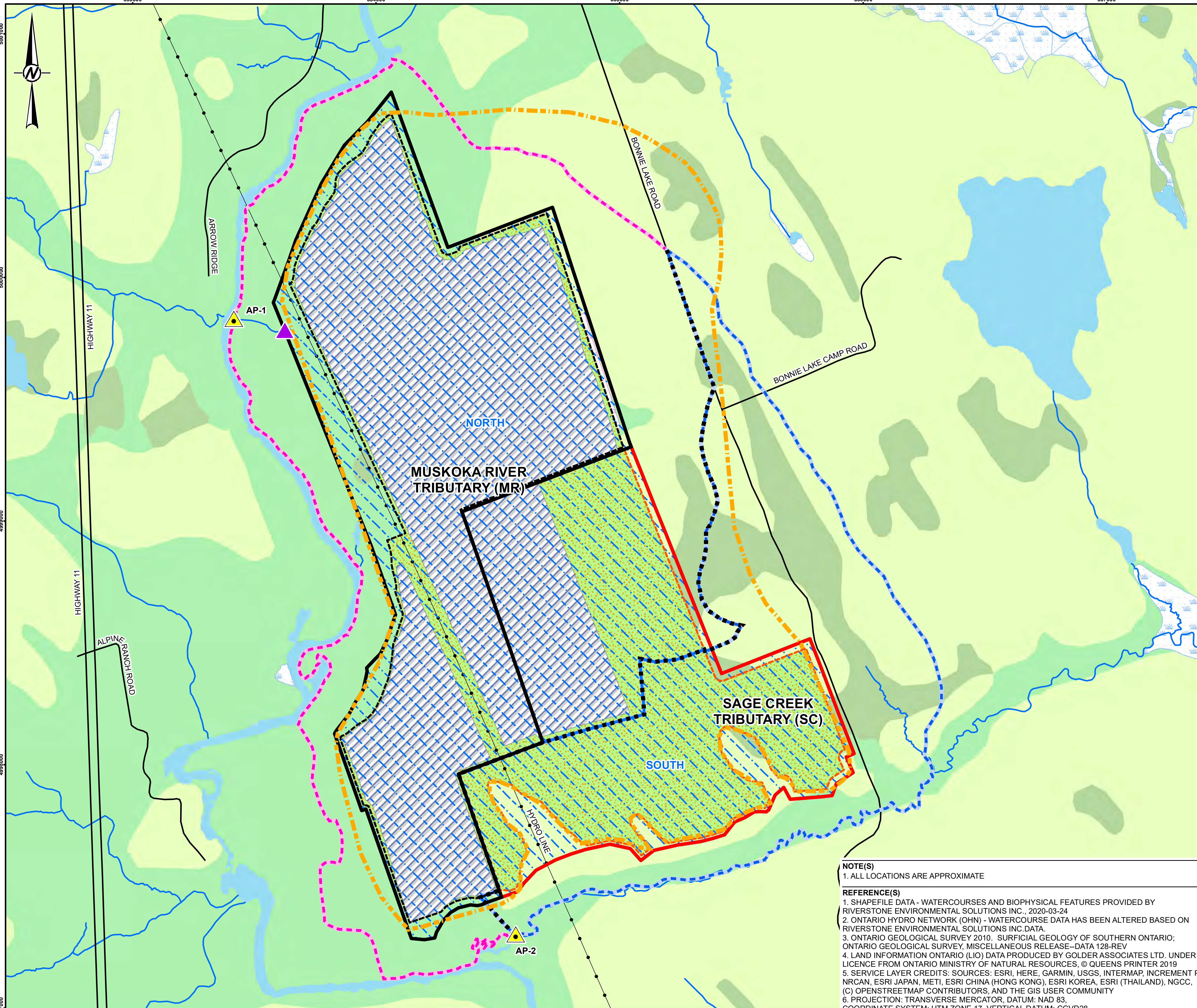
PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
WATER BALANCE - SCENARIO 2 (FULL DEVELOPMENT) - SAGE CREEK AND MUSKOKA RIVER

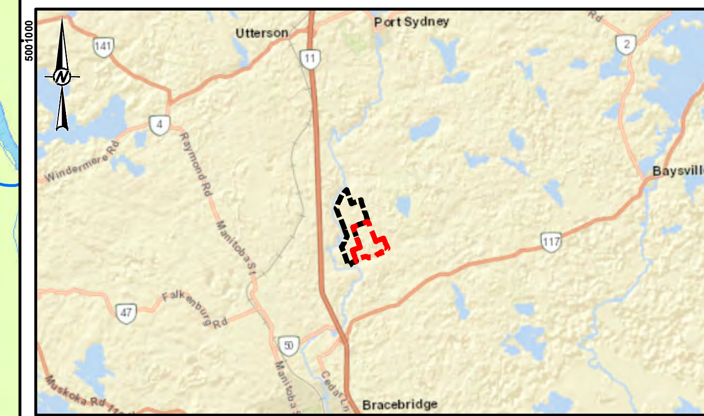
CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	27



KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 3
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- VEGETATED
- FLOODED QUARRY
- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600

1:16,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

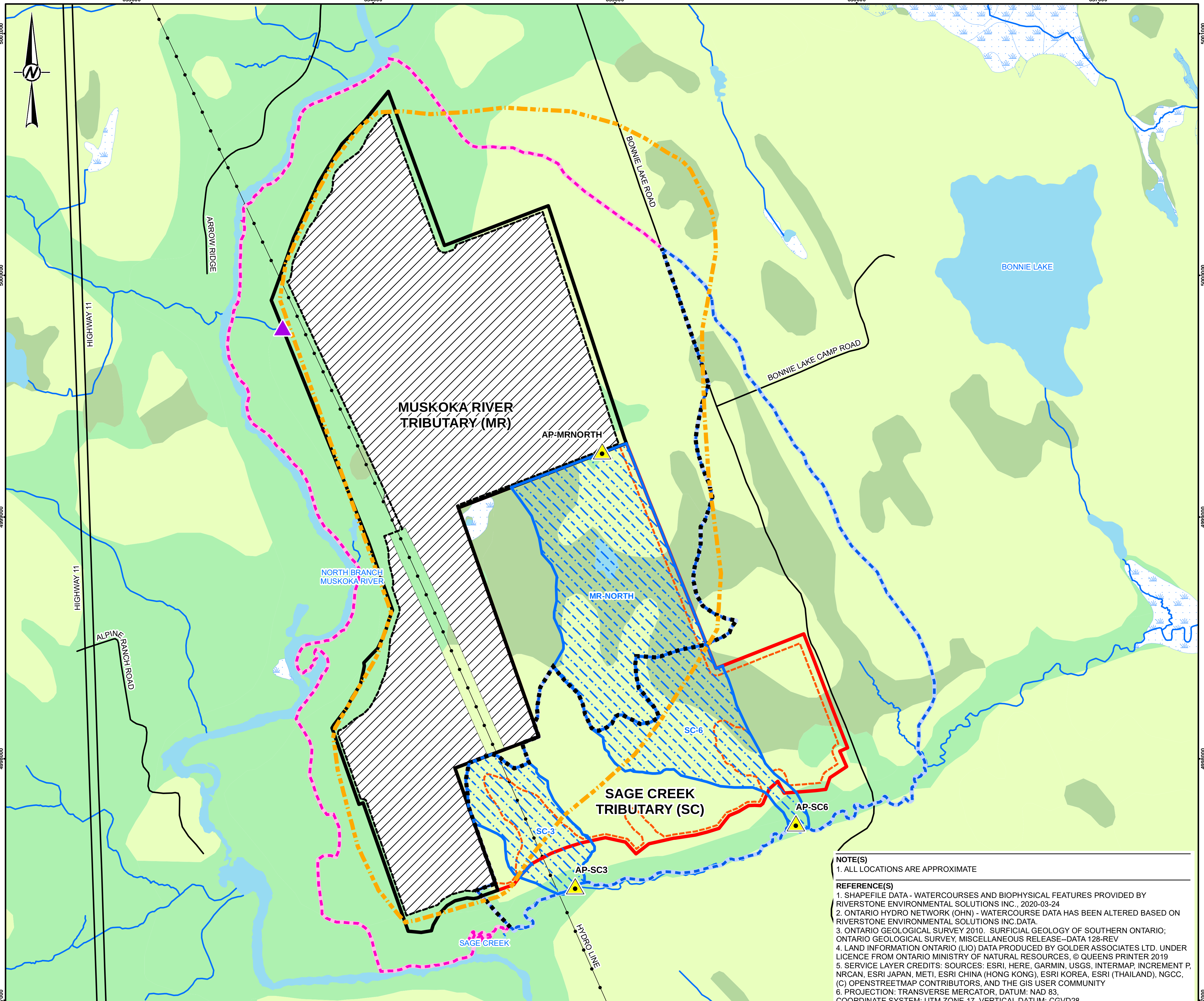
TITLE
WATER BALANCE – SCENARIO 3 (REHABILITATION) – SAGE CREEK AND MUSKOKA RIVER

CONSULTANT
GOLDER

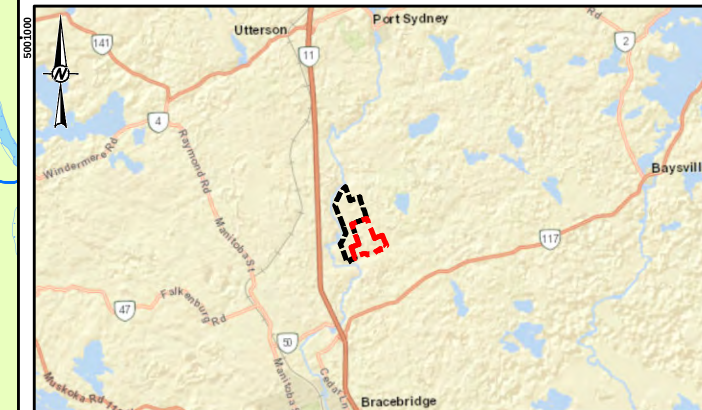
YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	28

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 1
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600
1:16,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

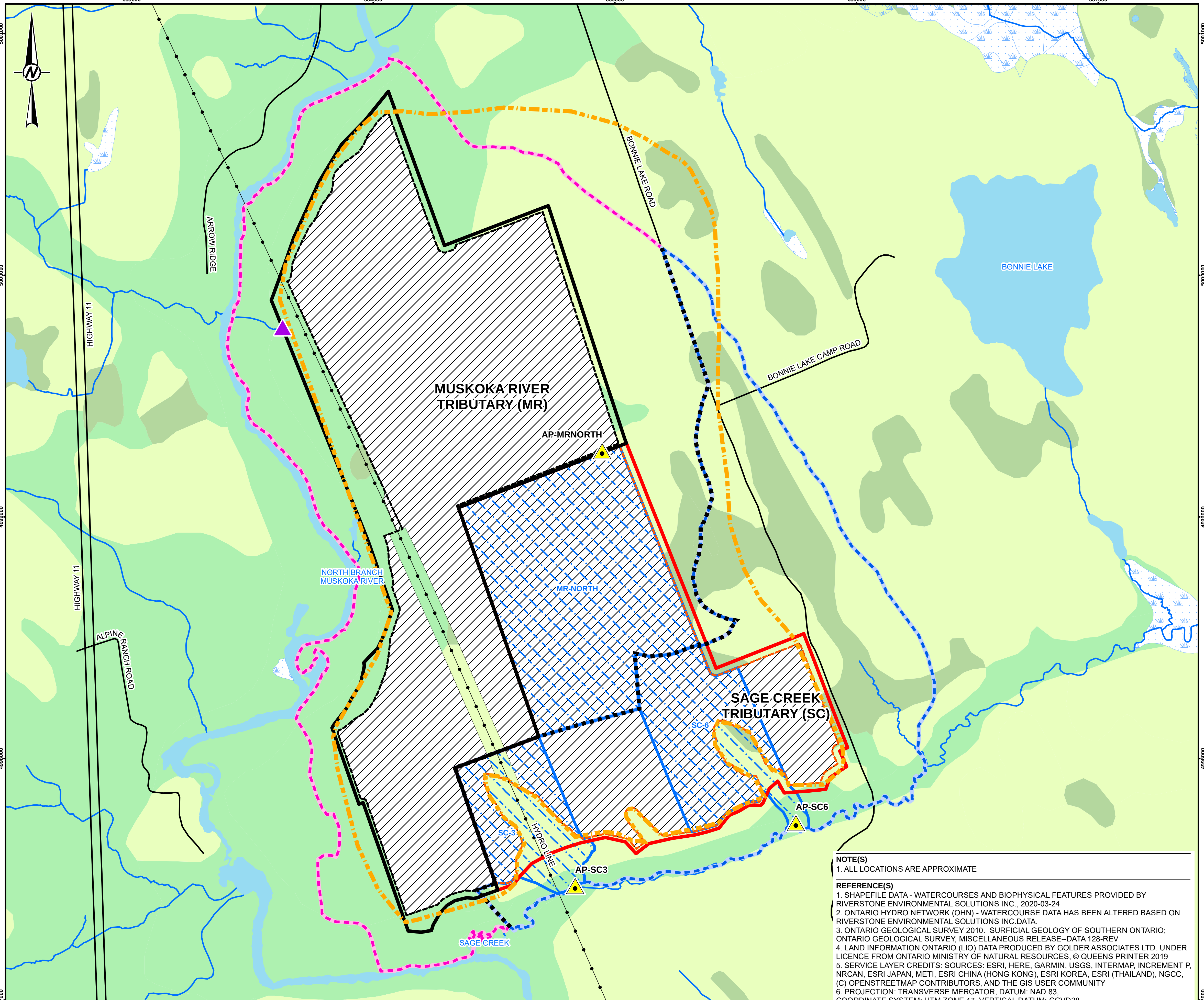
WATER BALANCE - SCENARIO 1 (LICENSED CHILDS PIT/QUARRY DEVELOPMENT) - SC-3, SC-6 AND MR-NORTH

CONSULTANT

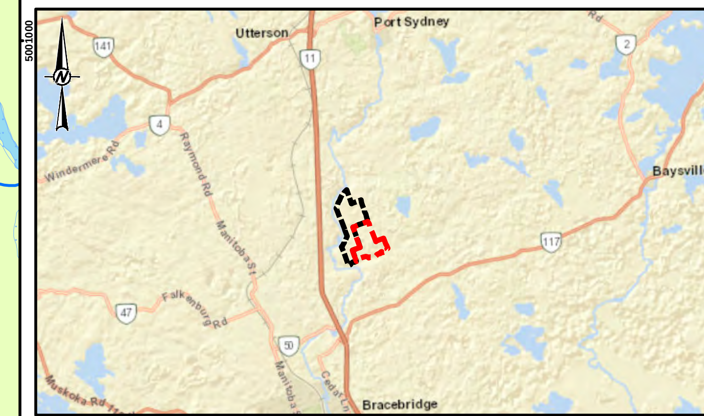
GOLDER

YYYY-MM-DD	2020-05-12
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	29



KEY MAP



SCALE 1:350,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 2
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600
1:16,000 METRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE
WATER BALANCE - SCENARIO 2 (FULL DEVELOPMENT) - SC-3, SC-6 AND MR-NORTH

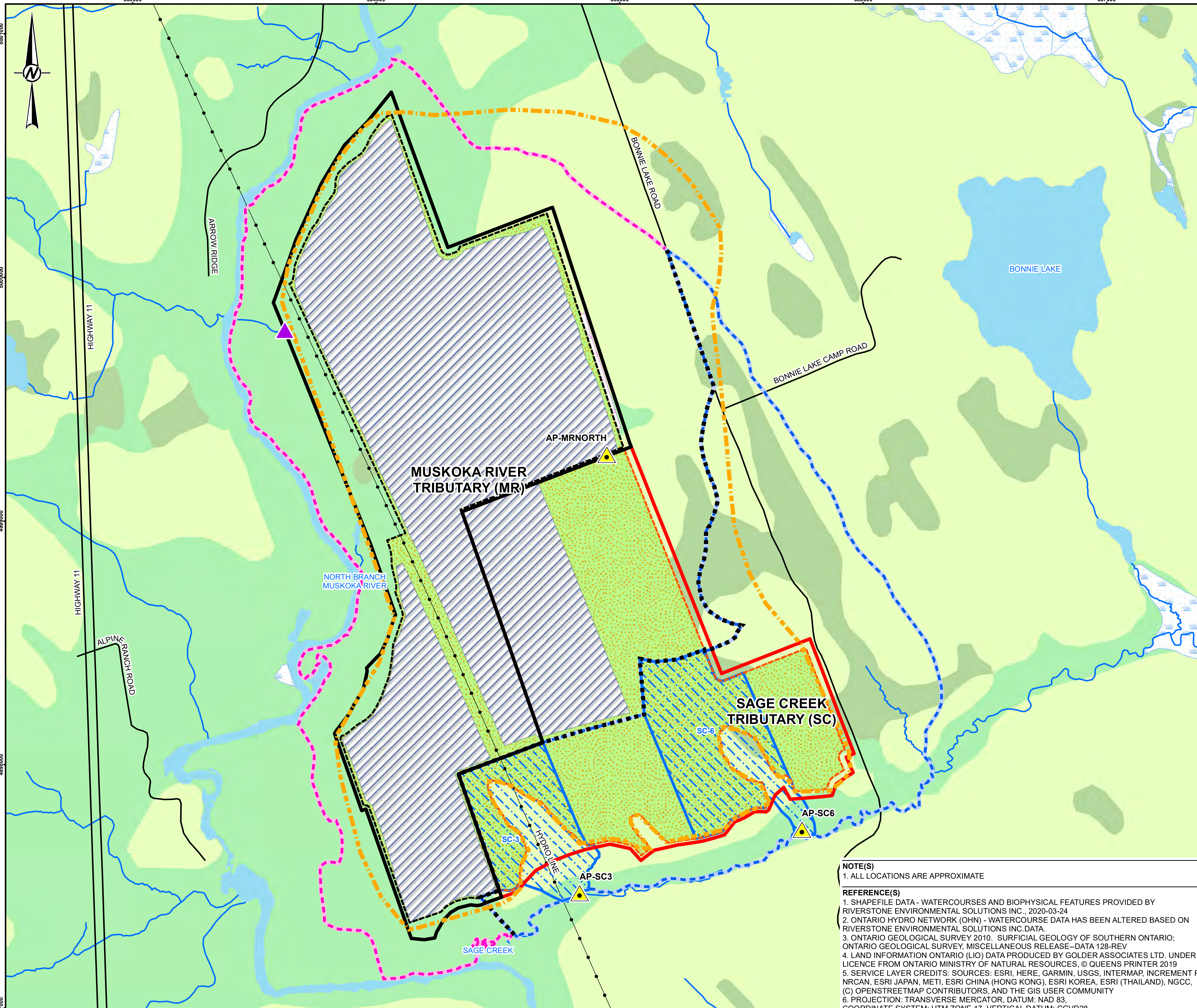
CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-13
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

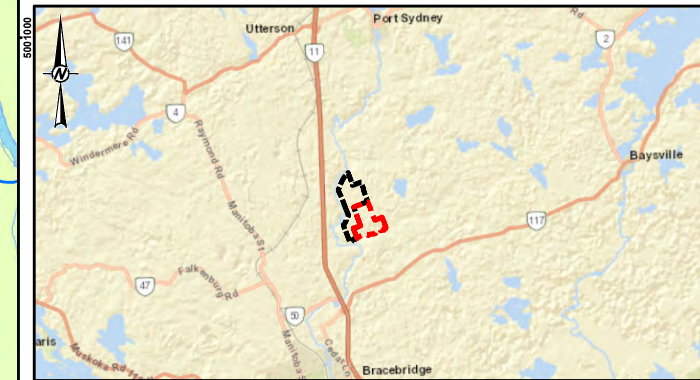
PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	30

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0008_CH_WaterBalance\1895639-0008-CH-0030.mxd



KEY MAP



SCALE 1:380,000

LEGEND

- QUARRY DRAINAGE POINT DURING REHABILITATION
- POINTS OF ASSESSMENT
- ROADWAY
- WATERCOURSE
- HYDRO LINE
- DIVIDE BETWEEN MUSKOKA RIVER AND SAGE CREEK TRIBUTARIES
- EXISTING CHILDS PIT/QUARRY LICENSE BOUNDARY
- EXISTING CHILDS PIT/QUARRY LIMIT OF EXTRACTION
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LICENSE BOUNDARY
- PROPOSED CHILDS PIT/QUARRY EXTENSION LANDS LIMIT OF EXTRACTION
- QUARRY CAPTURE ZONE - SCENARIO 3
- MUSKOKA RIVER TRIBUTARY
- SAGE CREEK TRIBUTARY
- POINTS OF ASSESSMENT AREA

LAND USE

- VEGETATED
- FLOODED QUARRY
- EXTRACTION AREA
- FOREST – ALLUVIAL
- FOREST – PRECAMBRIAN BEDROCK
- FOREST – TILL/ORGANICS
- OPEN WATER
- WETLAND

0 150 300 600

1:16,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SHAPEFILE DATA - WATERCOURSES AND BIOPHYSICAL FEATURES PROVIDED BY RIVERSTONE ENVIRONMENTAL SOLUTIONS INC., 2020-03-24
2. ONTARIO HYDRO NETWORK (OHN) - WATERCOURSE DATA HAS BEEN ALTERED BASED ON RIVERSTONE ENVIRONMENTAL SOLUTIONS INC.DATA.
3. ONTARIO GEOLOGICAL SURVEY 2010. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 128-REV
4. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
5. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
6. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 17, VERTICAL DATUM: CGVD28

CLIENT

FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT

HYDROGEOLOGICAL AND HYDROLOGICAL ASSESSMENTS - PROPOSED CHILDS PIT/QUARRY EXTENSION

TITLE

WATER BALANCE – SCENARIO 3 (REHABILITATION) – SC-3, SC-6 AND MR-NORTH

CONSULTANT

GOLDER

YYYY-MM-DD	2020-05-13
DESIGNED	----
PREPARED	BR
REVIEWED	MLE
APPROVED	KAM

PROJECT NO.	CONTROL	REV.	FIGURE
1895639	0008	0	31

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

25mm 0

Path: N:\Active\Spatial_IM\Fowler_Construction\Childs_Pit\99_PROJ\1895639_Fowler_ChildsPit\40_PROD\0008_CH_WaterBalance\1895639-0008-CH-0031.mxd

APPENDIX A

Borehole Logs and Water Well Record for TW12-1

PROJECT: 1540839

LOCATION: See Site Plan

RECORD OF BOREHOLE: OB-1

BORING DATE: November 3, 2015

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
		GROUND SURFACE					
0	Sonic Drilling 168 mm Diam.	TOPSOIL	0.00				
		Brown fine to medium SAND, some silt, trace gravel	0.24	1	121 DO	-	M
1		Brown fine to medium SAND, trace silt, trace gravel	0.76	2	121 DO	-	M
3–4				3	121 DO	-	M
5		Brown fine to coarse SAND, some gravel, trace silt	4.57	4	121 DO	-	M
				5	121 DO	-	M
6		Brown fine to medium SAND, trace silt, trace to some gravel	6.10	6	121 DO	-	M
7		Pink to grey GRANITIC GNEISS BEDROCK	6.71	7	121 DO	-	
		End of Borehole	7.62				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢ W ⊣ Wl — 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 75

GOLDER

LOGGED: KAM

CHECKED: KAM

PROJECT: 1540839

RECORD OF BOREHOLE: OB-2

SHEET 1 OF 1

LOCATION: N 4998421.0 ;E 634252.0

BORING DATE: November 2, 2015

DATUM: Geodetic

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○: 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20 40 60 80

BORING METHOD: Sonic Drilling, 168 mm Diam.

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	303.82					
0	Fine sand, some silt (TOPSOIL)	0.00	1	121 DO	-	M	Steel Protective Casing
	Red brown fine SAND, some silt, with silt pockets	0.24	2	121 DO	-	M	Cement
	Light brown fine SAND, trace to some silt, with silt pockets between 2.90 and 4.27 m depth	303.30 / 0.52	3	121 DO	-	M	Bentonite Seal
2			4	121 DO	-	M	
			5	121 DO	-	M	Native Backfill
			6	121 DO	-	M	
			7	121 DO	-	M	Silica Sand
5	Brown fine SAND, some silt, trace gravel, with silt seams	298.94 / 4.88	8	121 DO	-	M	
	Pink to black GRANITIC GNEISS BEDROCK	298.49 / 5.33	9	121 DO	-		51 mm Diam. PVC #10 Slot Screen
7			10	121 DO	-		Native Backfill
8	End of Borehole	295.90 / 7.92					

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

RECORD OF BOREHOLE: OB-3

PROJECT: 1540839 SHEET 1 OF 1

LOCATION: See Site Plan BORING DATE: November 2, 2015 DATUM:

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						
0	Sonic Drilling 168 mm Diam.	Fine to medium sand, some gravel, trace silt (TOPSOIL)	0.00	1	121 DO	-	M	
		Brown fine to medium SAND, trace silt, trace to some gravel	0.25	2	121 DO	-	M	
1		Pink to grey GRANITIC GNEISS BEDROCK	1.37	3	121 DO	-		
2		End of Borehole	2.44					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp W Wl — 20 40 60 80

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

MIS-BHS 001 1540839.GPJ GAL-MIS.GDT 4/22/20 JEM

DEPTH SCALE 1 : 75

GOLDER

LOGGED: KAM

CHECKED: KAM

PROJECT: 1540839

RECORD OF BOREHOLE: OB-4

LOCATION: N 4999208.0 ;E 634108.0

BORING DATE: November 2 & 3, 2015

DATUM: Geodetic

BORING METHOD: Sonic Drilling, 168 mm Diam.

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	307.43					
0	Brown GRAVELLY fine to medium SAND, trace silt, with cobbles	0.00	1	121 DO	-	M	Steel Protective Casing; Cement
	GRAVELLY fine to medium SAND, trace silt	305.75 / 1.68	2	121 DO	-	M	Bentonite Seal
2			3	121 DO	-	M	
			4	121 DO	-	M	
	Light brown fine to medium SAND, some gravel, trace silt	304.23 / 3.20	5	121 DO	-	M	
4	Brown GRAVELLY fine to medium SAND, trace to some silt, occasional cobble	303.16 / 4.27	6	121 DO	-	M	
	Brown fine to medium SAND, trace silt	301.94 / 5.49	7	121 DO	-	M	
6	Light brown fine SAND, some silt, with silt pockets	300.72 / 6.71	8	121 DO	-	M	
8			9	121 DO	-	M	
	Grey brown SANDY SILT, with silt pockets	298.44 / 8.99	10	121 DO	-	M	Native Backfill
10	Brown fine to medium SAND, trace silt, some gravel	296.91 / 10.52	11	121 DO	-	M	
	Brown GRAVELLY fine to medium SAND, trace silt	296.46 / 10.97	12	121 DO	-	M	
12	Light brown fine SAND, trace silt and gravel	295.24 / 12.19	13	121 DO	-	M	
	Brown fine to medium SAND, some gravel, trace silt	294.17 / 13.26	14	121 DO	-	M	
14	Brown fine to medium SAND, trace silt and gravel	293.26 / 14.17	15	121 DO	-	M	
	Brown fine to medium SAND, trace to some gravel, trace silt	292.80 / 14.63	16	121 DO	-	M	
16							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp —○W— Wl; 20 40 60 80

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 80

GOLDER

LOGGED: KAM

CHECKED: KAM

PROJECT: 1540839

RECORD OF BOREHOLE: OB-4

LOCATION: N 4999208.0 ;E 634108.0

BORING DATE: November 2 & 3, 2015

DATUM: Geodetic

BORING METHOD: Sonic Drilling, 168 mm Diam.

--- CONTINUED FROM PREVIOUS PAGE ---

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
Brown fine to medium SAND, trace to some gravel, trace silt	289.75	17	121 DO	-	M	
Brown fine to medium SAND, trace silt and gravel, with silt pockets	17.68 / 289.29	18	121 DO	-	M	
Brown fine to coarse SAND, some gravel, trace silt	18.14 / 287.92	19	121 DO	-	M	Native Backfill
Light brown fine to coarse SAND, some gravel, trace silt, occasional cobble	19.51 / 286.70	20	121 DO	-	M	
Brown fine to coarse SAND, trace to some silt, trace gravel	20.73 / 285.79	21	121 DO	-	M	
Brown GRAVELLY fine to coarse SAND, trace silt, occasional cobble	21.64 / 284.57	22	121 DO	-	M	
Brown GRAVELLY fine to medium SAND, trace to some silt	22.86 / 283.66	23	121 DO	-	M	Bentonite Seal
Brown GRAVELLY fine to coarse SAND, trace silt, occasional cobble	23.77 / 282.13	24	121 DO	-	M	
Brown GRAVELLY fine to medium SAND, trace silt	25.30 / 280.61	25	121 DO	-	M	Silica Sand
Brown fine to coarse SAND, some gravel, trace to some silt	26.82 / 280.30	26	121 DO	-	M	51 mm Diam. PVC #10 Slot Screen
Brown fine to medium SAND, trace to some silt, trace to some gravel	27.13 / 277.25	27	121 DO	-	M	
		28	121 DO	-	M	Native Backfill
End of Borehole	30.18					

DEPTH SCALE 1 : 80

GOLDER

LOGGED: KAM

CHECKED: KAM

MIS-BHS 001 1540839.GPJ GAL-MIS.GDT 4/29/20 JEM

RECORD OF BOREHOLE: OB-5

PROJECT: 1540839
LOCATION: N 4999652.0 ;E 634100.0
BORING DATE: November 3, 2015
SHEET 1 OF 2
DATUM: Geodetic

BORING METHOD: Sonic Drilling, 168 mm Diam.

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	310.35					
	TOPSOIL	0.00					Steel Protective Casing
	Grey brown to brown fine to medium SAND and GRAVEL, trace to some silt, occasional cobble, with some fine to coarse sand intervals between 5.49 and 7.92 m depth	0.25					Cement
1			1	121 DO	-	M	
							Bentonite Seal
3			2	121 DO	-	M	
7			3	121 DO	-	M	
							Native Backfill
8		302.12	4	121 DO	-	M	
	Brown fine to coarse SAND, trace silt and gravel	8.23					
9			5	121 DO	-	M	
	Brown fine SAND, some gravel, trace silt, occasional cobble	300.90 9.45					
10			6	121 DO	-	M	
	Brown fine SAND, trace silt	298.77 11.58					
12			7	121 DO	-	M	
	Grey brown SILTY fine SAND	296.79 13.56					
14			8	121 DO	-	M	Bentonite Seal
		295.72 14.63	9	121 DO	-		
15							

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 75

GOLDER

LOGGED: KAM
CHECKED: KAM

MIS-BHS 001 1540839.GPJ GAL-MIS.GDT 4/29/20 JEM

PROJECT: 1540839

RECORD OF BOREHOLE: OB-5

LOCATION: N 4999652.0 ;E 634100.0

BORING DATE: November 3, 2015

DATUM: Geodetic

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
15	Sonic Drilling, 168 mm Diam.	Brown fine to coarse SAND, trace silt and gravel, occasional coarse sand seam						Bentonite Seal
16				9	121 DO	-	M	Silica Sand
17			292.67 / 17.68					51 mm Diam. PVC #10 Slot Screen
18		Brown fine to coarse SAND, trace gravel, trace silt	292.21 / 18.14	10	121 DO	-	M	
		Brown GRAVELLY fine to coarse SAND, trace silt	291.45 / 18.90	11	121 DO	-	M	
19		Brown fine to coarse SAND, some silt and gravel	291.15 / 19.20	12	121 DO	-	M	
		Pink to grey GRANITIC GNEISS BEDROCK	289.93 / 20.42	13	121 DO	-		Native Backfill
20		End of Borehole						

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT: Wp W Wl 20 40 60 80

Depth scale: 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

MIS-BHS 001 1540839.GPJ GAL-MIS.GDT 4/29/20 JEM

DEPTH SCALE
1 : 75

GOLDER

LOGGED: KAM
CHECKED: KAM

RECORD OF BOREHOLE: DDH15-01

PROJECT: 1540839

LOCATION: N 4998414; E 635539

BORING DATE: December 1 to 4, 2015

DRILL CONTRACTOR: Downing Drilling

SHEET 1 OF 2

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS A (N E)	B (N E)
0		GROUND SURFACE		334.00			334			Pipe Ø32 mm
		OVERBURDEN		333.4 0.6						
2							332		Bentonite	Bentonite
4							330			
6							328			Filter Sand
8							326			
10		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					324			
12							322		Filter Sand	Screen
14							320			
16							318			
18							316		Bentonite	
20							314			

--- CONTINUED NEXT PAGE ---

DEPTH SCALE

1 : 100

GOLDER

LOGGED: SCL

CHECKED: *KM*

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-01

LOCATION: N 4998414; E 635539

BORING DATE: December 1 to 4, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS (A: N E; B: N E)
		--- CONTINUED FROM PREVIOUS PAGE ---		334.00					
20							314		Bentonite
22							312		
24		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					310		
26							308		Filter Sand Screen
28							306		
30		END OF BOREHOLE		304.0 30.0			304		
32									
34									
36									
38									
40									

SUD_ENV_001 Y:\SUDBURY\CAD-GIS\CAD\PROJECTS\2015\1540839 FOWLER CHILDS\1540839 MW.GPJ GLDR_LDN.GDT 4/29/20

DEPTH SCALE
1 : 100

GOLDER

LOGGED: SCL
CHECKED: KM

RECORD OF BOREHOLE: DDH15-02

PROJECT: 1540839

LOCATION: N 4998581; E 635328

BORING DATE: December 6 to 13, 2015

DRILL CONTRACTOR: Downing Drilling

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
0		GROUND SURFACE		331.95					Pipe Ø32 mm
		OVERBURDEN		331.4 0.6					
2							330		
4							328		A: Bentonite; B: Bentonite
6							326		
8							324		
10		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					322		B: Filter Sand
12							320		
14							318		A: Filter Sand
16							316		B: Screen
18							314		
20				312.1			312		

A: N E — B: N E

--- CONTINUED NEXT PAGE ---

DEPTH SCALE
1 : 100

GOLDER

LOGGED: SCL
CHECKED: *KM*

RECORD OF BOREHOLE: DDH15-02

PROJECT: 1540839
LOCATION: N 4998581; E 635328
BORING DATE: December 6 to 13, 2015
DRILL CONTRACTOR: Downing Drilling

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS (A: N, E; B: N, E)
		--- CONTINUED FROM PREVIOUS PAGE ---		331.95					
20		MONZOGRANITE - Pink - Gneissic with relict igneous textures		19.8					Screen; Filter Sand
22		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)		310.0 22.0			310		Bentonite
24							308		
26							306		
28							304		
30							302		
32							300		
34							298		
36							296		
38							294		
40							292		
		--- CONTINUED NEXT PAGE ---							

DEPTH SCALE
1 : 100

GOLDER

LOGGED: SCL
CHECKED: *KM*

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-02

LOCATION: N 4998581; E 635328

BORING DATE: December 6 to 13, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES – NUMBER	SAMPLES – TYPE	ELEVATION		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS (A: N E; B: N E)
		--- CONTINUED FROM PREVIOUS PAGE ---		331.95						
40										
42							290			Bentonite
44							288			
46							286			
48							284			
50		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					282			
52							280			Sand
54							278			
56							276			
58							274			
60							272			Bentonite
		--- CONTINUED NEXT PAGE ---								

DEPTH SCALE

1 : 100

GOLDER

LOGGED: SCL

CHECKED: *KM*

SUD_ENV_001 Y:\SUDBURY\CAD-GIS\CAD\PROJECTS\2015\1540839 FOWLER CHILDS\1540839 MW.GPJ GLDR_LDN.GDT 4/29/20

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-02

LOCATION: N 4998581; E 635328

BORING DATE: December 6 to 13, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	ELEVATION		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS A (N E) B (N E)
		--- CONTINUED FROM PREVIOUS PAGE ---		331.95						
60										
62							270			
64							268			Bentonite
66							266			
68		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					264			
70							262			
72							260			
74							258			Filter Sand
76				255.4 76.6			256			
78		MONZOGRANITE - gneissic fabric with relict igneous texture - fine-coarse crystal size - occasional grey gneiss bands - estimated equal proportions of quartz, plagioclase, and alkali feldspar - biotite present					254			
80							252			
		--- CONTINUED NEXT PAGE ---								

--- CONTINUED NEXT PAGE ---

DEPTH SCALE
1 : 100

GOLDER

LOGGED: SCL
CHECKED: KM

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-02

LOCATION: N 4998581; E 635328

BORING DATE: December 6 to 13, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		--- CONTINUED FROM PREVIOUS PAGE ---		331.95					
80									
82							250		
84							248		
86		MONZOGRANITE - gneissic fabric with relict igneous texture - fine-coarse crystal size - occasional grey gneiss bands - estimated equal proportions of quartz, plagioclase, and alkali feldspar - biotite present					246		Filter Sand
88							244		Screen
90							242		
		END OF BOREHOLE		240.4 91.6					
92									
94									
96									
98									
100									

INSTALLATION AND GROUNDWATER OBSERVATIONS: A N E; B N E

SUD_ENV_001 Y:\SUDBURY\CAD-GIS\CAD\PROJECTS\2015\1540839 FOWLER CHILDS\1540839 MW.GPJ GLDR_LDN.GDT 4/29/20

DEPTH SCALE

1 : 100

GOLDER

LOGGED: SCL

CHECKED: KM

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-03

LOCATION: N 4998983; E 635144

BORING DATE: December 4 to 6, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES – NUMBER	SAMPLES – TYPE	ELEVATION		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS A (N, E)	INSTALLATION AND GROUNDWATER OBSERVATIONS B (N, E)
0		GROUND SURFACE		323.88							Pipe Ø32 mm
		OVERBURDEN		323.2 / 0.7							
2							322			Bentonite	Bentonite
4							320				
6							318				
											Filter Sand
8							316				
10		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					314				
12							312			Filter Sand	Screen
14							310				
16							308				
18							306			Bentonite	
20							304				

--- CONTINUED NEXT PAGE ---

DEPTH SCALE

1 : 100

GOLDER

LOGGED: SCL

CHECKED: *KM*

PROJECT: 1540839

RECORD OF BOREHOLE: DDH15-03

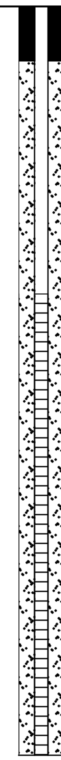
LOCATION: N 4998983; E 635144

BORING DATE: December 4 to 6, 2015

DATUM: Geodetic

DRILL CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS (A: N E; B: N E)
		--- CONTINUED FROM PREVIOUS PAGE ---		323.88					
20									Bentonite
22							302		
24		GREY GNEISS - estimated 10-30% miscaceous minerals - estimated granodioritic composition - laminated fabric - fine-medium crystal size - common veins or bands of quartzofeldspathic rock (pink with fine-coarse crystal size)					300		Filter Sand Screen
26							298		
28							296		
30		END OF BOREHOLE		294.0 29.9			294		
32									
34									
36									
38									
40									



DEPTH SCALE
1 : 100

GOLDER

LOGGED: SCL
CHECKED: KM

RECORD OF BOREHOLE: 18-04

PROJECT: 1895639

LOCATION: N 4998206.0 ;E 635070.0

BORING DATE: July 13, 2018

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		327.24							
0		Overburden		0.00							159 mm Diam. Steel Casing from 0.00 m to 4.27 m
2											Bentonite Seal
3		Metamorphic Bedrock		324.24 3.00							
4											Silica Sand
8											32 mm Diam. PVC #10 Slot Screen 'C'
11											Silica Sand
12											Bentonite Seal
13											Silica Sand
14											32 mm Diam. PVC #10 Slot Screen 'B'
15											

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 75

GOLDER

LOGGED: KAM

CHECKED: JPAO

PROJECT: 1895639

RECORD OF BOREHOLE: 18-04

LOCATION: N 4998206.0 ;E 635070.0

BORING DATE: July 13, 2018

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
15		Metamorphic Bedrock									
16											
17											
18											32 mm Diam. PVC #10 Slot Screen 'B'
19											
20											
21											Silica Sand
22											Bentonite Seal
23											Silica Sand
24											
25											
26											
27											32 mm Diam. PVC #10 Slot Screen 'A'
28											
29											
30											
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 75

GOLDER

LOGGED: KAM

CHECKED: JPAO

PROJECT: 1895639

RECORD OF BOREHOLE: 18-04

LOCATION: N 4998206.0 ;E 635070.0

BORING DATE: July 13, 2018

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- *CONTINUED FROM PREVIOUS PAGE* ---									
30		Metamorphic Bedrock									
31											32 mm Diam. PVC #10 Slot Screen 'A'
32											
33				294.17 33.07							
		End of Borehole									
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											

DEPTH SCALE

1 : 75

GOLDER

LOGGED: KAM

CHECKED: JPAO

TW12-1

Ontario Ministry of the Environment

Well Tag No. Tag#: A123104

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: ☐ Metric ☑ Imperial

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
FOWLER CONSTRUCTION COMPANY LIMITED			

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
P.O. BOX 630, 1206 ROSEWARNE DR.	BRACEBRIDGE	ON	P1L1T9	7056452214

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1255 BONNIE LAKE ROAD	MACAULEY	17	9

County/District/Municipality	City/Town/Village	Province	Postal Code
MUSKOKA	BRACEBRIDGE	Ontario	P1L1T9

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	635718	4998099		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
GREY	GRANITE		SOFT	0	330

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0	20	BENTONITE	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☑ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☑ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6 1/8	STEEL	.188	0	20

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Status of Well

☐ Water Supply ☐ Replacement Well ☑ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Water Details

Water found at Depth (m/ft) ☐ Gas — Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Water found at Depth (m/ft) ☐ Gas — Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Water found at Depth (m/ft) ☐ Gas — Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify NO WATER

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM) NIL

Disinfected? ☐ Yes ☑ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.

Comments: TEST HOLE NO WATER

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
HALIBURTON ARTESIAN WELL DRILLERS	6016

Business Address (Street Number/Name)	Municipality
BOX 423	HALIBURTON

Province	Postal Code	Business E-mail Address
ON	K0M1S0	

Bus.Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
7054572686	KUTTIG RICK

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T1112		20120530

Well owner's information package delivered ☐ Yes ☑ No

Date Package Delivered: YYYYMMDD

Date Work Completed: 20120419

Ministry Use Only

Audit No. Z139414

Received JUN 12 2012

Ministry's Copy

APPENDIX B

Pre-Construction Private Well Survey Results

CLIENT: **Fowler Construction**

LOCATION: **Bracebridge, ON**

LEGEND: NA - NOT AVAILABLE

ADDRESS		WELL DEPTH (ft)	STATIC WATER LEVEL (m)	TYPE	LOCATION
1005	Bonnie Lake Camp Road	NA	NA	NA	NA
1010	Bonnie Lake Camp Road	NA	NA	NA	NA
1010	Bonnie Lake Road	NA	NA	Dug	SW of home
1026	Bonnie Lake Road	450	4.69	Drilled	W of home
1034	Bonnie Lake Road	NA	NA	Dug	W of home
1036	Bonnie Lake Road	450	5.22	Drilled	N of home
1044	Bonnie Lake Road	25	NA	Dug	W of home
1050	Bonnie Lake Road	30	NA	Dug	S of home
1054	Bonnie Lake Road	NA	12.10	NA	NA
1056	Bonnie Lake Road	15	2.60	Dug	W of home
1062	Bonnie Lake Road	NA	2.00	Dug	E of home
1068	Bonnie Lake Road	65	2.30	Drilled	NW of home
1070	Bonnie Lake Road	60	NA	NA	NA
1074	Bonnie Lake Road	NA	NA	Drilled	SW of home
1078	Bonnie Lake Road	NA	2.30	Dug	NW of home
1080	Bonnie Lake Road	NA	NA	Drilled	W of home.
1082	Bonnie Lake Road	50	3.30	Dug	SW of home
1084	Bonnie Lake Road	400	NA	Drilled	E of home
1092	Bonnie Lake Road	398	0.90	Drilled	E of home
1094	Bonnie Lake Road	350	4.33	Drilled	W of home.
1096	Bonnie Lake Road	NA	NA	NA	NA
1150	Bonnie Lake Road	NA	NA	Drilled	NW of home
1163	Bonnie Lake Road	NA	NA	Drilled	S of home
1165	Bonnie Lake Road	NA	NA	Drilled	N of home
1166	Bonnie Lake Road	NA	NA	Drilled	SW of home
1174	Bonnie Lake Road	100	NA	Drilled	SW of home
1183	Bonnie Lake Road	NA	17.87	Drilled	NW of home

CLIENT: **Fowler Construction**

LOCATION: **Bracebridge, ON**

LEGEND: NA - NOT AVAILABLE

ADDRESS		WELL DEPTH (ft)	STATIC WATER LEVEL (m)	TYPE	LOCATION
1186	Bonnie Lake Road	275	NA	Drilled	S of home
1189	Bonnie Lake Road	200	NA	Drilled	NW of home
1190	Bonnie Lake Road	580	32 +	Drilled	SW of home
1193	Bonnie Lake Road	300	NA	Drilled	NW of home
1213	Bonnie Lake Road	30	1.30	Dug	S of home
1218	Bonnie Lake Road	400	NA	Drilled	W of home
1228	Bonnie Lake Road	NA	NA	NA	NA
1235	Bonnie Lake Road	5	NA	Drilled	NA
1239	Bonnie Lake Road	NA	NA	Dug	NE of home
1240	Bonnie Lake Road	NA	1.25	Dug	N of home
1254	Bonnie Lake Road	325	NA	Drilled	NW of home
1255	Bonnie Lake Road	NA	NA	NA	NA
1260	Bonnie Lake Road	NA	NA	Drilled	NW of home
1270	Bonnie Lake Road	3	NA	Dug	NW of home
1280	Bonnie Lake Road	15	0.87	Dug	N of home
1285	Bonnie Lake Road	400	8.60	Drilled	N of home
1290	Bonnie Lake Road	150	2.55	Drilled	S of home
1300	Bonnie Lake Road	300	NA	Drilled	W of home
1300	Bonnie Lake Road	NA	1.07	Dug	S of home
1303	Bonnie Lake Road	NA	0.50	Drilled	N of home
1309	Bonnie Lake Road	NA	NA	Drilled	W of home
1310	Bonnie Lake Road	400	NA	Drilled	SW of home
1350	Bonnie Lake Road	300	1.95	Drilled	S of home
1367	Bonnie Lake Road	NA	NA	Drilled	N of home
1387	Bonnie Lake Road	NA	11.50	Drilled	SW of home
1390	Bonnie Lake Road	380	NA	Drilled	W of home
1407	Bonnie Lake Road	1640	NA	Drilled	E of home

Childs Rd

CLIENT: **Fowler Construction**

LOCATION: **Bracebridge, ON**

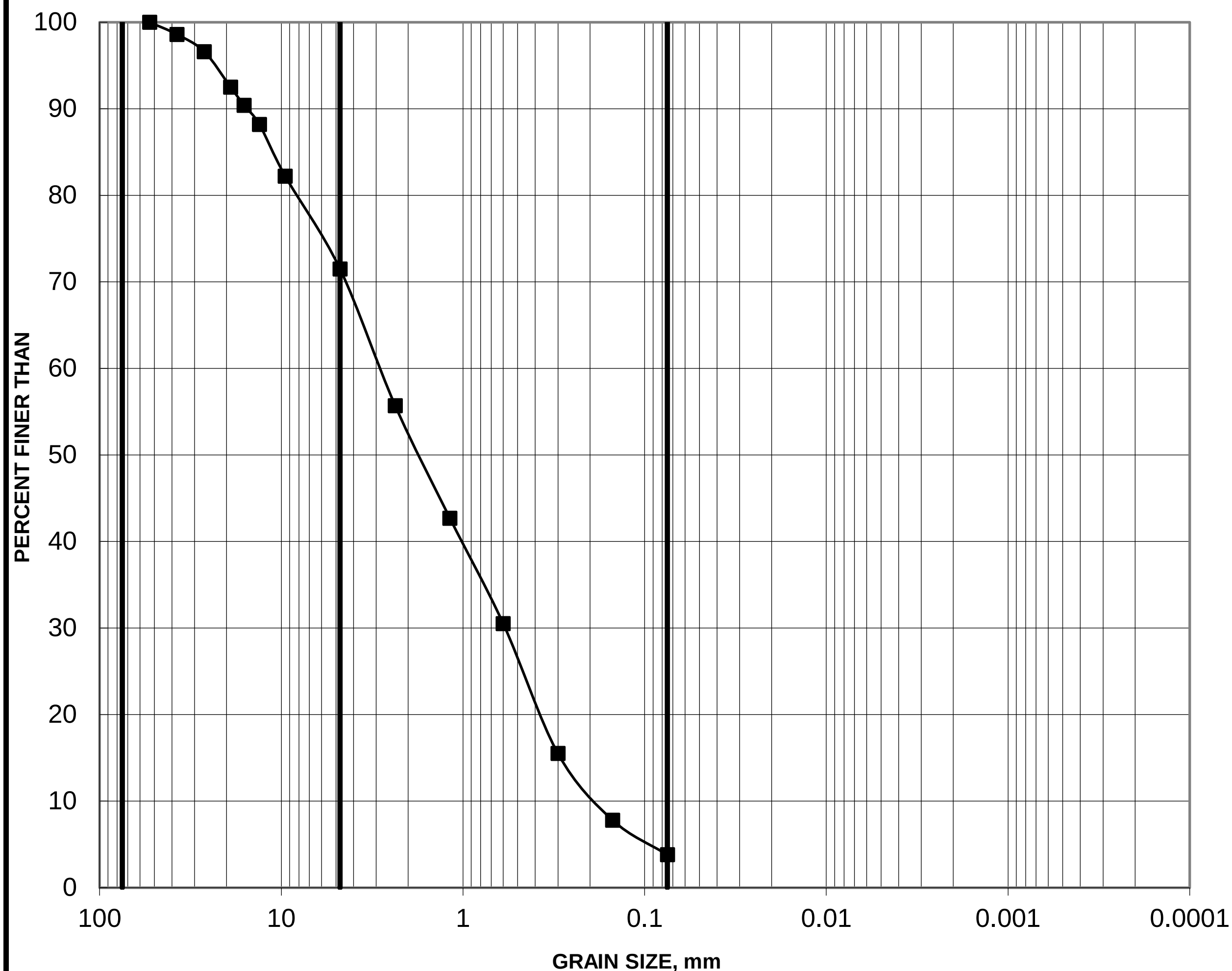
LEGEND: NA - NOT AVAILABLE

ADDRESS		WELL DEPTH (ft)	STATIC WATER LEVEL (m)	TYPE	LOCATION
1439	Bonnie Lake Road	480	10.20	Drilled	E of home
1478	Bonnie Lake Road	NA	NA	Drilled	W of home
1482	Bonnie Lake Road	NA	NA	Drilled	S of home
1492	Bonnie Lake Road	NA	3.00	Drilled	W of home
1498	Bonnie Lake Road	400	NA	Drilled	SE of home
1515	Bonnie Lake Road	30	NA	Dug	NW of home
1530	Bonnie Lake Road	NA	NA	NA	NA
1535	Bonnie Lake Road	NA	NA	NA	NA
1537	Bonnie Lake Road	NA	NA	NA	NA
1544	Bonnie Lake Road	15	NA	Dug	NW of home
1548	Bonnie Lake Road	328	NA	Drilled	NW of home
1548	Bonnie Lake Road	500	NA	Drilled	S of home
1255	Muskoka Roadd 117	NA	1.92	Dug	NW of home

APPENDIX C

Grain Size Curves

GRAIN SIZE DISTRIBUTION



Cobble Size	coarse	fine	coarse	medium	fine	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
OB-1	4	4.57-5.49

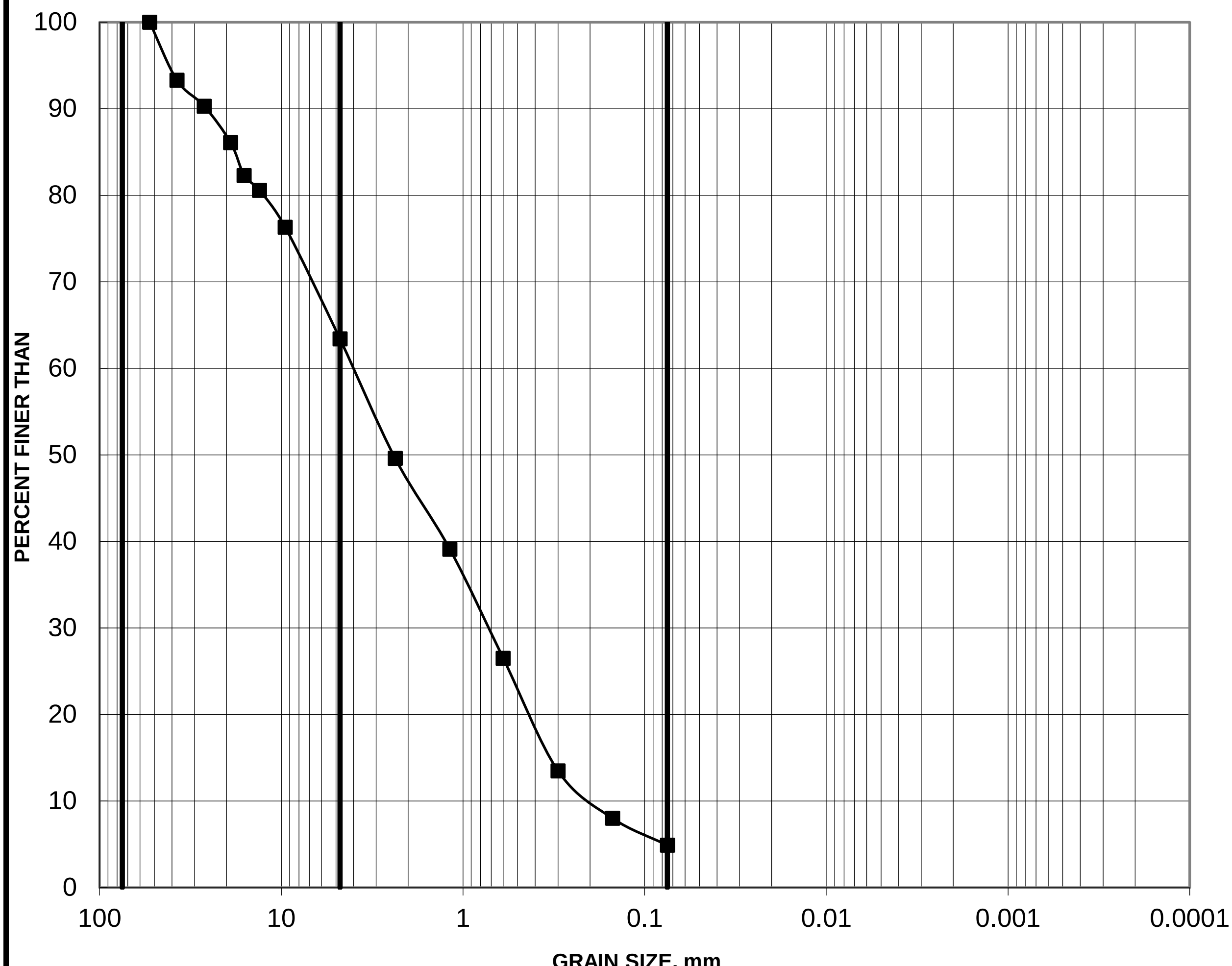
Note : Testing performed by Fowler Construction Co. Ltd.

Project: 1540839 **Golder Associates**

Created by: ___

Checked by: ___

GRAIN SIZE DISTRIBUTION



Cobble Size	coarse	fine	coarse	medium	fine	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
OB-1	5	5.49-6.10

Note : Testing performed by Fowler Construction Co. Ltd.

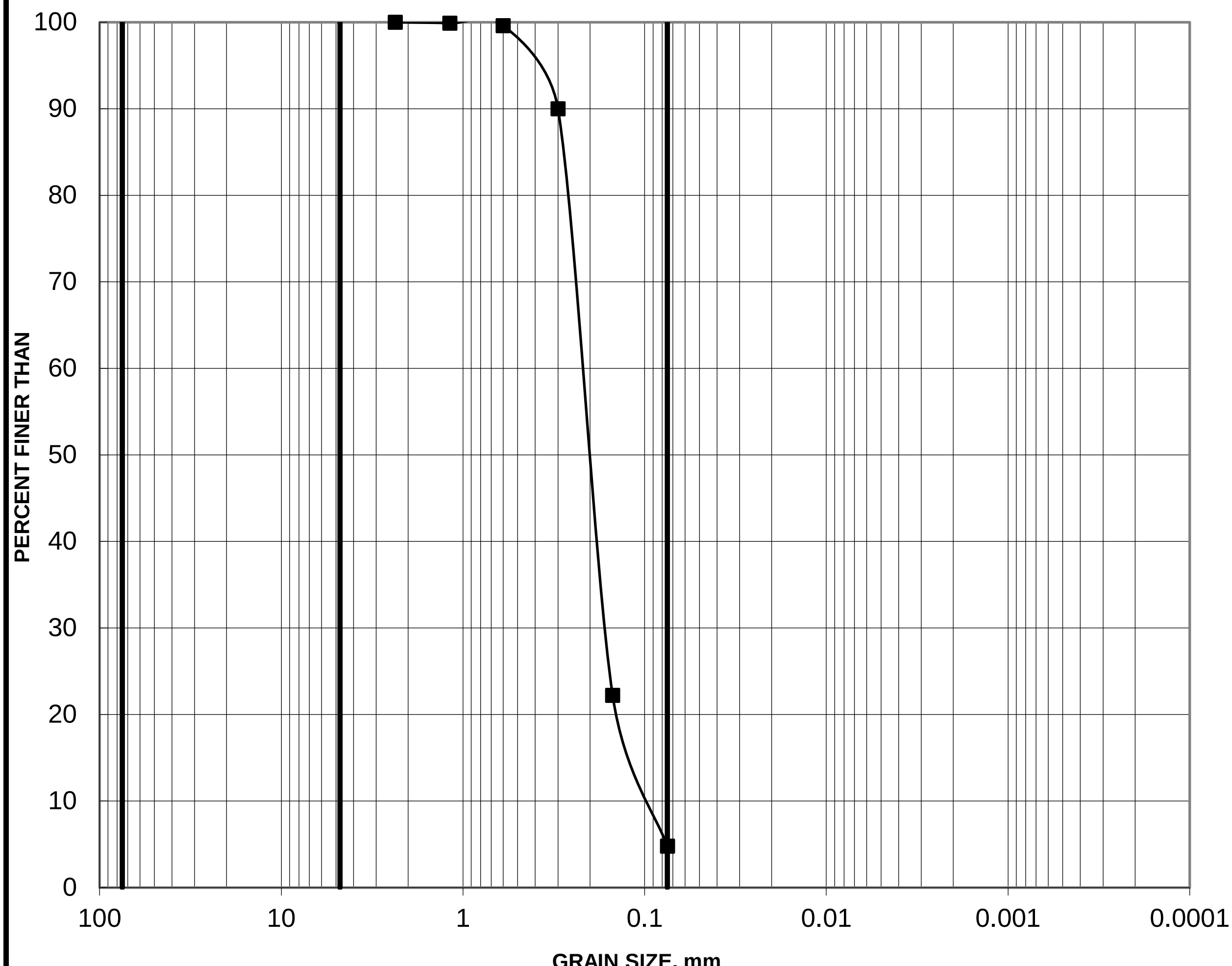
Project: 1540839

Golder Associates

Created by: ___

Checked by: ___

GRAIN SIZE DISTRIBUTION



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
OB-2	6	2.90-4.27

Note : Testing performed by Fowler Construction Co. Ltd.

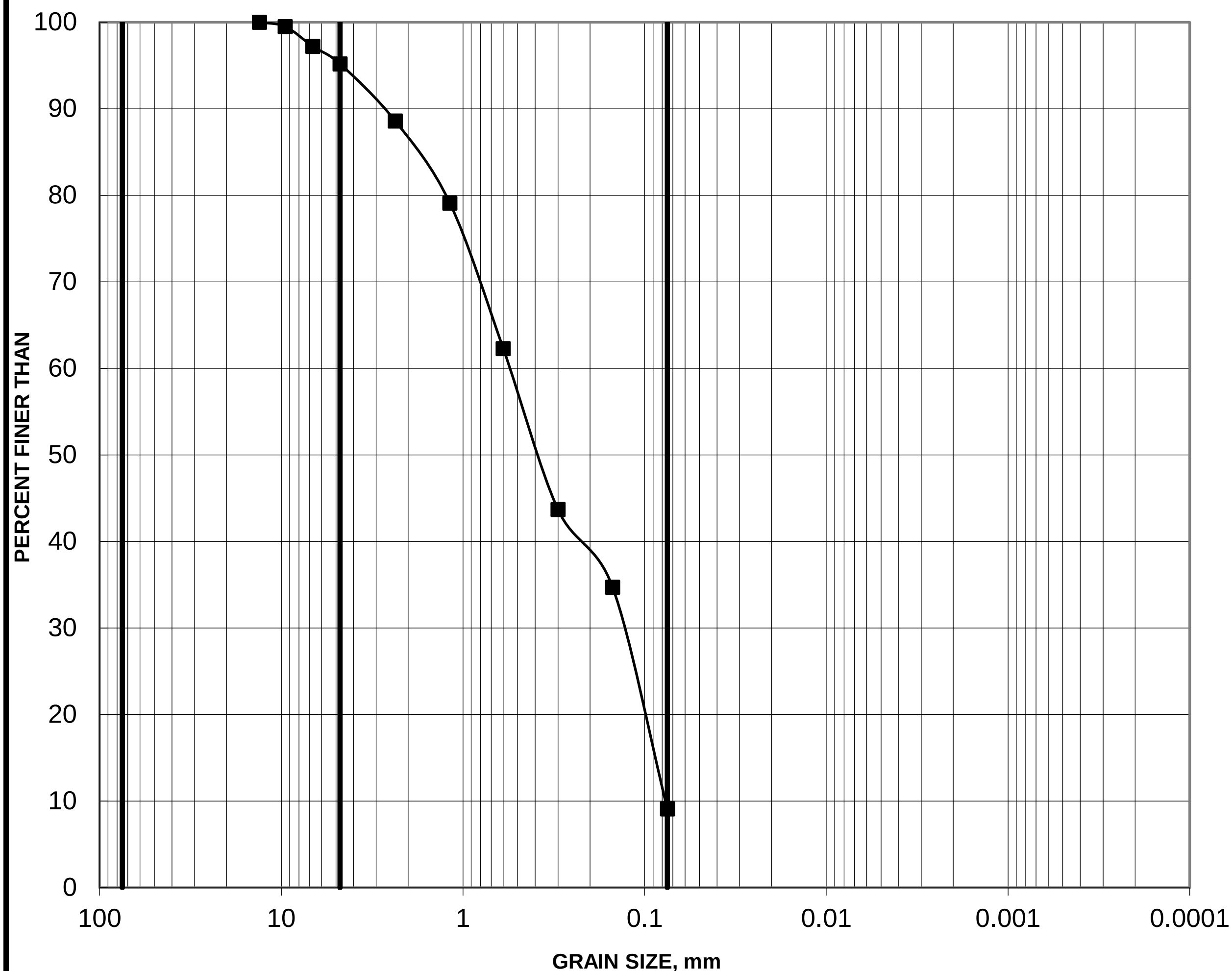
Project: 1540839

Golder Associates

Created by: ___

Checked by: ___

GRAIN SIZE DISTRIBUTION



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

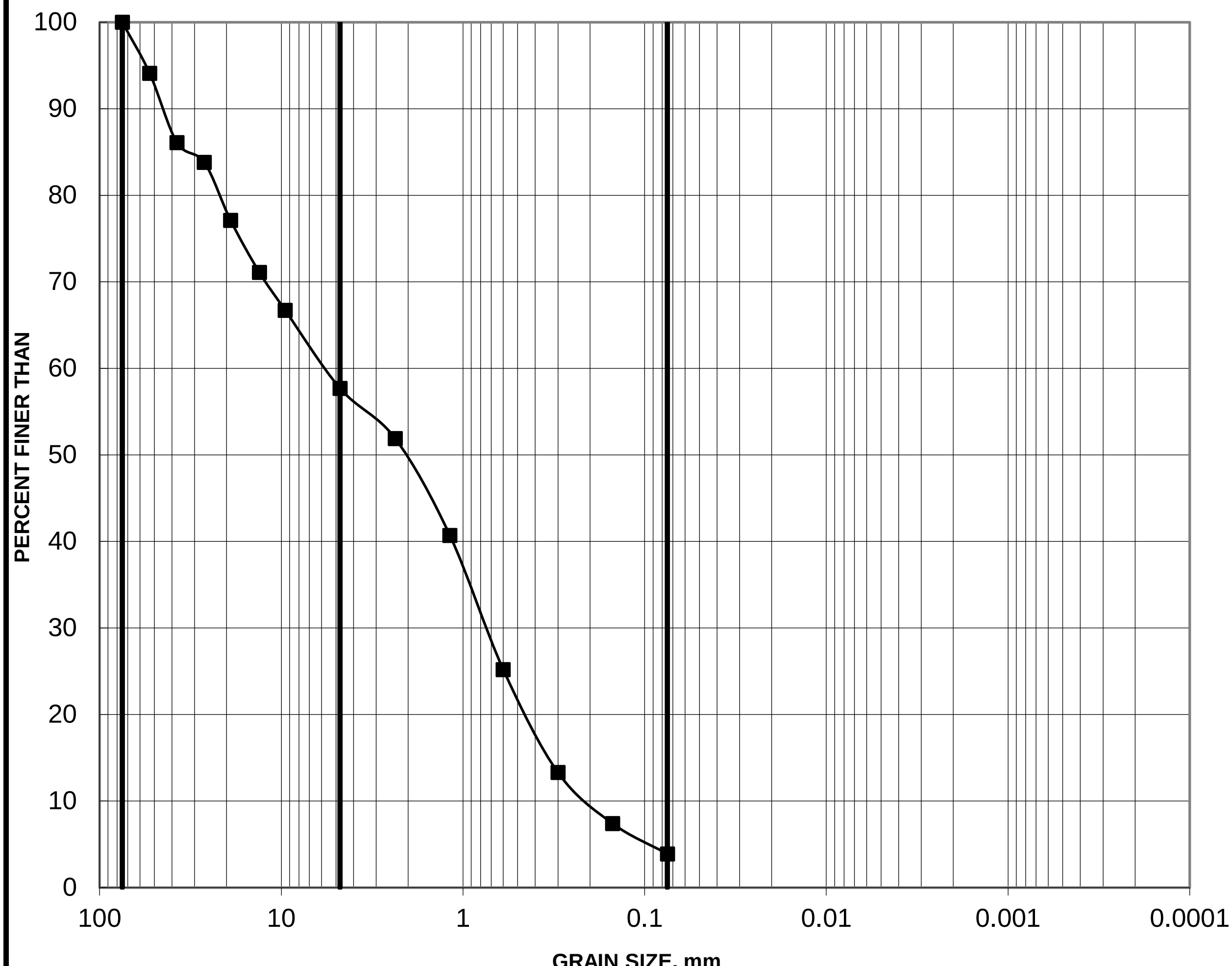
Borehole	Sample	Depth (m)
OB-3	2	0.25-1.37

Note : Testing performed by Fowler Construction Co. Ltd.

Created by: ___
Checked by: ___

Project: 1540839 **Golder Associates**

GRAIN SIZE DISTRIBUTION



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
OB-4	24	23.77-25.30

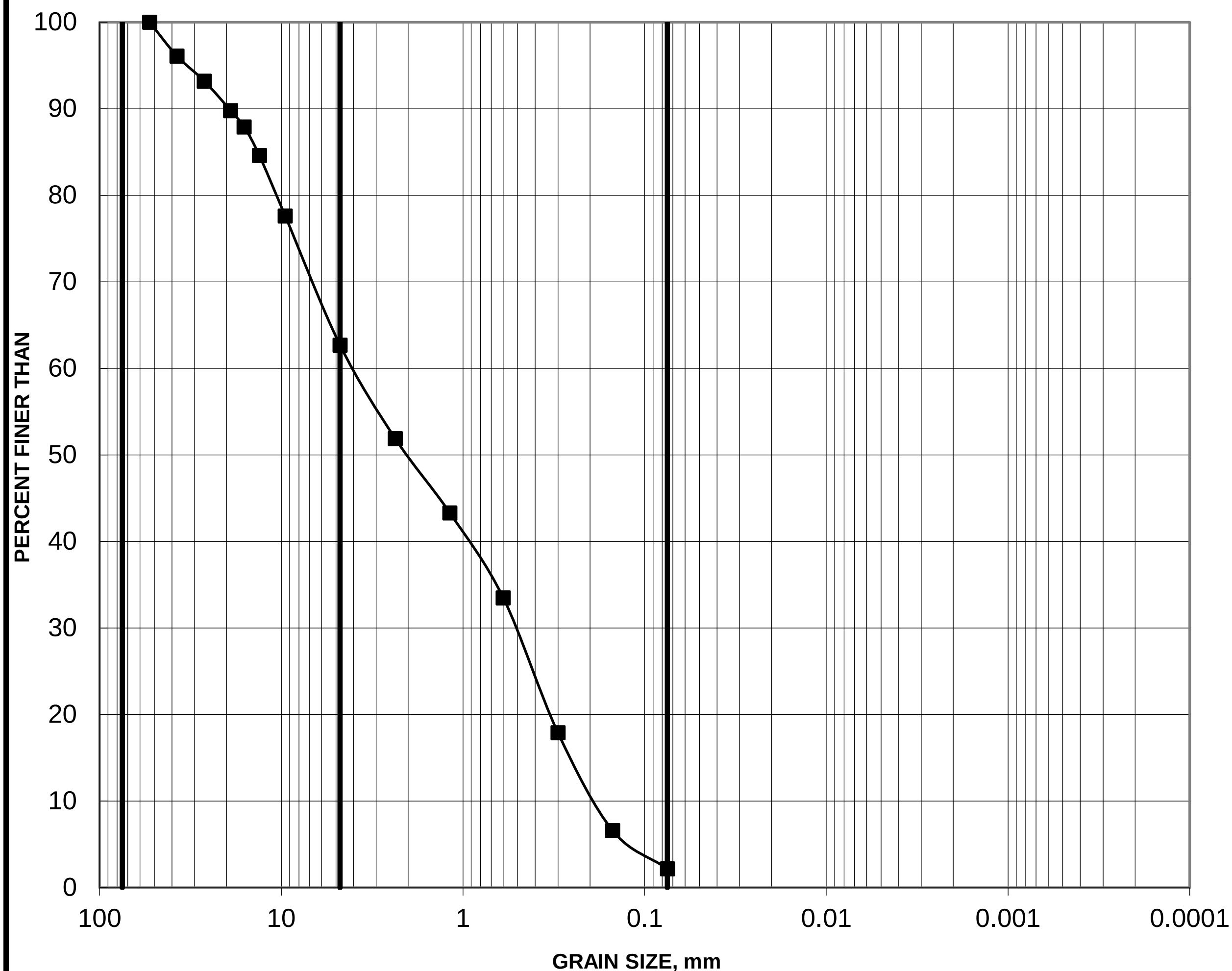
Note : Testing performed by Fowler Construction Co. Ltd.

Project: 1540839 **Golder Associates**

Created by: ___

Checked by: ___

GRAIN SIZE DISTRIBUTION



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
OB-5	11	18.14-18.90

Note : Testing performed by Fowler Construction Co. Ltd.

Project: 1540839

Golder Associates

Created by: ___

Checked by: ___

APPENDIX D

Results of Hydraulic Conductivity Testing

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-01A

INTERVAL (metres below ground surface)

Top of Interval = **24.1**
Bottom of Interval = **30.1**

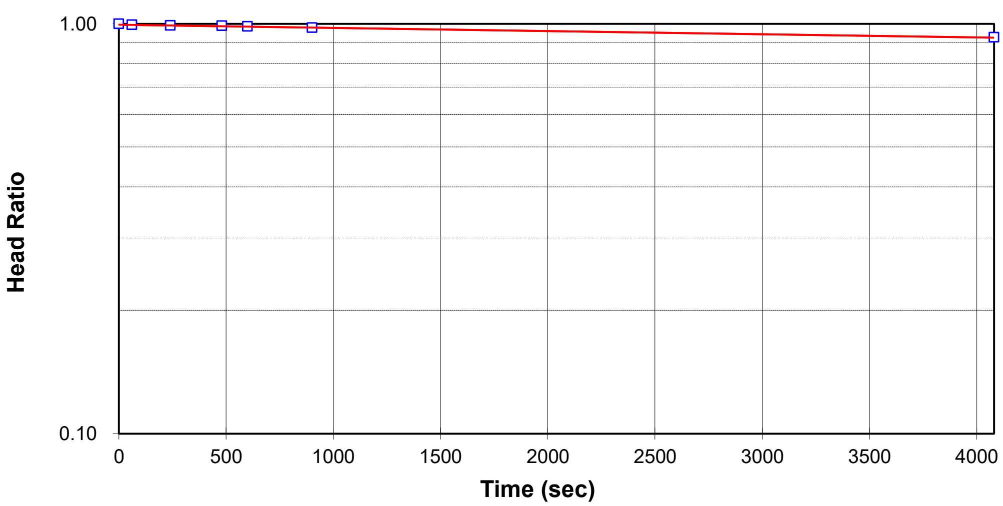
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	4.8E-02
L_e =	6.0
t_1 =	0
t_2 =	100000
h_1/h_0 =	1.00
h_2/h_0 =	0.17

RESULTS

K=	2E-09	m/sec
K=	2E-07	cm/sec



Project Name: Fowler Child Pit ARA Bracebridge
Project No.: 1895639
Test Date: 03/08/2018

Analysis By: DH
Checked By: CWT
Analysis Date: 27/08/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-01B

INTERVAL (metres below ground surface)

Top of Interval = 8.8
Bottom of Interval = 14.9

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

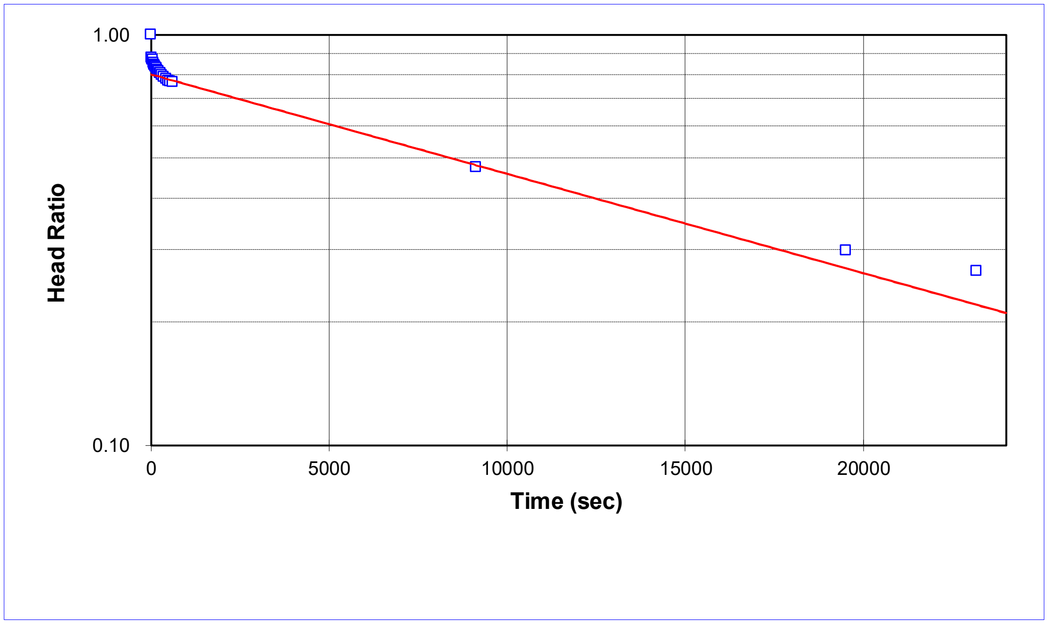
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	1.6E-02
R_e =	4.8E-02
L_e =	6.1
t_1 =	0
t_2 =	24000
h_1/h_0 =	0.80
h_2/h_0 =	0.21

RESULTS

K=	6E-09	m/sec
K=	6E-07	cm/sec



Project Name: Fowler Child Pit/Quarry ARA Bracebridge
Project No.: 1895639
Test Date: 26/06/2018
Analysis By: DH
Checked By: CWT
Analysis Date: 23/07/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-2A

INTERVAL (metres below ground surface)

Top of Interval = 79.4
Bottom of Interval = 91.6

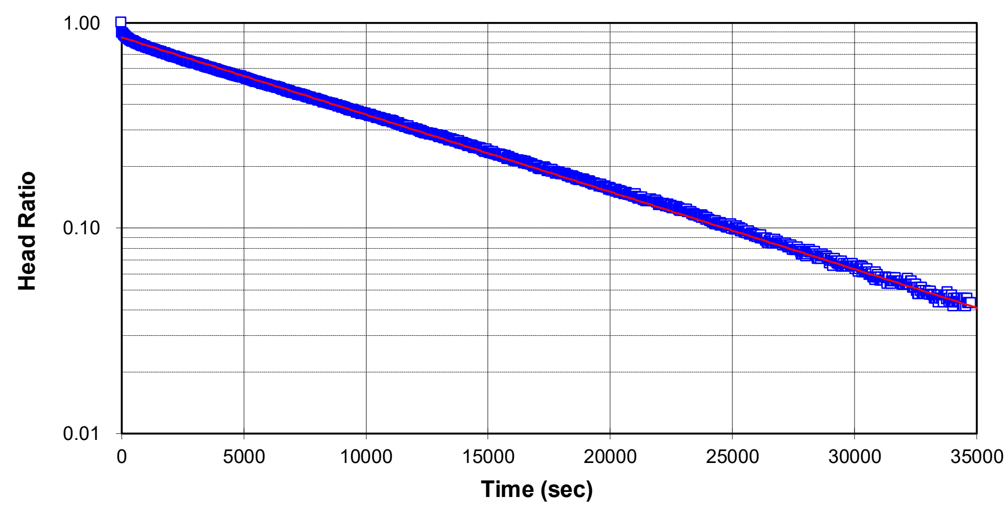
$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	4.8E-02
L_e =	12.2
t_1 =	0
t_2 =	35000
h_1/h_0 =	0.85
h_2/h_0 =	0.04

RESULTS

K=	5E-09	m/sec
K=	5E-07	cm/sec



Project Name: Fowler Child Pit ARA Bracebridge
Project No.: 1895639
Test Date: 20/09/2018

Analysis By: DH
Checked By: CWT
Analysis Date: 01/10/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-02B

INTERVAL (metres below ground surface)

Top of Interval =	**12.9**
Bottom of Interval =	**20.5**

$$K = \frac{r_c^{\,2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

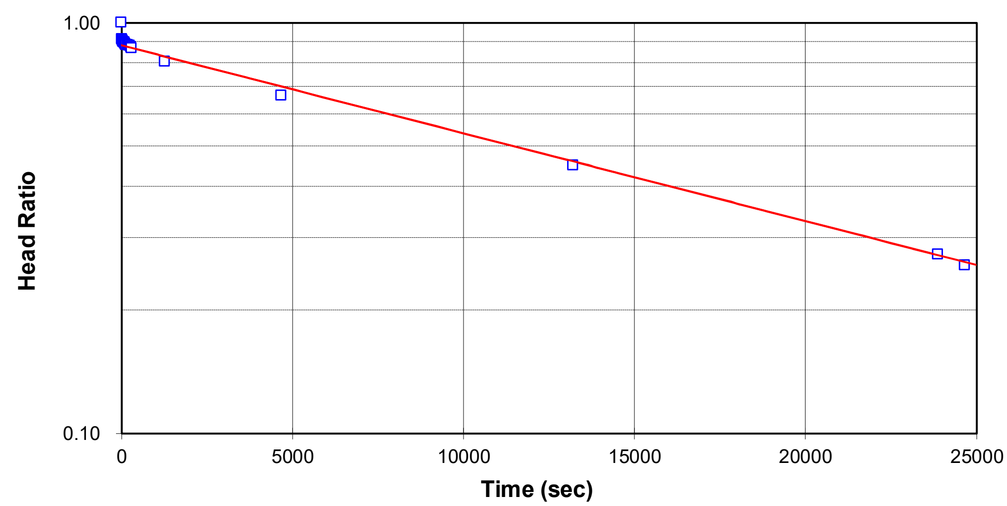
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	1.6E-02
R_e =	4.8E-02
L_e =	7.6
t_1 =	0
t_2 =	24000
h_1/h_0 =	0.88
h_2/h_0 =	0.27

RESULTS

K=	4E-09	m/sec
K=	4E-07	cm/sec



Project Name:	Fowler Child Pit/Quarry ARA Bracebridge	Analysis By:	DH
Project No.:	1895639	Checked By:	CWT
Test Date:	26/06/2018	Analysis Date:	23/07/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-03A

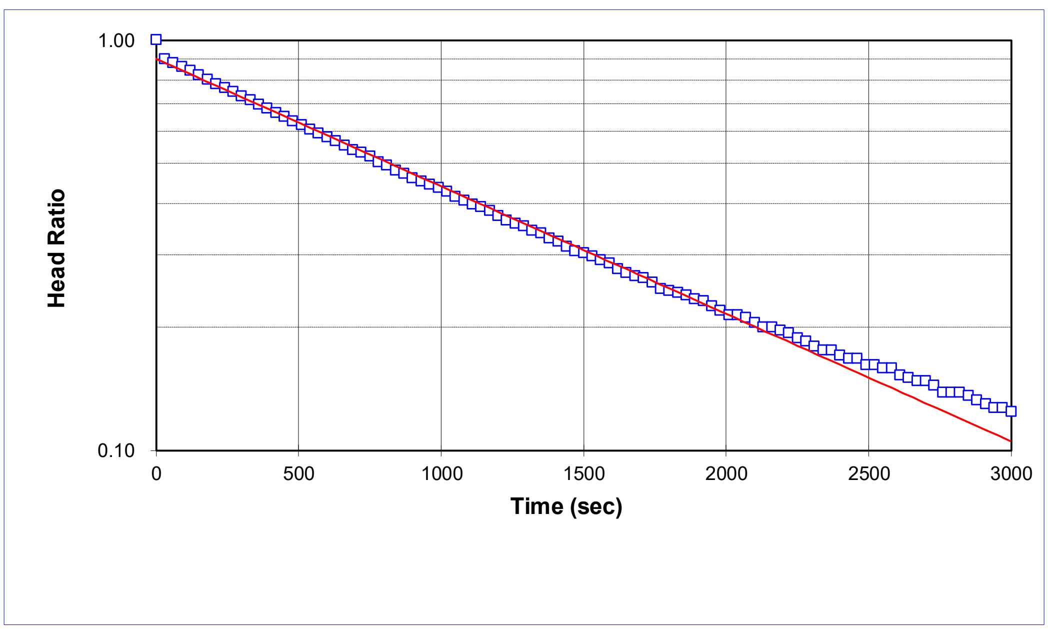
INTERVAL (metres below ground surface)

Top of Interval = **23.6**
Bottom of Interval = **29.9**

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS		RESULTS		
r_c =	1.6E-02			
R_e =	4.8E-02			
L_e =	6.3	K=	7E-08	m/sec
t_1 =	0	K=	7E-06	cm/sec
t_2 =	2010			
h_1/h_0 =	0.90			
h_2/h_0 =	0.21			



Project Name: Fowler Child Pit/Quarry ARA Bracebridge
Project No.: 1895639
Test Date: 25/06/2018
Analysis By: DH
Checked By: CWT
Analysis Date: 24/07/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST DDH15-03B

INTERVAL (metres below ground surface)

Top of Interval = 8.6
Bottom of Interval = 14.7

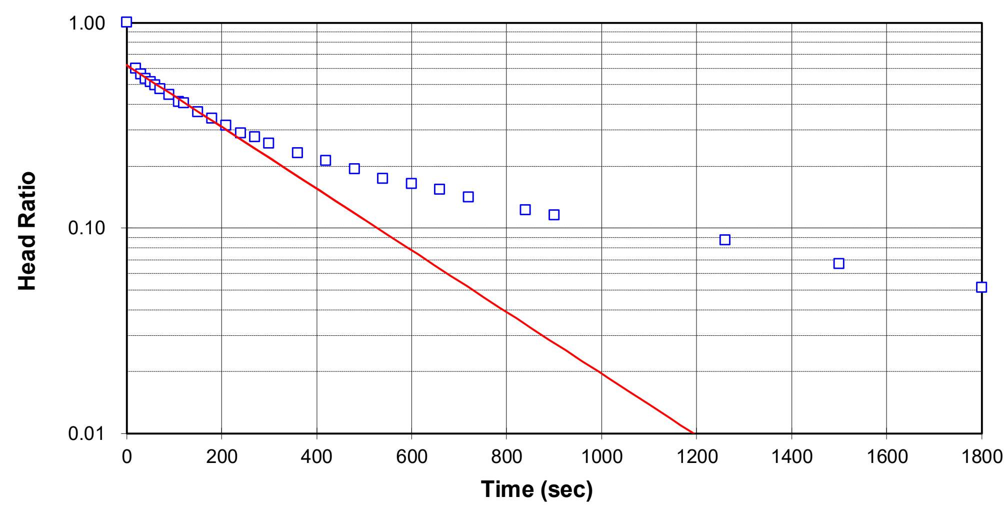
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	4.8E-02
L_e =	6.1
t_1 =	0
t_2 =	500
h_1/h_0 =	0.62
h_2/h_0 =	0.11

RESULTS

K=	3E-07	m/sec
K=	3E-05	cm/sec



Project Name: Fowler Child Pit/Quarry ARA Bracebridge
Project No.: 1895639
Test Date: 25/06/2018
Analysis By: DH
Checked By: CWT
Analysis Date: 24/07/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST BH18-04A

INTERVAL (metres below ground surface)

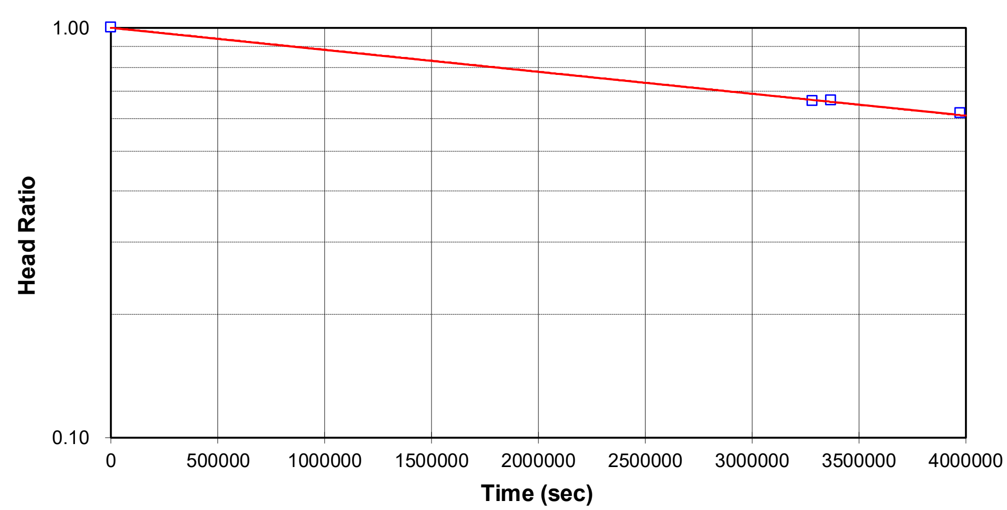
Top of Interval = 23.9
Bottom of Interval = 33.1

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	7.6E-02
L_e =	9.1
t_1 =	0
t_2 =	4000000
h_1/h_0 =	1.00
h_2/h_0 =	0.61

RESULTS		
K=	8E-12	m/sec
K=	8E-10	cm/sec



Project Name: Fowler Child Pit ARA Bracebridge
Project No.: 1895639
Test Date: 20/09/2018

Analysis By: DH
Checked By: CWT
Analysis Date: 01/10/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST BH18-04B

INTERVAL (metres below ground surface)

Top of Interval = 13.4
Bottom of Interval = 21.0

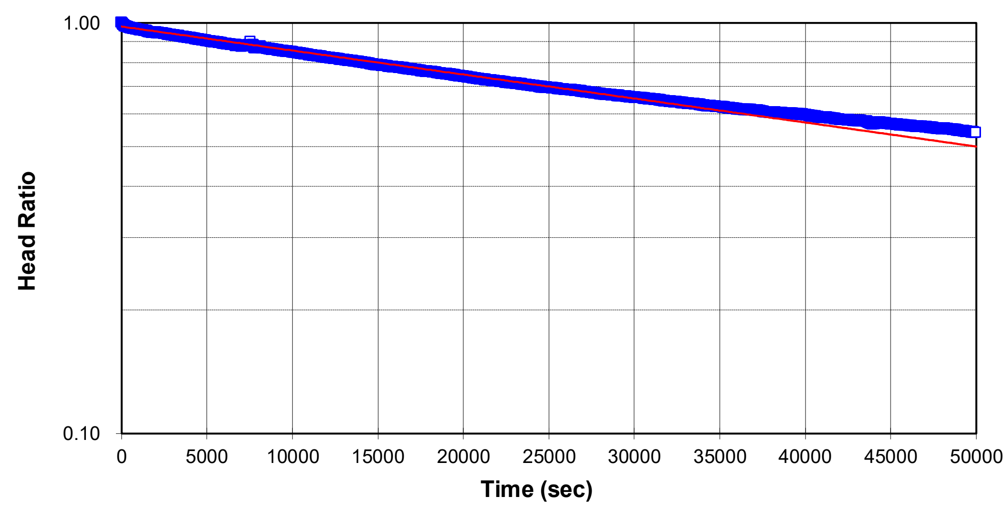
$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	1.6E-02
R_e =	7.6E-02
L_e =	7.6
t_1 =	0
t_2 =	50000
h_1/h_0 =	0.98
h_2/h_0 =	0.50

RESULTS

K=	1E-09	m/sec
K=	1E-07	cm/sec



Project Name: Fowler Child Pit ARA Bracebridge
Project No.: 1895639
Test Date: 20/09/2018

Analysis By: DH
Checked By: CWT
Analysis Date: 01/10/2018

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST BH18-04C

INTERVAL (metres below ground surface)

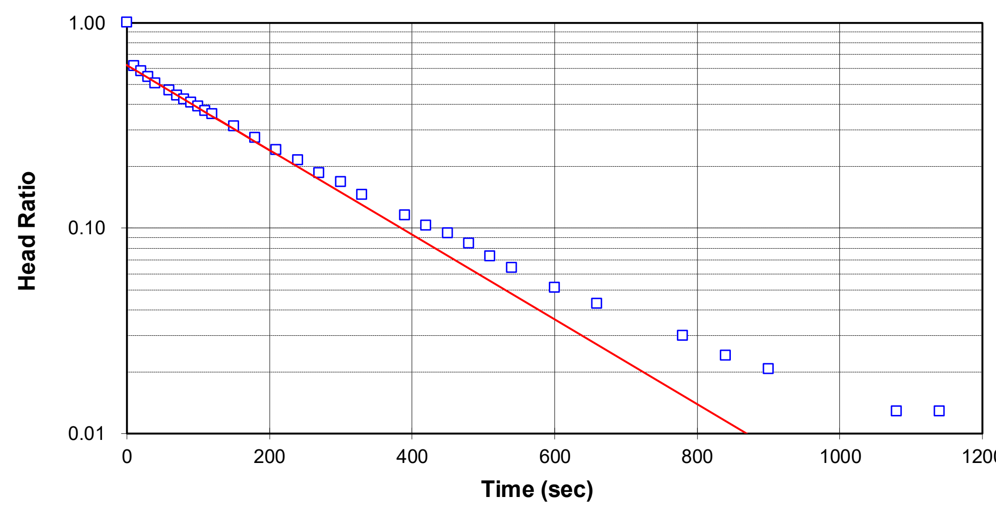
Top of Interval = 4.9
Bottom of Interval = 11.0

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$

where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS		RESULTS		
r_c =	1.6E-02			
R_e =	7.6E-02			
L_e =	6.1	K=	4E-07	m/sec
t_1 =	0	K=	4E-05	cm/sec
t_2 =	200			
h_1/h_0 =	0.62			
h_2/h_0 =	0.24			



Project Name: Fowler Child Pit ARA Bracebridge
Project No.: 1895639
Test Date: 20/09/2018

Analysis By: DH
Checked By: CWT
Analysis Date: 24/09/2018

Golder Associates Ltd.

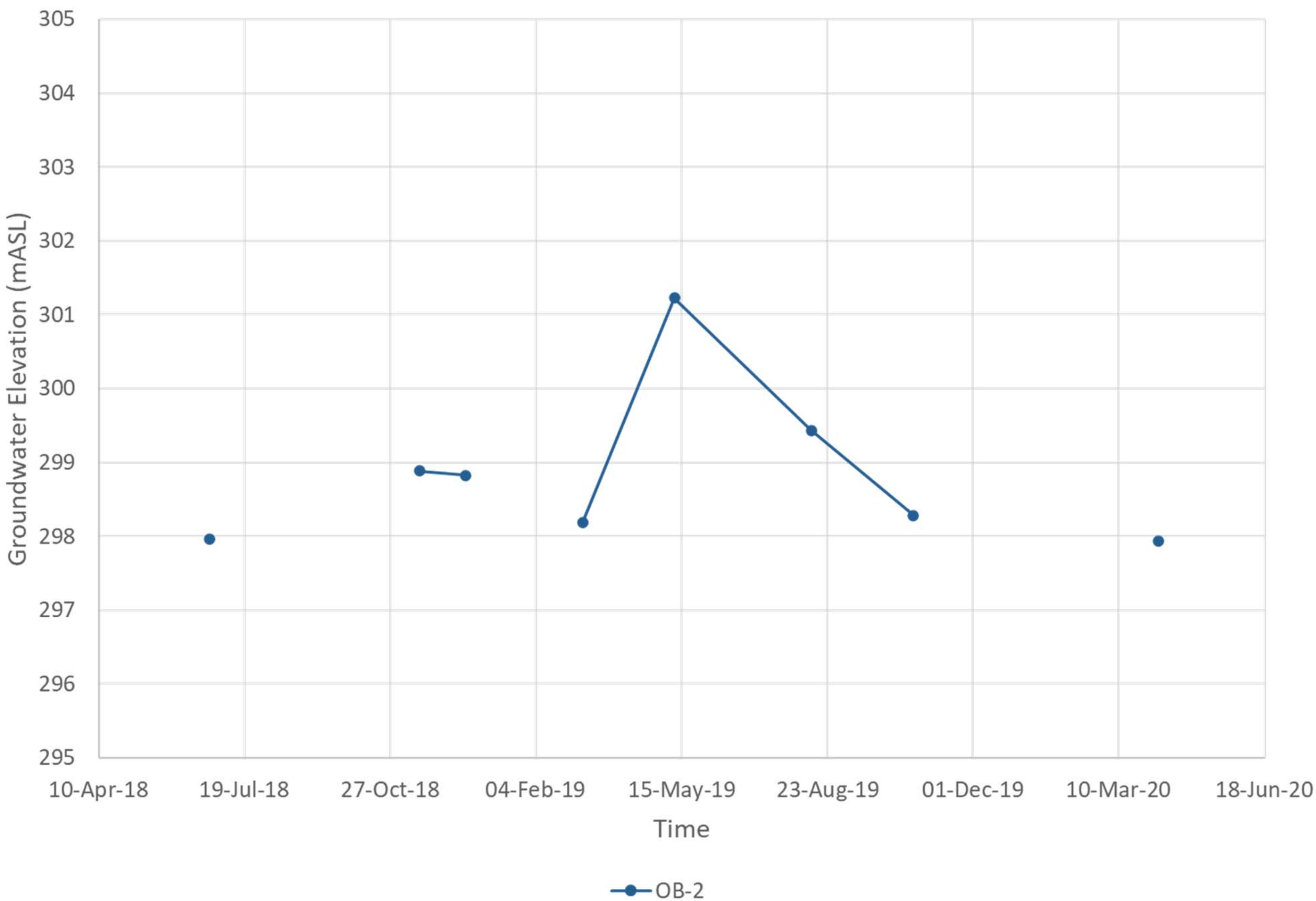
APPENDIX E

Groundwater Elevation Data

Table E-1
Groundwater Elevation Data

Borehole Location	Northing	Easting	Ground Surface (mASL)	TOP (mASL)	25-Jun-18	16-Nov-18	18-Dec-18	03-Jan-19	01-Feb-19	08-Mar-19	10-May-19	12-Aug-19	21-Oct-19	06-Apr-20
DDH15-1A	4998413	635538.5	333.996	334.919	331.04	330.60	331.74	- -	- -	331.76	332.05	330.72	329.77	331.92
DDH15-1B	4998413	635538.5	333.996	334.903	331.22	330.69	331.83	- -	- -	331.53	332.12	330.85	330.15	332.06
DDH15-2A	4998581	635327.6	331.954	332.857	324.54	324.60	324.18	- -	- -	324.47	324.50	323.82	322.96	324.58
DDH15-2B	4998581	635327.6	331.954	332.896	327.92	328.06	329.04	- -	- -	329.00	329.20	328.01	327.57	329.20
DDH15-3A	4998984	635143.6	323.877	324.799	322.29	322.34	322.46	- -	- -	322.45	322.48	320.88	320.28	321.79
DDH15-3B	4998984	635143.6	323.877	324.82	321.96	322.15	322.75	- -	- -	322.73	322.79	321.12	320.54	322.00
BH18-4A	4998206	635070	327.239	328.122	- -	310.83	318.69	319.42	320.32	321.00	321.56	321.17	320.73	321.81
BH18-4B	4998206	635070	327.239	328.144	- -	320.16	322.56	322.59	322.38	322.34	322.14	320.91	321.31	322.29
BH18-4C	4998206	635070	327.239	328.162	- -	325.31	325.27	325.32	325.19	325.25	325.36	323.94	324.48	325.43
TW12-1	4998118	635729	321.236	322.078	- -		315.52	315.55	- -	315.40	315.76	313.93	312.69	315.58
OB-2	4999652	634099.5	310.348	311.251	297.97	298.89	298.83	- -	- -	298.19	301.23	299.44	298.29	297.94
OB-4	4999208	634108	307.427	308.265	dry	dry	dry	- -	- -	dry	dry	dry	dry	dry
OB-5	4999652	634099.5	310.348	311.251	dry	dry	dry	- -	- -	dry	dry	dry	dry	dry

TOP - top of pipe
mASL - metres above sea level



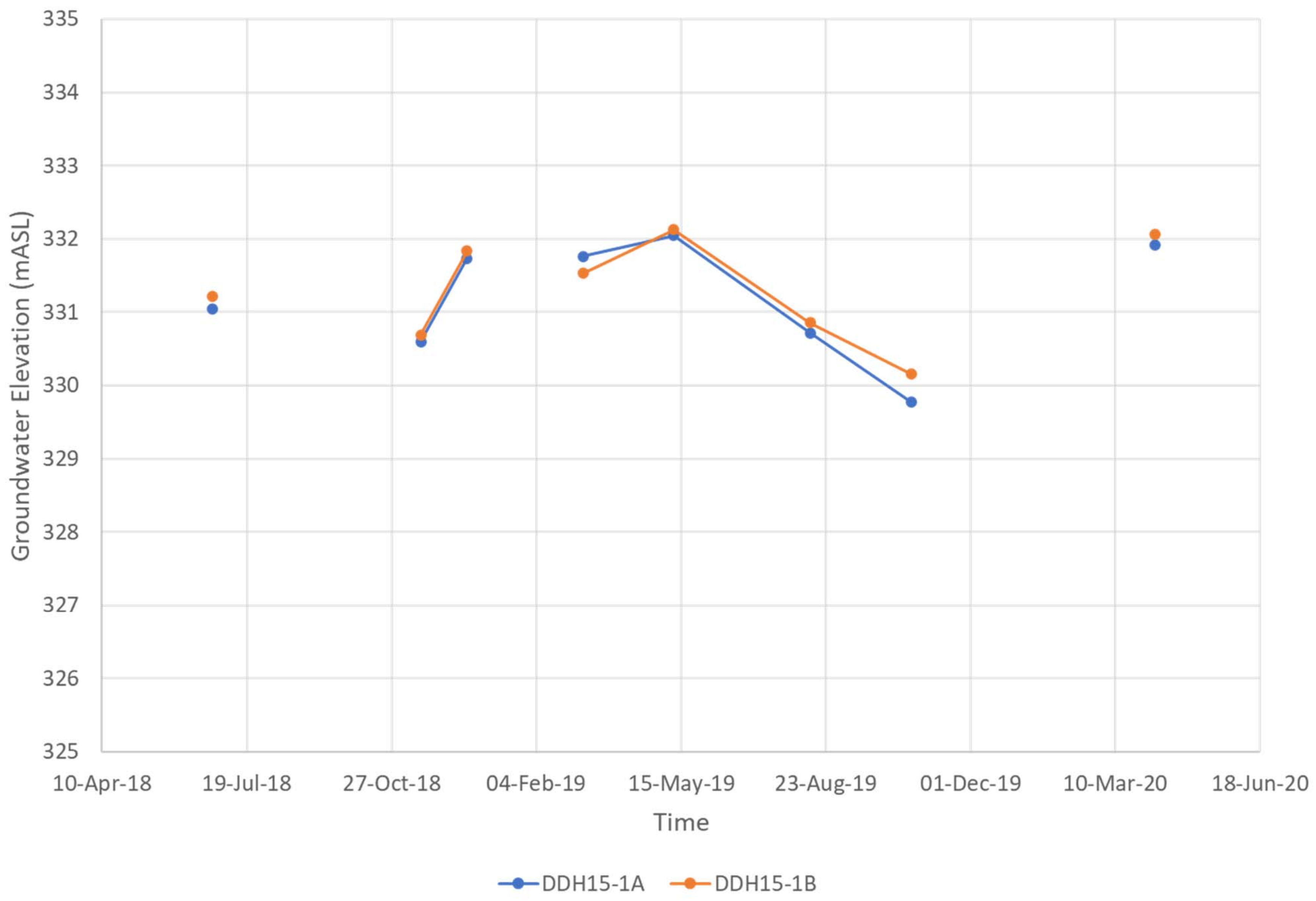
GOLDER

Date: May 2020 Drawn: JPAO

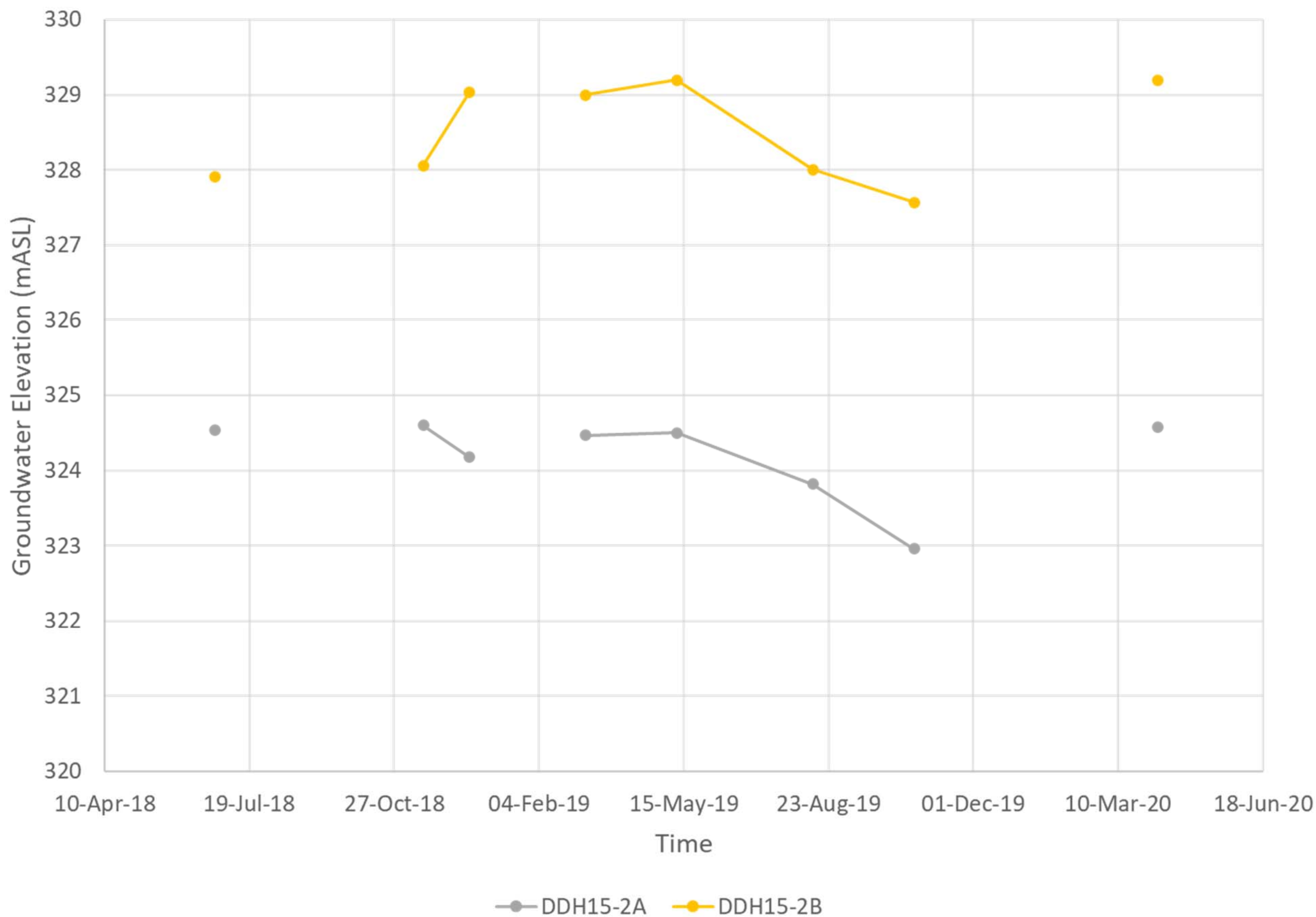
Project: 1895639 Checked: KAM

OB-2 Groundwater Elevation Data
June 25, 2018 to April 6, 2020

FIGURE E1



GOLDER	Date: May 2020 Drawn: JPAO Project: 1895639 Checked: KAM	DDH15-1 Groundwater Elevation Data June 25, 2018 to April 6, 2020	FIGURE E2



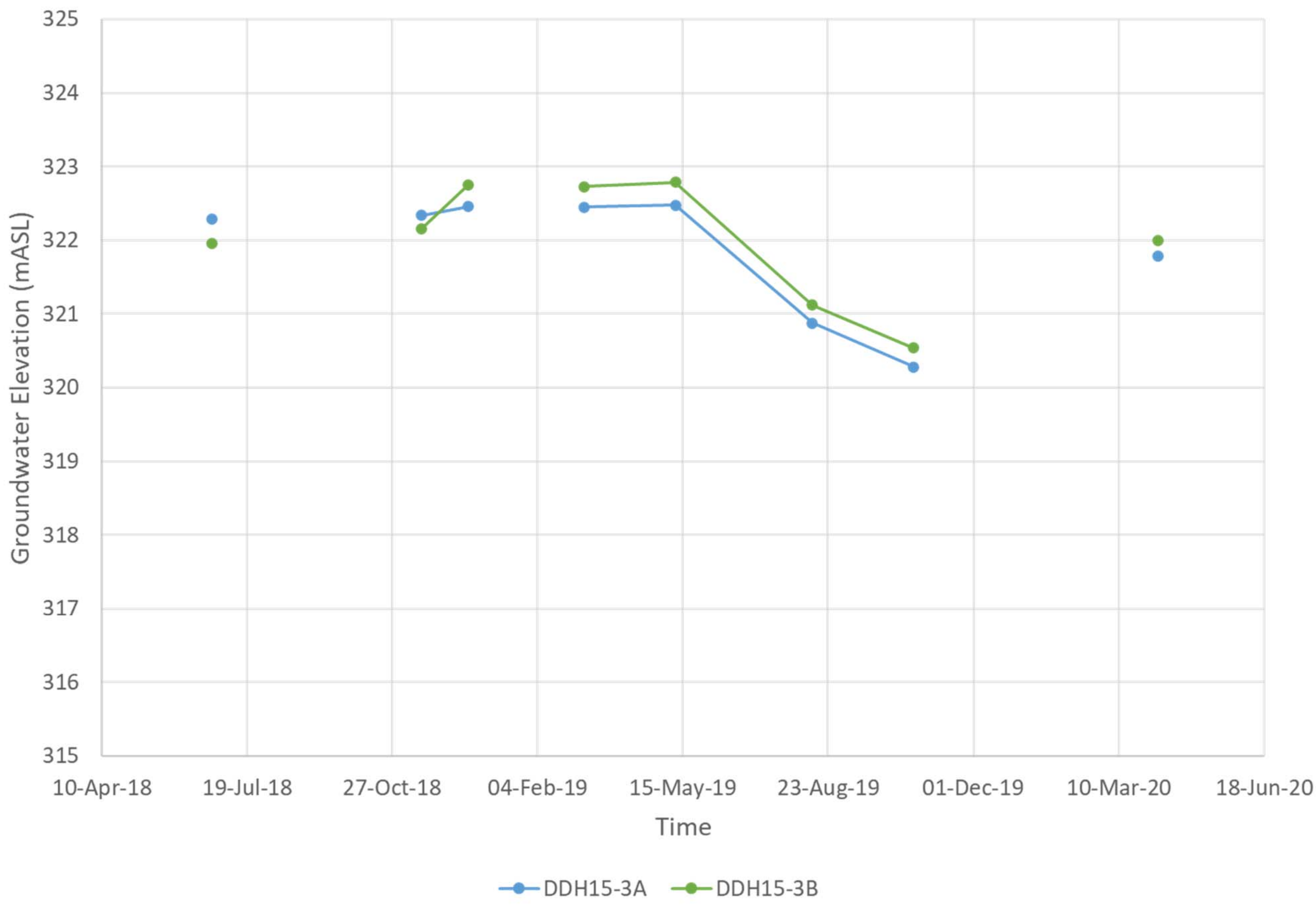
GOLDER

Date: May 2020 Drawn: JPAO

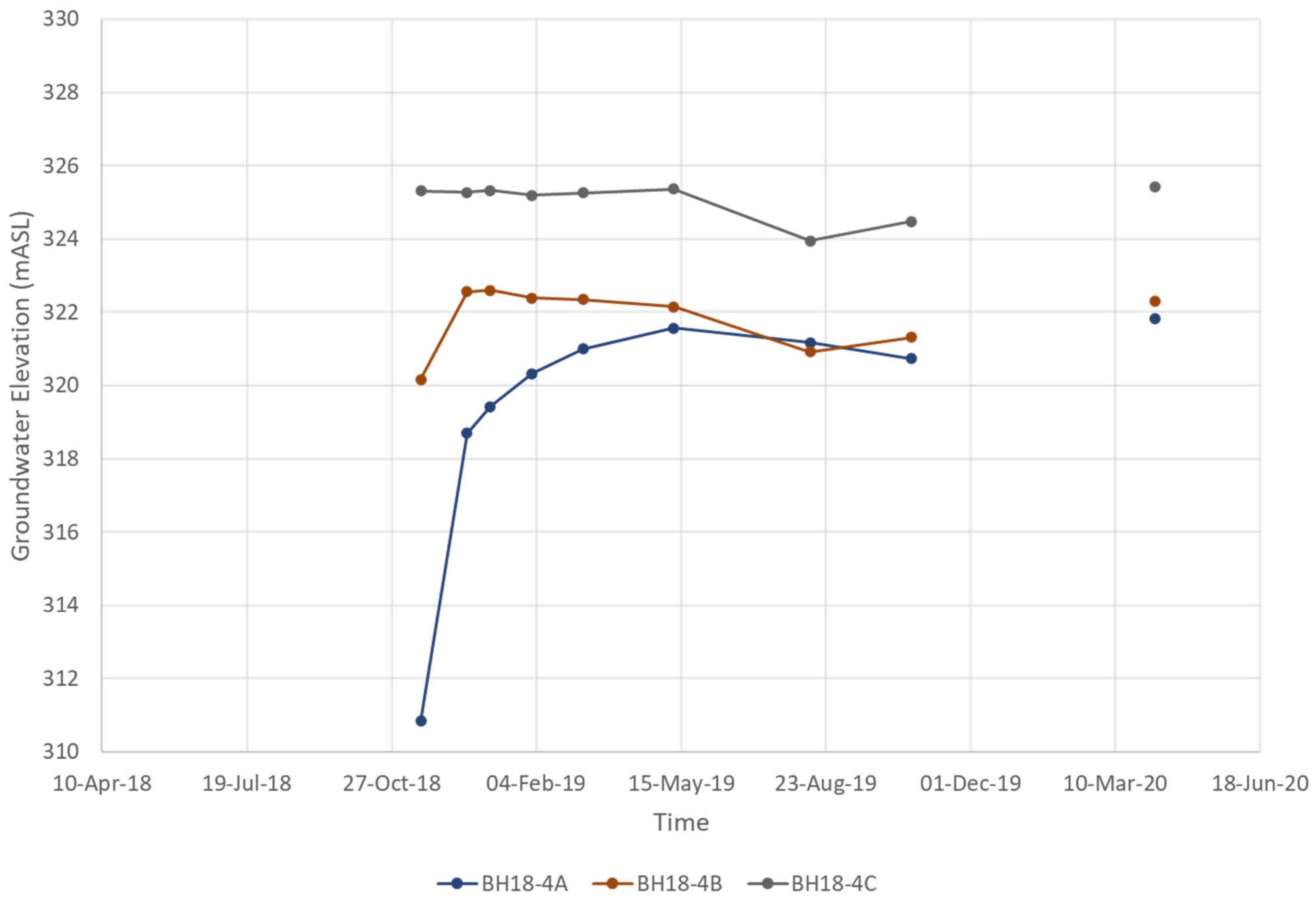
Project: 1895639 Checked: KAM

DDH15-2 Groundwater Elevation Data
June 25, 2018 to April 6, 2020

FIGURE E3



GOLDER	Date: May 2020 Drawn: JPAO Project: 1895639 Checked: KAM	DDH15-3 Groundwater Elevation Data June 25, 2018 to April 6, 2020	FIGURE E4



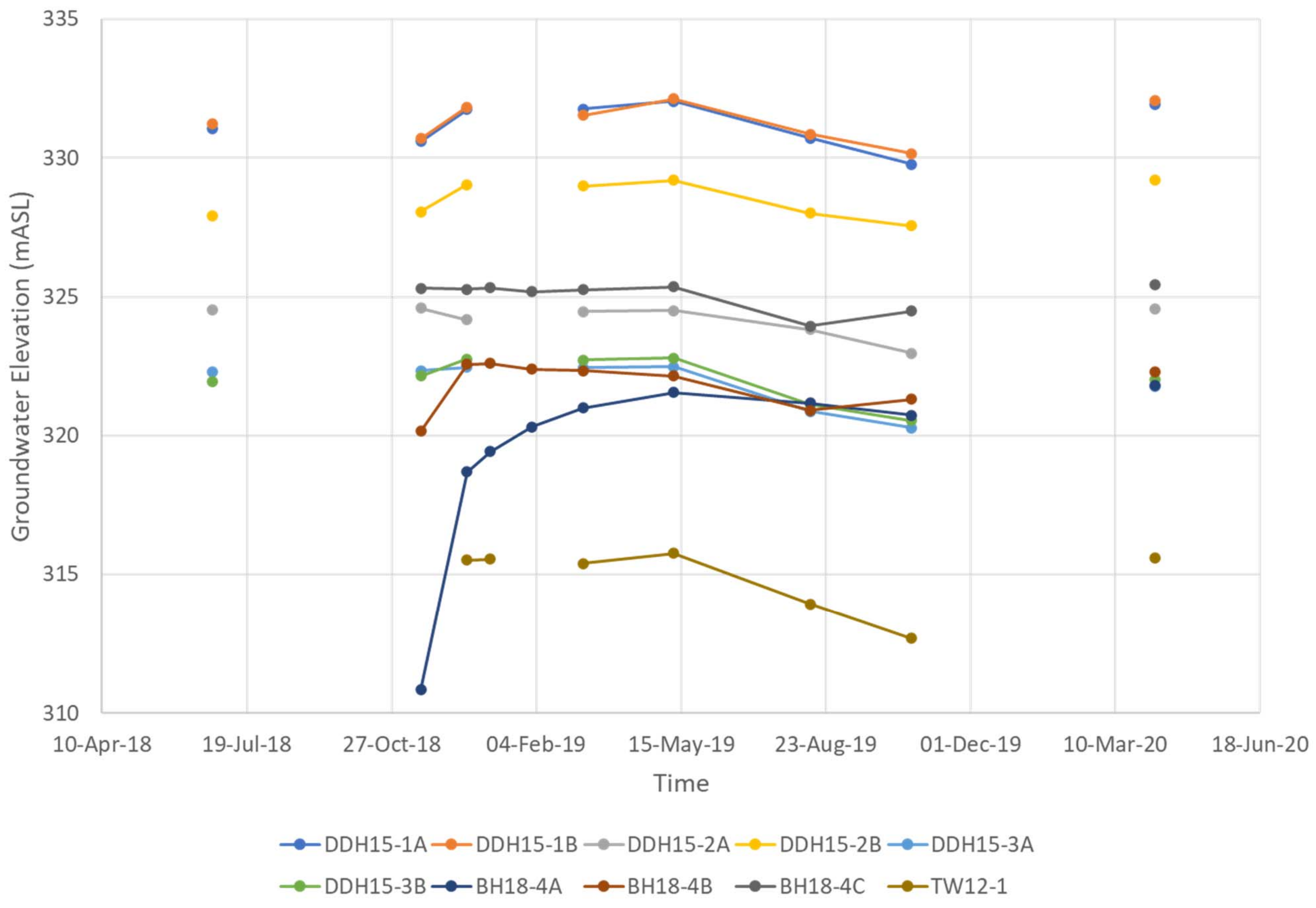
GOLDER

Date: May 2020 Drawn: JPAO

Project: 1895639 Checked: KAM

BH18-4 Groundwater Elevation Data
November 16, 2018 to April 6, 2020

FIGURE E5



GOLDER

Date: May 2020	Drawn: JPAO	Bedrock Groundwater Elevation Data (all locations) June 25, 2018 to April 6, 2020	FIGURE E6
Project: 1895639	Checked: KAM		

APPENDIX F

Complete Private Well Surveys – Current Investigation

GOLDER

PW-4

February 2020

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address:	
Municipal Addre	
Telephone Numb	
Email (optional):	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)
Do you drink bottled water?	(YES/ NO)

c) Water Well Details

Well Usage:	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	Front yard near front door.
Well Type:	(e.g., hand dug, bored, drilled)
Casing Type:	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6" (inches or metres)
Well Depth:	pumped 180 +/- (feet or metres)
Well Age:	2002 17 (years)

Original Drilling Date: 2002 (year)

Do you have a MOE Ontario Well Tag on your well? No (YES/ NO) Please provide Well Tag No:

Other comments:

a. **Water Quantity**

Water level: well buried water sand (depth from ground surface) (feet or metres)

Pump Type: (e.g., submersible, suction lift, jet)

Pump Location: (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: no issues

Other comments:

b. **Water Quality**

Water Quality: OK (good, poor) Comments:

Water quality issues? iron (sediment) (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: UV sed filter big ones (e.g., none, softener, UV, carbon filter) [illegible] day have to

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO) When bought the house

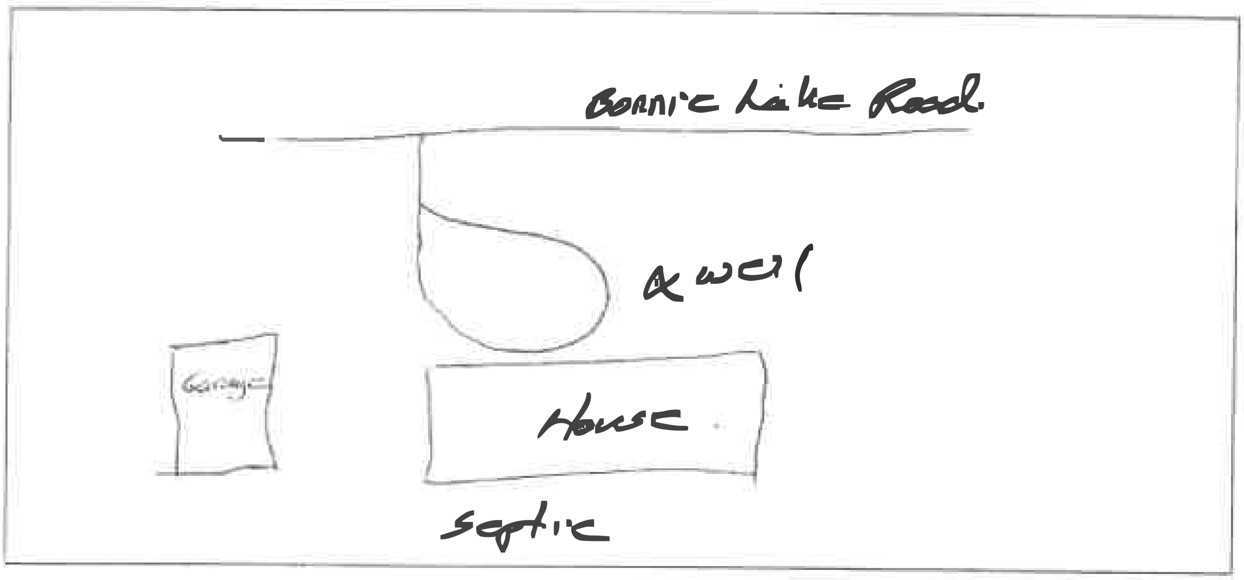
Other Comments:

c. Additional Remarks

Do you have a septic system? (YES / NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

February 2020

PW-5

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address:	
Municipal Address:	
Telephone Number:	
Email (optional):	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)
Do you drink bottled water?	(YES/ NO)

c) Water Well Details

Well Usage:		(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?		
Well Type:		(e.g., hand dug, bored, drilled)
Casing Type:		(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	150 +/-	(feet or metres)
Well Age:	N/A	(years)

Original Drilling Date: (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:

Other comments:

a. Water Quantity

Water level: Burried under snow (depth from ground surface) (feet or metres)

Pump Type: ~~dug well~~ (e.g., submersible, suction lift, jet)

Pump Location: (house or well)

Well Capacity: — (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: Never run out

Other comments:

b. Water Quality

Water Quality: good (good, poor) Comments:

Water quality issues? Little iron fine (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: Carbon - sediment filter (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well? 1 year

Do you have any analytical laboratory reports? bact. (YES/ NO)

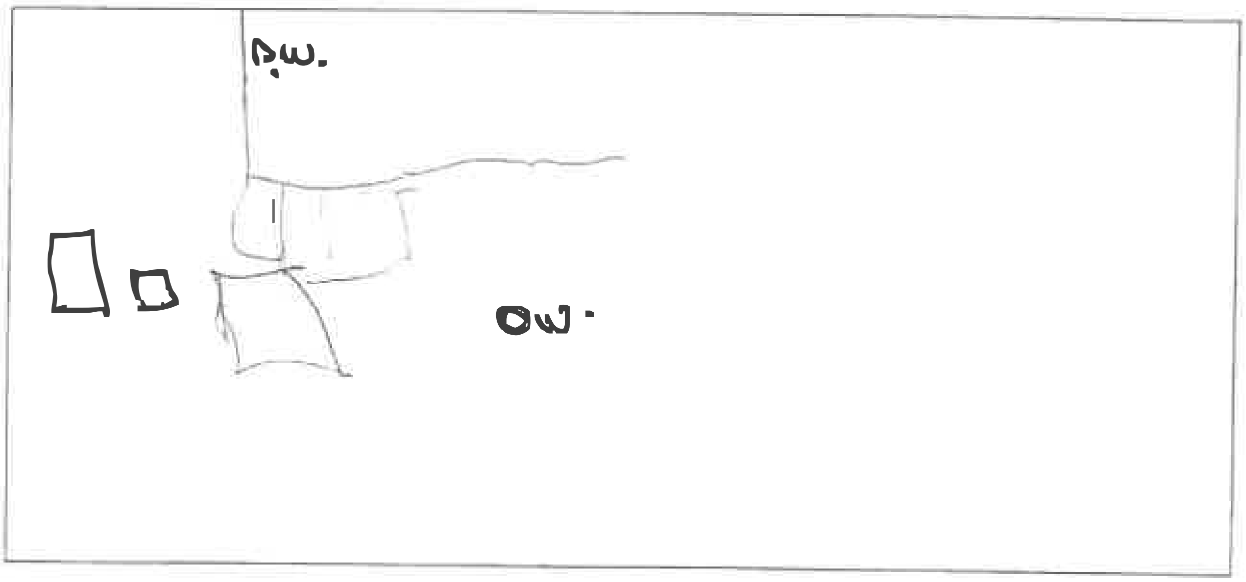
Other Comments:

D. Additional Remarks

Do you have a septic system? (YES NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-7

February 2020

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:

Resident:

Street Addr

Municipal A

Telephone N

Email (optio

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)	
Do you drink bottled water?	(YES/ NO)	Sometimes

c) Water Well Details

Well Usage:		(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	Between House & Garage	
Well Type:		(e.g., hand dug, bored, drilled)
Casing Type:		(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6 inch	(inches or metres)
Well Depth:	121.9 m	(feet or metres)
Well Age:	14 yrs	(years)

13.49

Original Drilling Date:	(year) 20/12/2006.
Do you have a MOE Ontario Well Tag on your well?	(YES/ NO) Please provide Well Tag No: A048609
Other comments:	

a. Water Quantity

Water level: 13.49 m T.O.C	(~~depth from ground surface~~) (feet or metres) T. Depth 121.9 m
Pump Type:	(e.g. submersible, suction lift, jet) 15 pump
Pump Location:	(house or well)
Well Capacity: 5gals/min	(gallons per minute/ litres per minute)
Please describe any water quantity problems experienced with the well:	
Other comments:	

b. Water Quality

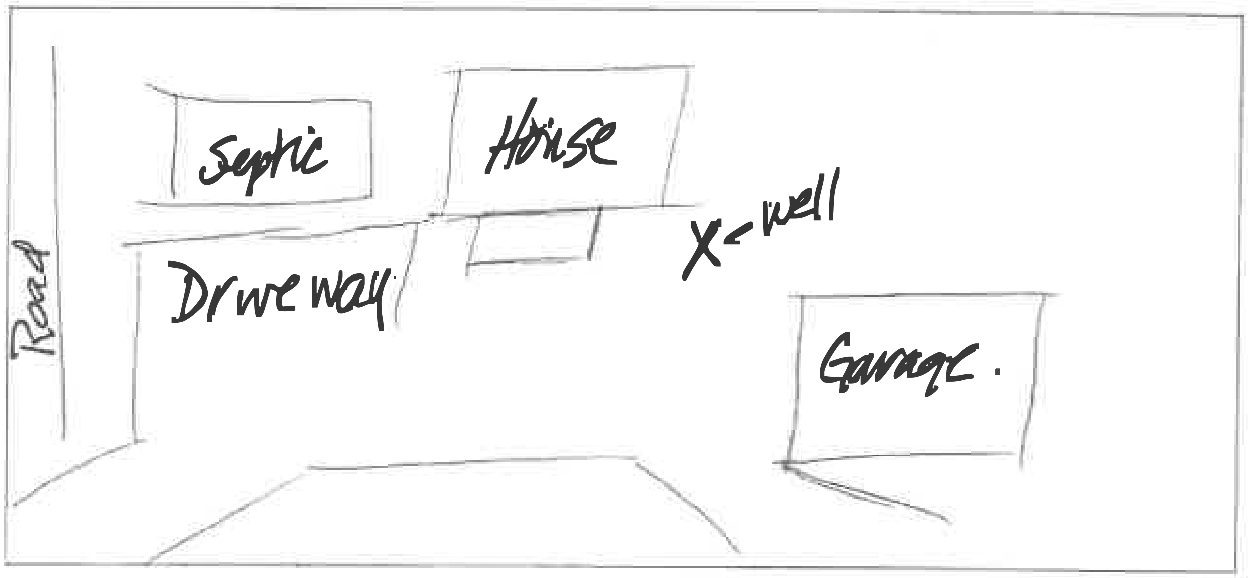
Water Quality:	(good, poor) Comments:
Water quality issues?	(e.g., turbidity, mineral, salt, sulphur, gas, bacteria)
Treatment system:	(e.g., none, softener, UV, carbon filter)
How often do you sample water from your well?	
Do you have any analytical laboratory reports? nothing recent	(YES/ NO)
Other Comments:	

c. Additional Remarks

Do you have a septic system? (YES/ NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-8

February 2020 | Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:

Resident:

Street Address

Municipal Addr

Telephone Nur

Email (optional

b) Available Water Supply

Do you use your well water for drinking purposes? (YES/NO) — NO

Do you drink bottled water? (YES/ NO) — YES

c) Water Well Details

Well Usage:	DOMESTIC	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	SOUTH WEST CORNER OF DECK.	
Well Type:	DRILLED	(e.g., hand dug, bored, drilled)
Casing Type:	STEEL	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	APPROX 150'	(feet or metres)
Well Age:	17 YEARS.	(years)

Original Drilling Date: 2017 (year)

Do you have a MOE Ontario Well Tag on your well? YES. (YES/ NO) Please provide Well Tag No: A008871

Other comments:

a. Water Quantity

Water level: ~~UNKNOWN~~ 2.49 m T.O.C ~~(depth from ground surface)~~ (feet or metres)

Pump Type: SUBMERSIBLE (e.g., submersible, suction lift, jet)

Pump Location: WELL (house or well)

Well Capacity: UNKNOWN. (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: NEVER HAVE RUN OUT OF WATER YET.

Other comments:

b. Water Quality

Water Quality: POOR. (good, poor) Comments:

-HAVE SPENT APPROXIMATELY $7,000.00 ON EQUIPMENT TO HELP.

Water quality issues? TANNINS, SULPHER, COLOR (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: SOFTENER, UV, PARTICULATE FILTER. (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well? NEVER SINCE EQUIPMENT INSTALLED.

Do you have any analytical laboratory reports? (YES/ NO)

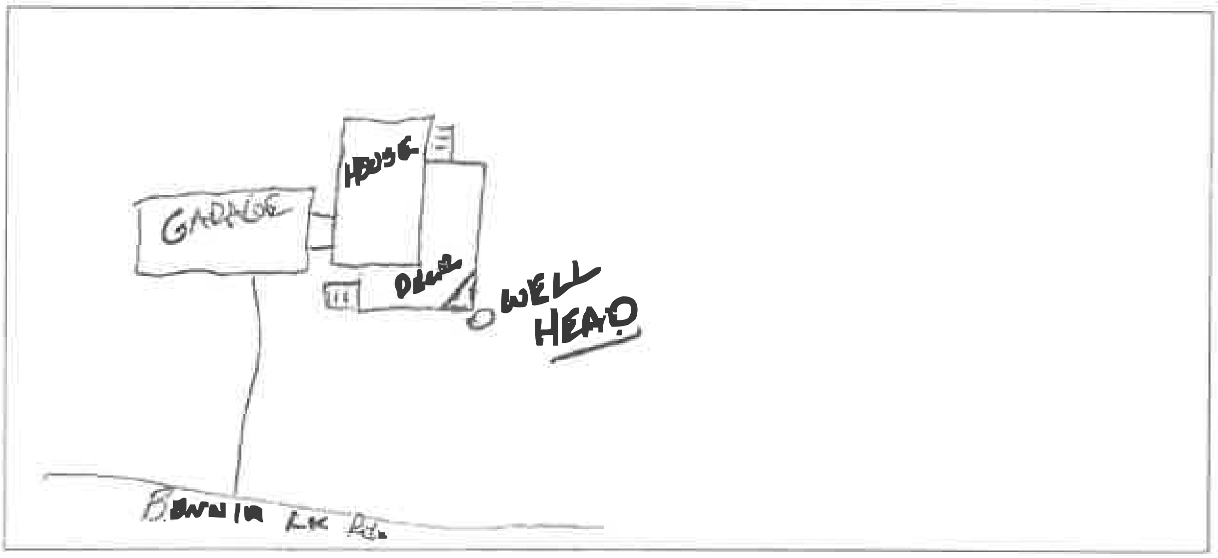
Other Comments:

c. Additional Remarks

Do you have a septic system? (YES / NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-9

February 2020 | Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:

Resident:

Street Addre

Municipal Ad | mber:

Telephone N

Email (optional):

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO) — YES
Do you drink bottled water?	(YES/NO) — NO

c) Water Well Details

Well Usage:	DOMESTIC	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	BESIDE HOUSE	
Well Type:	DRILLED	(e.g., hand dug, bored, drilled)
Casing Type:	STEEL	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6	(inches or metres) — inches
Well Depth:	300	(feet or metres) — feet
Well Age:	1987	(years)

Original Drilling Date: 1987 (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:

Other comments:

a. **Water Quantity**

Water level: Not Expected (depth from ground surface) (feet or metres)

Pump Type: SUBMERSIBLE (e.g., submersible, suction lift, jet)

Pump Location: WELL (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well:

Other comments:

b. **Water Quality**

Water Quality: (good/ poor) Comments:

Water quality issues? IRON (e.g., turbidity, mineral; salt, sulphur, gas, bacteria)

Treatment system: FILTER (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO)

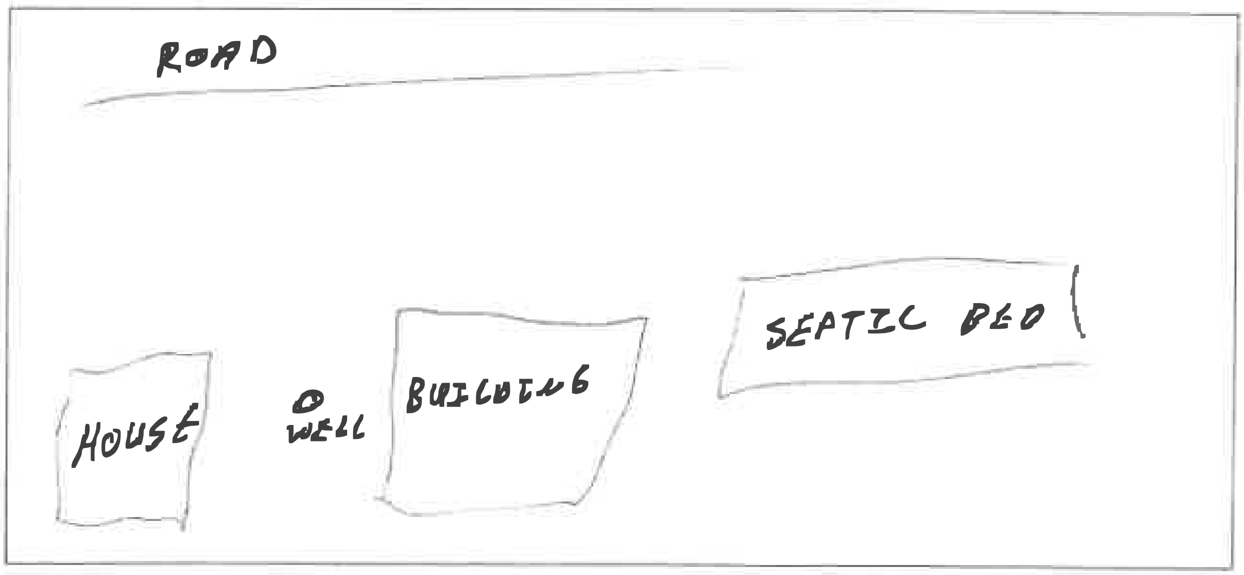
Other Comments:

c. **Additional Remarks**

Do you have a septic system? (YES NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-13

February 2020

Project No. 1895839

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address:	
Municipal Addr	
Telephone Num	
Email (optional)	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/NO) YES
Do you drink bottled water?	(YES/NO) NO

c) Water Well Details

Well Usage:	Household	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?		
Well Type:	Drilled	(e.g., hand dug, bored, drilled)
Casing Type:	steel	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	300- 400 feet	(feet or metres)
Well Age:	10.	(years)

Original Drilling Date: Nov 2010. (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No: A106 52C

Other comments: well drilled in Bedrock all the way down.

a. Water Quantity

Water level: 1.97m T.O.C (~~depth from ground surface~~) (feet or metres)

Pump Type: (e.g., submersible, suction lift, jet)

Pump Location: (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: High Iron

Other comments:

b. Water Quality

Water Quality: good. (good, poor) **Comments:**

Water quality issues? no issue (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: iron Filter (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well? 2 time a year.

Do you have any analytical laboratory reports? (YES/NO)

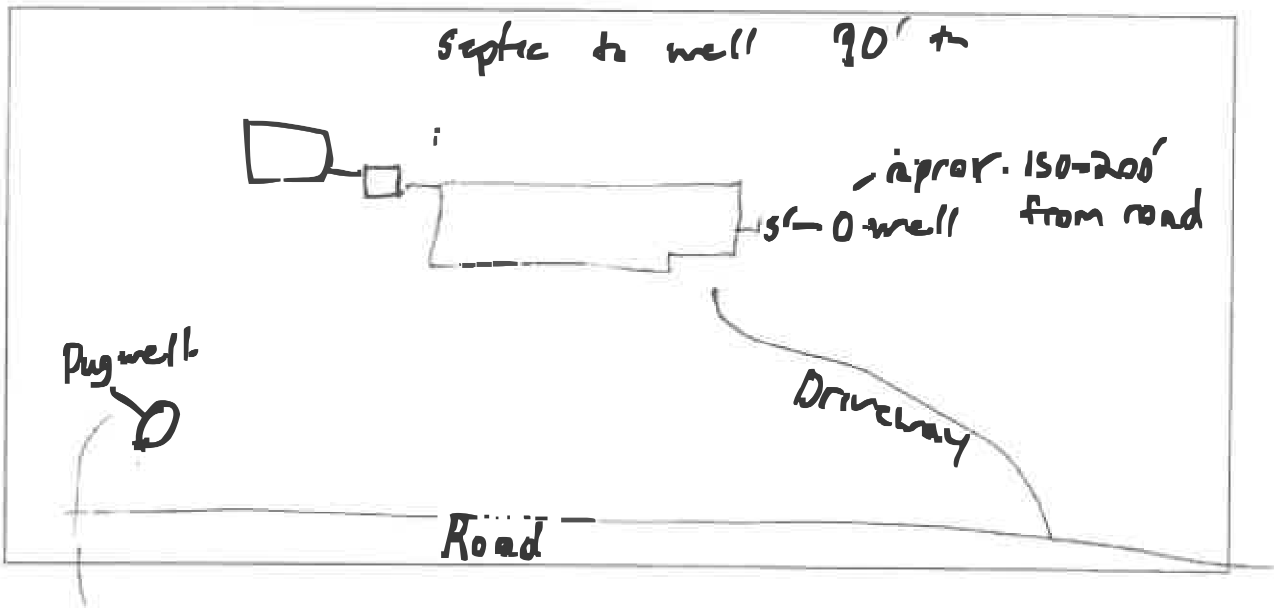
Other Comments:

e. **Additional Remarks**

Do you have a septic system? **(YES/ NO)**

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



Used for irrigation
no info on water quality.
Depth 14'

GOLDER

PW-15

February 2020

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address:	
Municipal Address:	
Telephone Number:	
Email (optional):	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)	YES
Do you drink bottled water?	(YES/ NO)	NO

c) Water Well Details

Well Usage:	domestic	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	20 ft from house	
Well Type:	drilled	(e.g., hand dug, bored, drilled)
Casing Type:	STEEL	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	320	(feet or metres)
Well Age:	34	(years)

Original Drilling Date:	1996	(year)
Do you have a MOE Ontario Well Tag on your well?	NO	(YES/ NO) Please provide Well Tag No:
Other comments:		

a. Water Quantity

Water level:	10.22m ~~35 Ft.~~ T.O.C.	(~~depth from ground surface~~) (feet or metres)
Pump Type:	SUBMERSIBLE	(e.g., submersible, suction lift, jet)
Pump Location:	WELL	(house or well)
Well Capacity:	5 gals.	(gallons per minute/ litres per minute)
Please describe any water quantity problems experienced with the well:	NONE	
Other comments:		

b. Water Quality

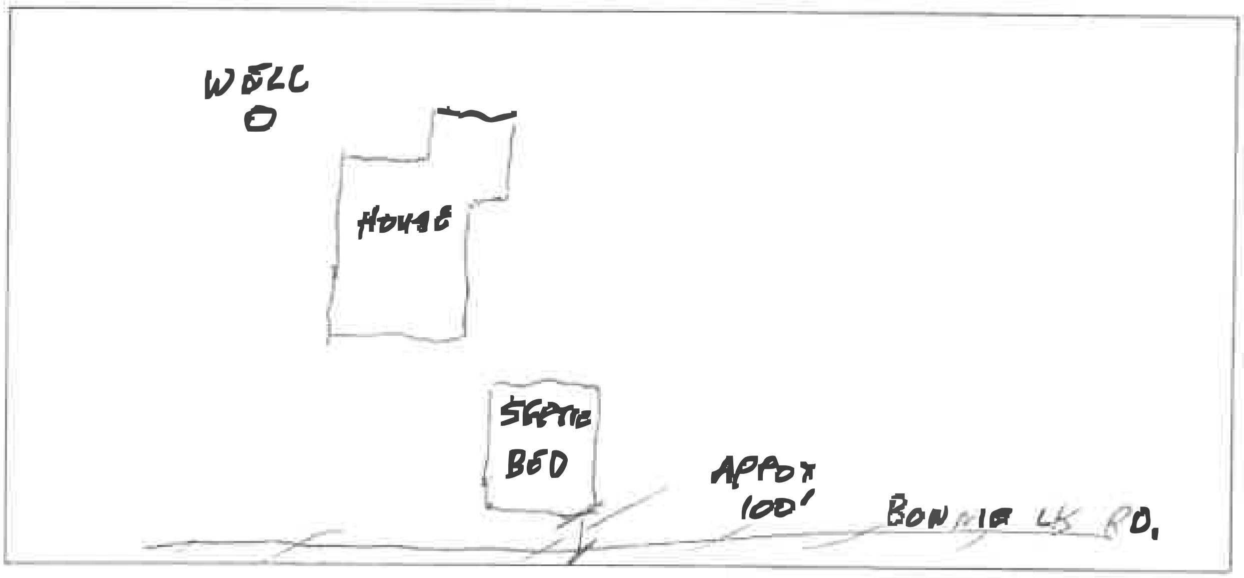
Water Quality:	GOOD	(good, poor) Comments:
Water quality issues?	NONE.	(e.g., turbidity, mineral, salt, sulphur, gas, bacteria)
Treatment system:	NONE	(e.g., none, softener, UV, carbon filter)
How often do you sample water from your well?	AT LEAST ONCE A YEAR	
Do you have any analytical laboratory reports?	YES	(YES/ NO)
Other Comments:		

c. **Additional Remarks**

Do you have a septic system? YES **(YES/ NO)**

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-18

February 2020 Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) **Well Owner Information**

Well Owner:

Resident:

Street Address:

Municipal Addr

Telephone Num

Email (optional)

b) **Available Water Supply**

Do you use your well water for drinking purposes?	(YES/ NO) YES
Do you drink bottled water?	(YES/ NO) NO

c) **Water Well Details**

Well Usage:	Domestic	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?		front yard
Well Type:	Drilled	(e.g., hand dug, bored, drilled)
Casing Type:	Steel	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6 "	(inches or metres)
Well Depth:	400 '	(feet or metres)
Well Age:	30 (+ -)	(years)

Original Drilling Date: (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:

Other comments:

a. Water Quantity

Water level: ~~12 feet~~ 454 m T.o.c. (~~depth from ground surface~~) (feet or metres)

Pump Type: jet (e.g., submersible, suction lift, jet)

Pump Location: well (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: plenty of water for daily use ran out once when hose was left on

Other comments:

b. Water Quality

Water Quality: iron + bacteria (good, poor) Comments:

Water quality issues? (e.g., turbidity, minerals, salt, sulphur, gas, bacteria)

Treatment system: iron filter (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well? 2-3 / year

Do you have any analytical laboratory reports? (YES/ NO)

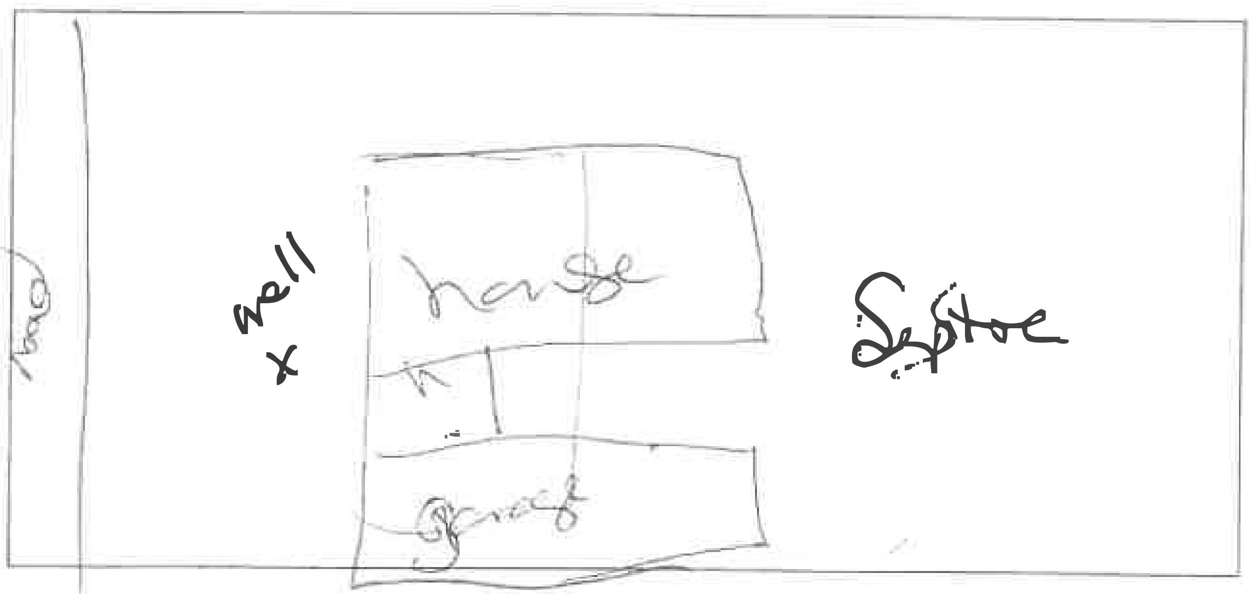
Other Comments:

c. Additional Remarks

Do you have a septic system? (YES / NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-19

February 2020

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address:	
Municipal Addres	
Telephone Numb	
Email (optional):	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES NO)
Do you drink bottled water?	(YES/ NO)

c) Water Well Details

Well Usage:	domestic	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?		
Well Type:	drilled	(e.g., hand dug, bored, drilled)
Casing Type:	steel	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:		(inches or metres)
Well Depth:		(feet or metres)
Well Age:	10 +	(years)

Original Drilling Date: 2009? (year)

A066044

Do you have a MOE Ontario Well Tag on your well? (YES/NO) Please provide Well Tag No: A0EE A088044

Other comments:

a. Water Quantity

Water level: 4.36m T.o.c. (~~depth from ground surface~~) (~~feet~~ or metres)

Pump Type: (e.g., submersible, suction lift, jet)

Pump Location: (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well:

Other comments:

b. Water Quality

Water Quality: good (good, poor) Comments:

Water quality issues? None aware of (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: none (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO)

Other Comments:

c. Additional Remarks

Do you have a septic system? (YES/ NO)

Whitney Bed

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:

GOLDER

PW-20

February 2020

Project No. 1895839

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Address	
Municipal Add	
Telephone Nu	
Email (optiona	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)
Do you drink bottled water?	(YES/ NO) occasionally

c) Water Well Details

Well Usage:	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	Front of house
Well Type:	(e.g., hand dug, bored, drilled)
Casing Type:	(e.g. steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	(inches or metres)
Well Depth:	(feet or metres)
Well Age:	(years)

Original Drilling Date: (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:
Yes but burried

Other comments:

a. Water Quantity

Water level: Well burried under straw (depth from ground surface) (feet or metres)

Pump Type: (e.g., submersible, suction lift, jet)

Pump Location: (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well:

Other comments:

b. Water Quality

Water Quality: high iron content (good, poor) Comments:

Water quality issues? (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO)

Other Comments:

c. Additional Remarks

Do you have a septic system? **(YES/ NO)**

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:

PW-21

February 2020

Project No. 1895839

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:	
Resident:	
Street Addı	
Municipal A	
Telephone	
Email (optio	

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/ NO)
Do you drink bottled water?	(YES/ NO)

c) Water Well Details

Well Usage:	domestic	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	75' from SOUTH CORNER OF HOUSE	
Well Type:	drilled	(e.g., hand dug, bored, drilled)
Casing Type:	steel	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	400'	(feet or metres)
Well Age:	16yrs	(years)

Original Drilling Date: Aug 2004 (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:

Other comments:

a. Water Quantity

need to go back when water is not in use.

Water level: 200ft + ? T.O.C. (depth from ground surface) (feet or metres)

Pump Type: submersible (e.g., submersible, suction lift, jet)

Pump Location: well (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: none

Other comments:

b. Water Quality

Water Quality: good (good, poor) Comments:

Water quality issues? (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: none (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO)

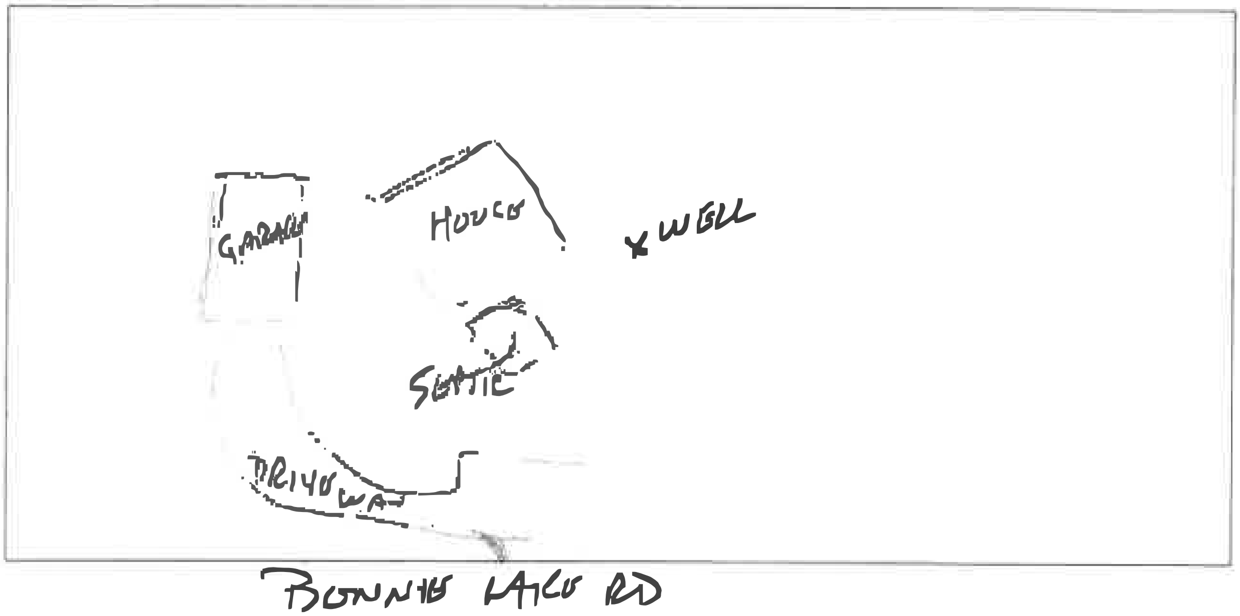
Other Comments:

c. **Additional Remarks:**

Do you have a septic system? (YES/ NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-22

February 2020

Project No. 1895639

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:

Resident:

Street Address:

Municipal Addre

Telephone Numl

Email (optional):

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/NO)
Do you drink bottled water?	(YES/NO)

c) Water Well Details

Well Usage:		(e.g. domestic, livestock, commercial, irrigation, not used)
Where is your well located?	Beside house	
Well Type:		(e.g., hand dug, bored, drilled)
Casing Type:		(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	~400 ft	(feet or metres)
Well Age:	2017	(years)

Golder Associates Ltd.
1931 Robertson Road, Ottawa, Ontario, K2H 5B7, Canada

T: +1 613 592 9600 F: +1 613 592 9601

Original Drilling Date: 2017 (year)

Do you have a MOE Ontario Well Tag on your well? (YES/NO) Please provide Well Tag No:

Other comments:

a. Water Quantity

Water level: 10.09 m TOC (~~depth from ground surface~~) (feet or metres)

Pump Type: (e.g. submersible, suction lift, jet)

Pump Location: well (house or well)

Well Capacity: (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well:

Other comments:

b. Water Quality

Water Quality: Good (good, poor) Comments:

Water quality issues? Hard (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: No (e.g., none, softener, UV, carbon filter)

How often do you sample water from your well? Not since house bought 2019

Do you have any analytical laboratory reports? bact. (YES/NO)

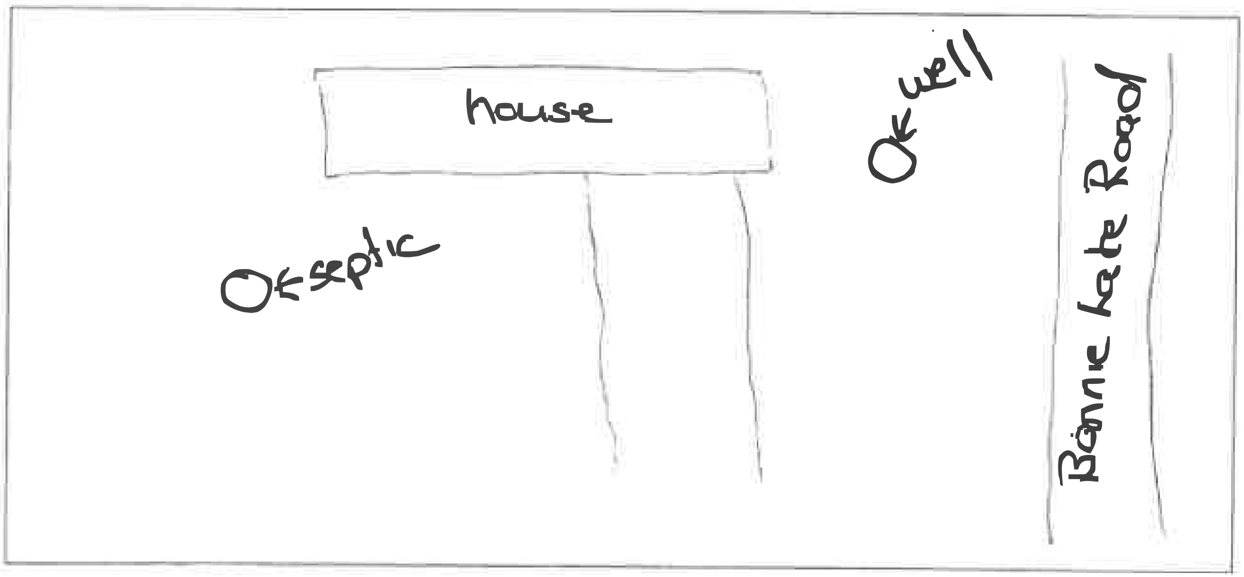
Other Comments:

c. **Additional Remarks**

Do you have a septic system? (YES/ NO)

Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:



GOLDER

PW-25

February 2020

Project No. 1895839

WATER WELL SURVEY FORM

The survey consists of the following questionnaire which requests basic water well information. Please answer the questionnaire as thoroughly as possible.

a) Well Owner Information

Well Owner:

Resident:

Street Addre

Municipal Ad

Telephone N

Email (option

b) Available Water Supply

Do you use your well water for drinking purposes?	(YES/NO) YES
Do you drink bottled water?	(YES/NO) NO

c) Water Well Details

Well Usage:	Domestic	(e.g., domestic, livestock, commercial, irrigation, not used)
Where is your well located?	2 drilled wells: 1- on the north side of Driveway 1- on north side of front yard.	
Well Type:	Drilled	(e.g., hand dug, bored, drilled)
Casing Type:	Steel.	(e.g., steel, concrete, culvert, stone/ wood, cribbed)
Well Diameter:	6"	(inches or metres)
Well Depth:	550' / 328'	(feet or metres)
Well Age:	1989 / 2007	(years)

Original Drilling Date: 1989/2007 (year)

Do you have a MOE Ontario Well Tag on your well? (YES/ NO) Please provide Well Tag No:

Other comments:

a. Water Quantity

well in driveway

Water level: 8.24m T.O.C. (depth from ground surface) (feet or metres)

Pump Type: Submersible (e.g., submersible, suction lift, jet)

Pump Location: well (house or well)

Well Capacity: 1989 unknown 2007-1gpm (gallons per minute/ litres per minute)

Please describe any water quantity problems experienced with the well: Both wells have required Hydrofracturing multiple times to improve recovery due to Iron build up.

Other comments:

b. Water Quality

Water Quality: Iron. high. (good, poor) Comments:

Water quality issues? Iron (e.g., turbidity, mineral, salt, sulphur, gas, bacteria)

Treatment system: Iron filter/softener (e.g.; none, softener, UV, carbon filter)

How often do you sample water from your well?

Do you have any analytical laboratory reports? (YES/ NO)

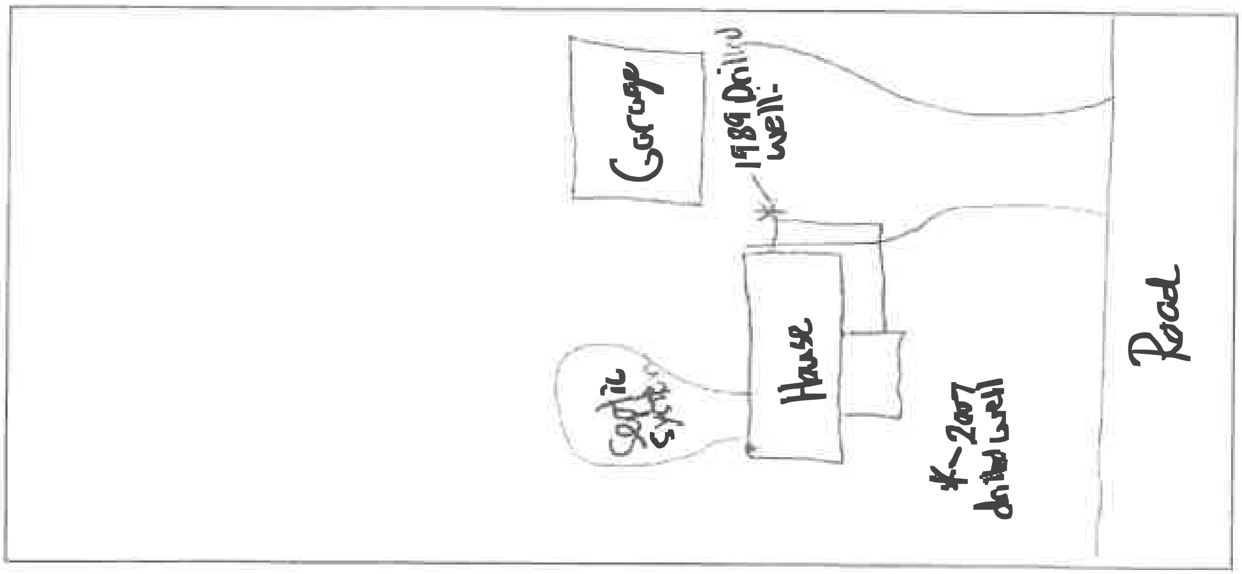
Other Comments:

c. Additional Remarks

Do you have a septic system? (YES/ NO)

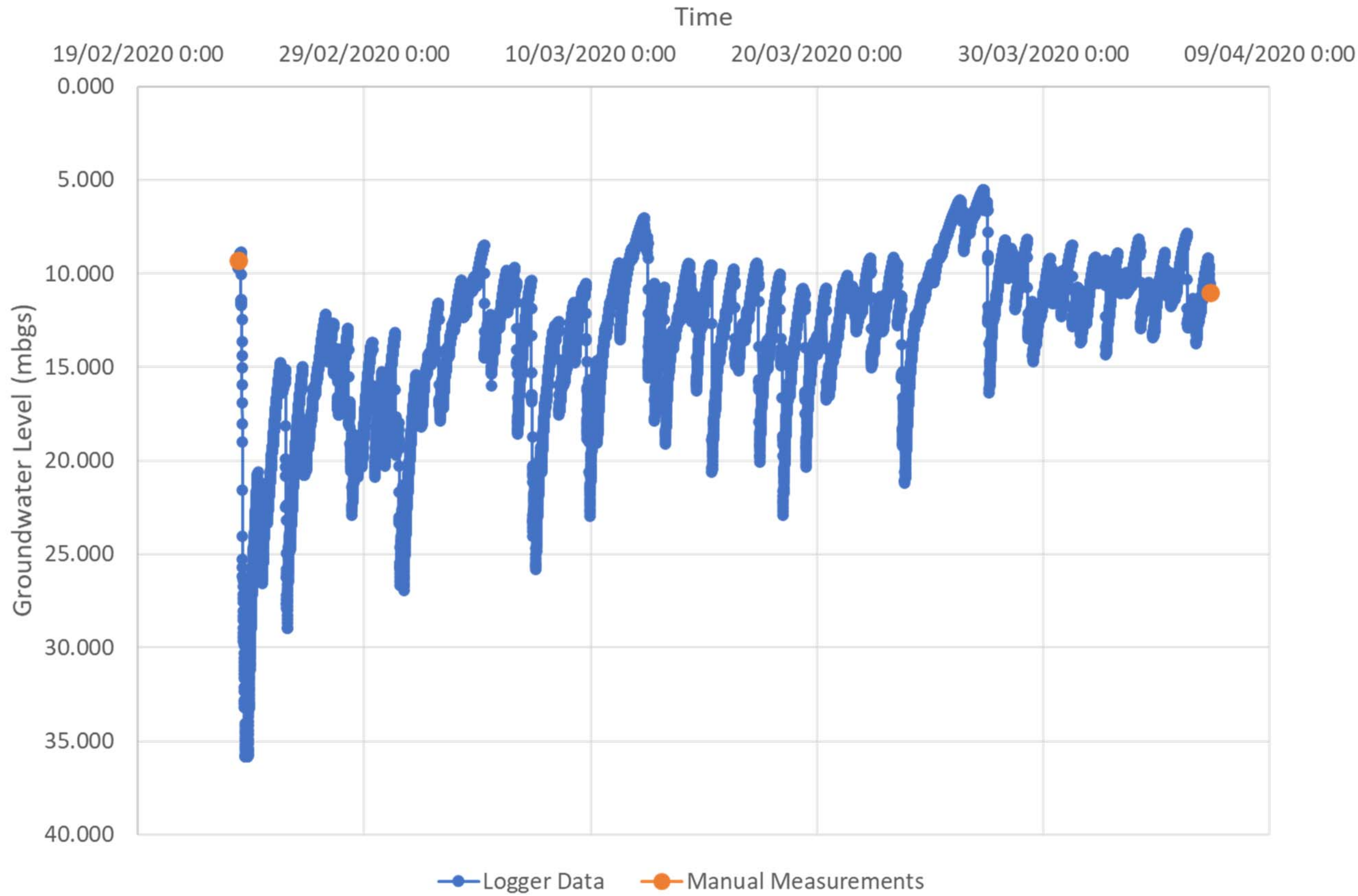
Other Comments:

Please provide a sketch of well(s) and septic system (if present) relative to building, road, or other landmarks in the space provided below:

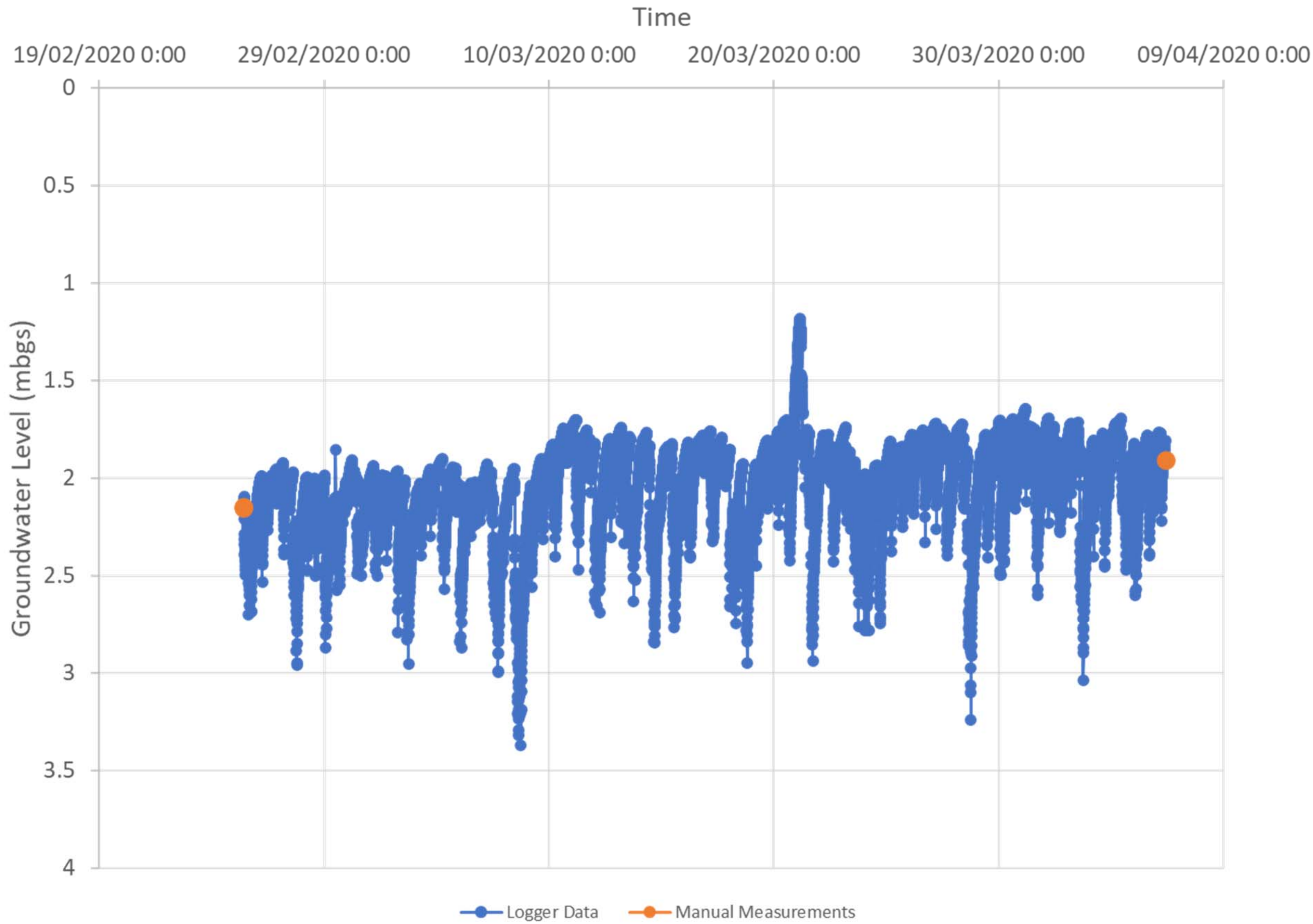


APPENDIX G

Private Well Water Level Logger Data

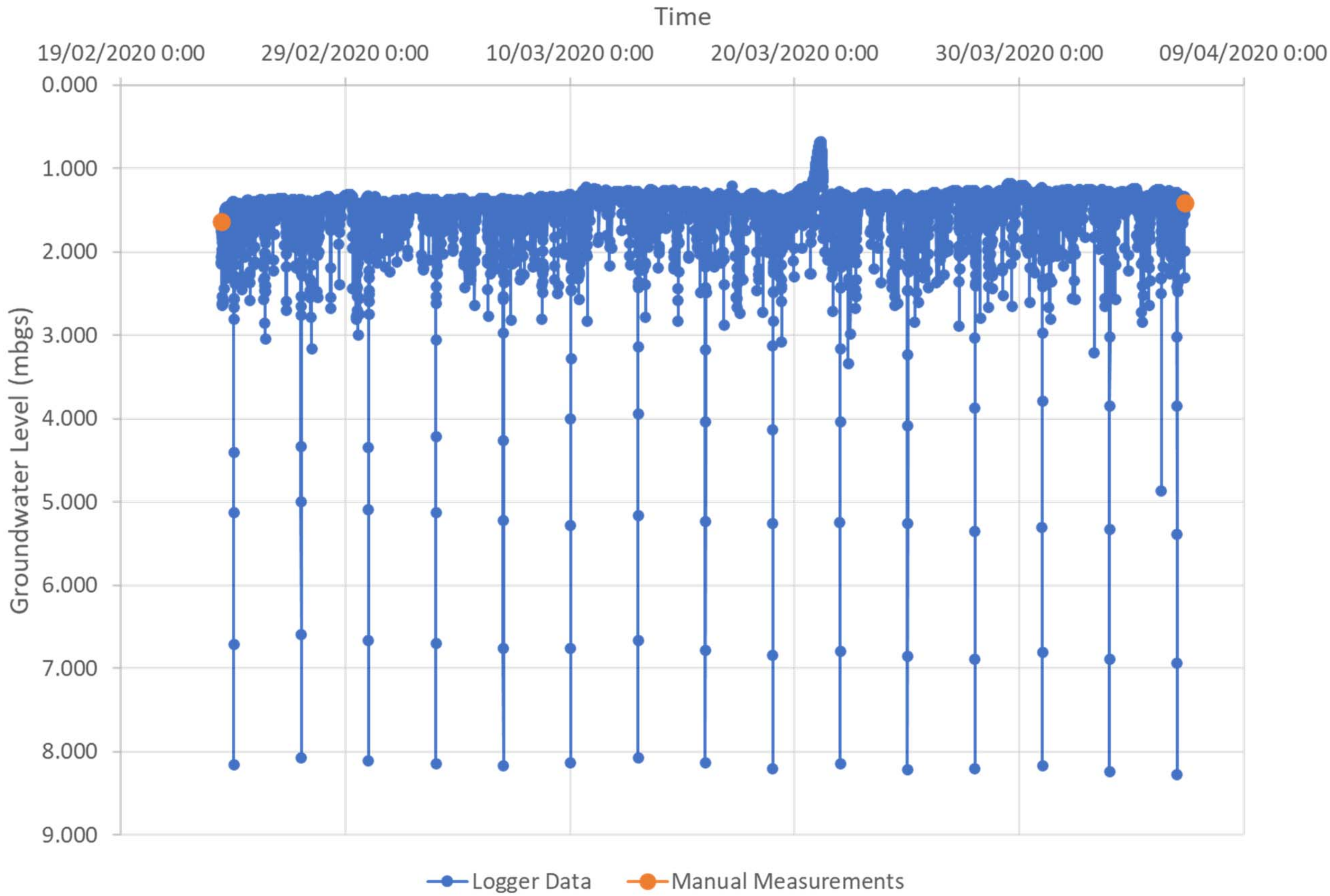


GOLDER	Date: May 2020 Drawn: JPAO		PW-7 Groundwater Level Data February 23, 2020 to April 6, 2020	FIGURE G1
	Project: 1895639 Checked: KAM			



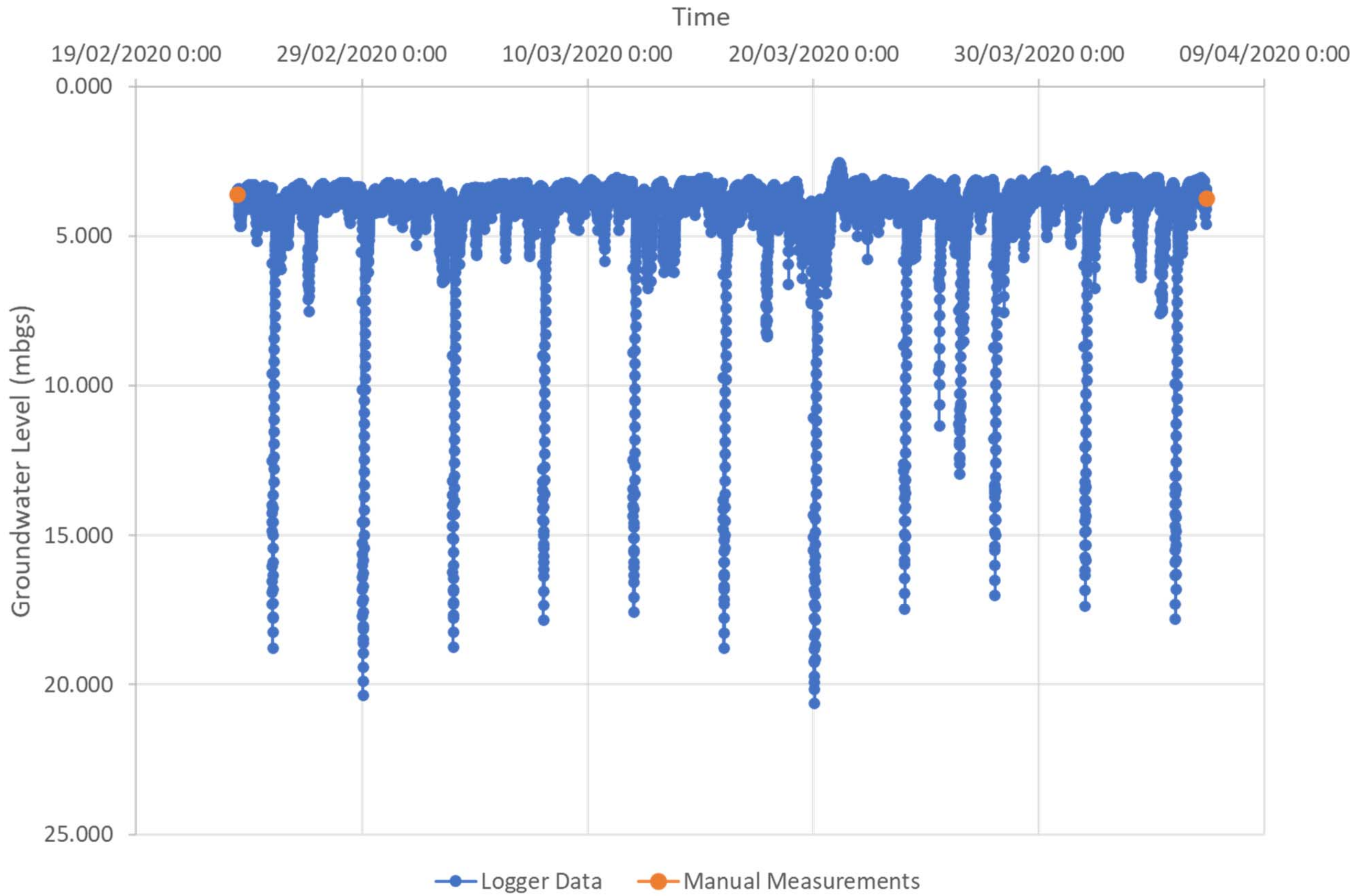
GOLDER

	Date: May 2020 Drawn: JPAO Project: 1895639 Checked: KAM	PW-8 Groundwater Level Data February 25, 2020 to April 6, 2020	FIGURE G2



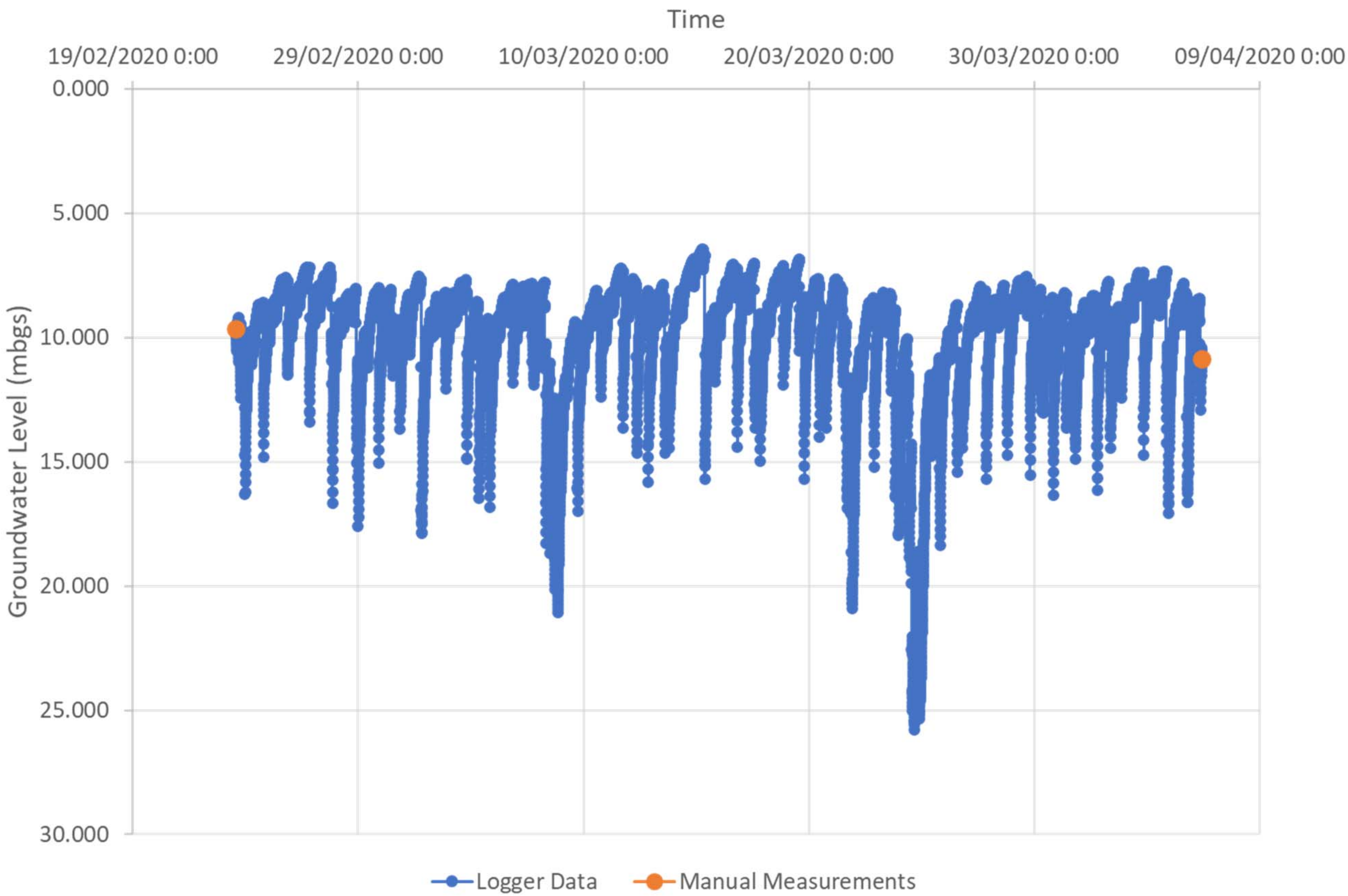
GOLDER

Date: May 2020	Drawn: JPAO	PW-13 Groundwater Level Data February 23, 2020 to April 6, 2020	FIGURE G3
Project: 1895639	Checked: KAM		



GOLDER

Date: May 2020	Drawn: JPAO	PW-18 Groundwater Level Data February 23, 2020 to April 6, 2020	FIGURE G4
Project: 1895639	Checked: KAM		



GOLDER	Date: May 2020 Drawn: JPAO Project: 1895639 Checked: KAM	PW-22 Groundwater Level Data February 23, 2020 to April 6, 2020	FIGURE G5

APPENDIX H

Surface Water Quality Results

Table H1: Water Quality Results at Surface Water Monitoring Stations Fowler Childs Pit/Quarry

Sampling Date	UNITS	PWQO {interim} [1]	CWQG {long term} [2]	08/Apr/2019 [3]					20/June/2019 [3]						29/Aug/2019 [3]						25/Nov/2019 [3]						RDL
Sample ID				SW-2	SW-3	SW-4	SW-5	SW-6	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-1	SW-2	SW-3	SW-4 [4]	SW-5	SW-6 [4]	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	
Field Measured Parameters																											
pH	-	-	-	-	-	-	-	-	4.3	6.0	5.7	5.0	5.8	5.9	5.5	7.8	6.8	-	6.8	-	4.5	6.3	6.4	5.3	6.0	5.3	-
Temperature	(°C)	-	-	-	-	-	-	-	16.8	19.4	9.5	11.2	19.3	14.6	16.4	15.6	10.2	-	19.0	-	0.4	0.6	2.7	3.2	0.9	2.1	-
Conductivity	µS/cm	-	-	-	-	-	-	-	22.9	21.7	18.2	12.1	22.9	10.0	34.6	31.5	20.2	-	37.9	-	51.2	37.9	21.7	11.8	58.4	32.2	-
Dissolved Oxigen (DO)	mg/L	-	-	-	-	-	-	-	5.4	-	9.2	1.7	6.8	9.5	5.2	8.9	9.7	-	4.9	-	11.1	13.9	12.0	9.9	12.5	13.3	-
Laboratory Calculated Parameters																											
Hardness ($CaCO_3$)	mg/L	-	-	-	-	-	-	-	4.0	6.3	7.0	3.5	6.6	3.2	9.7	12	8.0	-	14	-	9.5	11	9.0	4.6	11	10	1.0
Inorganics																											
Orthophosphate (P)	mg/L	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010
pH	pH	6.5 - 8.5 [5]	6.5-9	**6.27**	**6.13**	**5.78**	**6.11**	**5.95**	**4.63**	**6.21**	**6.39**	**5.57**	**5.96**	**6.17**	**5.73**	7.03	6.80	-	7.03	-	**4.47**	**6.21**	6.70	**5.51**	**6.12**	**5.26**	0.0
Total Suspended Solids	mg/L	-	-	6	94	1	5	7	<1	2	5	<1	10	1	2	<1	5	-	3	-	1	1	24	<1	5	<1	1
Nitrite (N)	mg/L	-	{0.060}	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010	<0.010	-	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010
Dissolved Chloride (Cl)	mg/L	-	-	9.0	<1.0	<1.0	9.7	2.5	2.5	3.6	<1.0	<1.0	3.2	1.7	5.6	1.7	<1.0	-	2.7	-	2.4	5.6	<1.0	<1.0	6.1	3.0	1.0
Nitrate (N)	mg/L	-	550 {13}	0.22	<0.10	0.18	0.25	0.12	<0.50	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	0.11	<0.10	0.15	0.11	0.12	0.10
Nitrate + Nitrite (N)	mg/L	-	-	0.22	<0.10	0.18	0.25	0.12	<0.50	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	0.11	<0.10	0.15	0.11	0.12	0.10
Dissolved Sulphate (SO_4)	mg/L	-	-	<1.0	1.8	1.8	<1.0	<1.0	<1.0	<1.0	2.9	2.0	<1.0	<1.0	<1.0	2.2	3.3	-	1.7	-	<1.0	1.6	4.1	2.7	1.8	7.5	1.0
Metals																											
Total Aluminum (Al)	µg/L	-	{5 - 100[6]} [7]	240	380	150	240	240	530	220	90	150	300	210	170	66	84	-	110	-	400	190	410	130	490	190	5.0
Total Antimony (Sb)	µg/L	{20}	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50
Total Arsenic (As)	µg/L	100 {5}	{5}	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Barium (Ba)	µg/L	-	-	16	12	13	16	15	16	13	12	15	14	11	20	9.4	9.1	-	12	-	27	16	11	16	20	29	2.0
Total Beryllium (Be)	µg/L	11 - 1100 [8]	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50
Total Bismuth (Bi)	µg/L	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Boron (B)	µg/L	{200}	29,000 {1,500}	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	<10	-	<10	<10	<10	<10	<10	<10	10
Total Cadmium (Cd)	µg/L	0.2 {0.1 - 0.5} [9]	1 {0.09[6]}	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	0.12	<0.10	<0.10	<0.10	<0.10	0.18	0.10
Total Calcium (Ca)	µg/L	-	-	2600	1500	980	2600	1300	1200	1900	2100	1000	1900	920	2200	2700	2000	-	3300	-	2300	2700	2600	1000	2800	2700	200
Total Chromium (Cr)	µg/L	8.9 [10]	{1[6]}	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	<5.0	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0
Total Cobalt (Co)	µg/L	0.9		<0.50	<0.50	<0.50	<0.50	<0.50	0.54	<0.50	<0.50	<0.50	<0.50	<0.50	0.60	<0.50	<0.50	-	<0.50	-	0.74	<0.50	<0.50	<0.50	0.52	<0.50	0.50
Total Copper (Cu)	µg/L	5 {1 - 5} [11]	{2 - 4} [12]	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	**1.3**	-	**1.2**	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Iron (Fe)	µg/L	300	300	**410**	**340**	<100	**440**	120	**680**	**690**	150	<100	**770**	160	**550**	**490**	250	-	**930**	-	**310**	**330**	**550**	<100	**640**	<100	100
Total Lead (Pb)	µg/L	5 - 25 {1 - 5} [13]	{1 - 7} [14]	<0.50	<0.50	<0.50	<0.50	<0.50	1.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	-	0.94	<0.50	0.74	<0.50	0.70	<0.50	0.50
Total Lithium (Li)	µg/L	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	<5.0	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0
Total Magnesium (Mg)	µg/L	-	-	570	350	230	570	320	270	400	370	200	430	200	580	820	370	-	1000	-	580	630	470	230	720	540	50
Total Manganese (Mn)	µg/L	-	-	41	21	12	43	44	19	32	15	10	37	10	35	27	11	-	45	-	40	27	11	9.0	42	110	2.0
Total Molybdenum (Mo)	µg/L	{40}	{73}	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50
Total Nickel (Ni)	µg/L	25	{25 - 150} [15]	<1.0	<1.0	<1.0	<1.0	<1.0	1.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Potassium (K)	µg/L	-	-	410	200	<200	430	250	<200	<200	270	<200	<200	<200	<200	350	230	-	460	-	<200	270	350	<200	310	<200	200
Total Selenium (Se)	µg/L	100	{1[6]}	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0
Total Silicon (Si)	µg/L	-	-	2700	2900	2100	2700	2200	1600	680	3800	2500	680	1700	1400	3100	4000	-	3100	-	3100	2500	4300	2000	2900	2500	50
Total Silver (Ag)	µg/L	0.1	{0.25}	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10
Total Sodium (Na)	µg/L	-	-	5300	760	560	5600	1600	800	2100	940	580	2100	1100	1700	1900	990	-	2400	-	1300	3400	1200	480	3600	1600	100
Total Strontium (Sr)	µg/L	-	-	23	14	11	24	12	12	19	22	13	19	8.2	36	31	23	-	36	-	25	28	29	14	30	25	1.0
Total Tellurium (Te)	µg/L	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Thallium (Tl)	µg/L	0.3	{0.8}	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-	<0.050	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050
Total Tin (Sn)	µg/L	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0

Table H1: Water Quality Results at Surface Water Monitoring Stations Fowler Childs Pit/Quarry

Sampling Date	UNITS	PWQO {interim} [1]	CWQG {long term} [2]	08/Apr/2019 [3]					20/June/2019 [3]						29/Aug/2019 [3]						25/Nov/2019 [3]						RDL
Sample ID				SW-2	SW-3	SW-4	SW-5	SW-6	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	SW-1	SW-2	SW-3	SW-4 [4]	SW-5	SW-6 [4]	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	
Total Titanium (Ti)	µg/L	-	-	7.5	20	<5.0	11	5.1	7.2	5.1	<5.0	<5.0	9.6	<5.0	<5.0	<5.0	<5.0	-	<5.0	-	<5.0	<5.0	21	<5.0	27	<5.0	5.0
Total Tungsten (W)	µg/L	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Total Uranium (U)	µg/L	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10
Total Vanadium (V)	µg/L	6	-	<0.50	0.95	<0.50	0.65	<0.50	<0.50	0.67	0.80	<0.50	0.72	<0.50	0.58	0.68	0.83	-	0.98	-	0.70	<0.50	1.8	<0.50	1.4	<0.50	0.50
Total Zinc (Zn)	µg/L	30 {20}	{30}	6.6	<5.0	8.4	6.8	9.1	13	5.8	<5.0	8.2	5.3	6.1	14	<5.0	<5.0	-	**22**	-	**23**	7.8	<5.0	10	9.8	18	5.0
Total Zirconium (Zr)	µg/L	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0

Notes:

1. Ontario Ministry of Environment and Energy (MOEE 1999). Policies Guidelines Provincial Water Quality Objectives (PWQO). Originally published in 1994, reprinted 1999. Guideline objectives representative for current and {interim} PWQOs.
PWQO exceedances are highlighted in bold.
2. Canadian Council of Ministers of the Environment's Canadian Environmental Quality Guidelines (CWQG 1999) with site-specific guidelines for the Protection of Aquatic Life (2003). Guideline objectives representative for short term and {long term}.
CWQG exceedances {long term} are highlighted in grey.
3. Concentrations represent total concentrations (samples were not filtered).
4. Measured field data not available. Surface water station was dry at time of field visit.
5. pH values of <6.5 and >8.5 are outside the range considered acceptable by the PWQO for pH.
6. Objective guideline smaller than laboratory detection limit.
7. Objective dependent on pH; CWQG=5 if pH <6.5; CWQG=100, if pH>6.5.
8. Objective dependent on Hardness as $CaCO_3$; PWQO=11 if Hardness<75 mg/L; PWQO=1100 if Hardness>75 mg/L.
9. Objective dependent on Hardness as $CaCO_3$; PWQO=0.1 if Hardness<100 mg/L; PWQO=0.5 if Hardness>100 mg/L.
10. PWQO for Trivalent Chromium used in the absence of PWQO for Total Chromium.
11. Objective dependent on Hardness as CaCO3; PWQO=1 if Hardness<20 mg/L; PWQO=5 if Hardness>20 mg/L.
12. Objective dependent on Hardness (as CaCO3); CWQG=2 if Hardness is 0 to <82 mg/L; CWQG=$0.2*e^{[0.8545[\ln(hardness)]-1.465]}$, if Hardness>82 to 180 mg/L; CWQG=4 if Hardness is>180 mg/L.
13. Objective dependent on Alkalinity as CaCO3: PWQO=5 if Alkalinity<20; PWQO=25 if Alkalinity>80. Interim objective dependent on Hardness as CaCO3; PWQO=1 if Hardness<30 mg/L; PWQO=3 if Hardness=30 to 80 mg/L; PWQO=5 if Hardness>80 mg/L.
14. Objective dependent on Hardness (as CaCO3); CWQG=1 if Hardness is 0 to <60 mg/L; CWQG=$e^{[1.273[\ln(hardness)]-4.705]}$, if Hardness>60 to 180 mg/L; CWQG=7 if Hardness is>180 mg/L.
15. Objective dependent on Hardness (as CaCO3); CWQG=25 if Hardness is 0 to <60 mg/L; CWQG=$e^{[0.76[\ln(hardness)]+1.06]}$, if Hardness>60 to 180 mg/L; CWQG=150 if Hardness is>180 mg/L.

°C = degrees celsius; µS/cm = microsiemens per centimeter; µg/L = micrograms per litre; mg/L = milligrams per litre; pH = potential hydrogen; RDL = reporting detection limit

Maxxam
A Bureau Veritas Group Company

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 709779-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/04/15
Report #: R5671141
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B991645
Received: 2019/04/08, 17:11

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride by Automated Colourimetry	6	N/A	2019/04/11	CAM SOP-00463	SM 4500-Cl E m
Total Metals Analysis by ICPMS	6	N/A	2019/04/11	CAM SOP-00447	EPA 6020B m
Nitrate (NO3) and Nitrite (NO2) in Water (1)	6	N/A	2019/04/10	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	6	2019/04/09	2019/04/09	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	6	N/A	2019/04/12	CAM SOP-00461	EPA 365.1 m
Sulphate by Automated Colourimetry	6	N/A	2019/04/11	CAM SOP-00464	EPA 375.4 m
Low Level Total Suspended Solids	6	2019/04/09	2019/04/10	CAM SOP-00428	SM 23 2540D m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 709779-01-01

<u>Attention: Marta Lopez-Egea</u>

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/04/15
Report #: R5671141
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B991645
Received: 2019/04/08, 17:11

Encryption Key

Ronklin Gracian
Project Manager
15 Apr 2019 12:57:51

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

RESULTS OF ANALYSES OF WATER

Maxxam ID		JJY981		JJY982	JJY983			JJY983	
Sampling Date		2019/04/08 10:15		2019/04/08 11:30	2019/04/08 12:25			2019/04/08 12:25	
COC Number		709779-01-01		709779-01-01	709779-01-01			709779-01-01	
	UNITS	**SW-1**	**QC Batch**	**SW-2**	**SW-3**	**RDL**	**QC Batch**	**SW-3 Lab-Dup**	**QC Batch**
Inorganics									
Orthophosphate (P)	mg/L	<0.010	6064767	<0.010	<0.010	0.010	6064767		
pH	pH	5.51	6060871	6.27	6.17		6060871	6.13	6060871
Total Suspended Solids	mg/L	<1	6061549	6	94	1	6061100		
Dissolved Sulphate (SO4)	mg/L	<1.0	6064764	<1.0	1.8	1.0	6064764		
Dissolved Chloride (Cl-)	mg/L	2.6	6064757	9.0	<1.0	1.0	6064757		
Nitrite (N)	mg/L	<0.010	6060815	<0.010	<0.010	0.010	6060815		
Nitrate (N)	mg/L	<0.10	6060815	0.22	<0.10	0.10	6060815		
Nitrate + Nitrite (N)	mg/L	<0.10	6060815	0.22	<0.10	0.10	6060815		

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam ID		JJY984		JJY985		JJY986		
Sampling Date		2019/04/08 13:00		2019/04/08 13:15		2019/04/08 13:25		
COC Number		709779-01-01		709779-01-01		709779-01-01		
	UNITS	**SW-4**	**QC Batch**	**SW-5**	**QC Batch**	**SW-6**	**RDL**	**QC Batch**
Inorganics								
Orthophosphate (P)	mg/L	<0.010	6064767	<0.010	6064767	<0.010	0.010	6064767
pH	pH	5.78	6060871	6.11	6060871	5.95		6060871
Total Suspended Solids	mg/L	1	6061549	5	6061100	7	1	6061549
Dissolved Sulphate (SO4)	mg/L	1.8	6064764	<1.0	6064764	<1.0	1.0	6064764
Dissolved Chloride (Cl-)	mg/L	<1.0	6064757	9.7	6064757	2.5	1.0	6064757
Nitrite (N)	mg/L	<0.010	6060815	<0.010	6062713	<0.010	0.010	6060815
Nitrate (N)	mg/L	0.18	6060815	0.25	6062713	0.12	0.10	6060815
Nitrate + Nitrite (N)	mg/L	0.18	6060815	0.25	6062713	0.12	0.10	6060815

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		JJY981	JJY982	JJY983	JJY984	JJY985	JJY986		
Sampling Date		2019/04/08 10:15	2019/04/08 11:30	2019/04/08 12:25	2019/04/08 13:00	2019/04/08 13:15	2019/04/08 13:25		
COC Number		709779-01-01	709779-01-01	709779-01-01	709779-01-01	709779-01-01	709779-01-01		
	UNITS	**SW-1**	**SW-2**	**SW-3**	**SW-4**	**SW-5**	**SW-6**	**RDL**	**QC Batch**
Metals									
Total Aluminum (Al)	ug/L	230	240	380	150	240	240	5.0	6064752
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6064752
Total Arsenic (As)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Barium (Ba)	ug/L	11	16	12	13	16	15	2.0	6064752
Total Beryllium (Be)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6064752
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Boron (B)	ug/L	<10	<10	<10	<10	<10	<10	10	6064752
Total Cadmium (Cd)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6064752
Total Calcium (Ca)	ug/L	970	2600	1500	980	2600	1300	200	6064752
Total Chromium (Cr)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6064752
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6064752
Total Copper (Cu)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Iron (Fe)	ug/L	210	410	340	<100	440	120	100	6064752
Total Lead (Pb)	ug/L	0.57	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6064752
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6064752
Total Magnesium (Mg)	ug/L	250	570	350	230	570	320	50	6064752
Total Manganese (Mn)	ug/L	19	41	21	12	43	44	2.0	6064752
Total Molybdenum (Mo)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6064752
Total Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Potassium (K)	ug/L	300	410	200	<200	430	250	200	6064752
Total Selenium (Se)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	6064752
Total Silicon (Si)	ug/L	2600	2700	2900	2100	2700	2200	50	6064752
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6064752
Total Sodium (Na)	ug/L	1300	5300	760	560	5600	1600	100	6064752
Total Strontium (Sr)	ug/L	9.5	23	14	11	24	12	1.0	6064752
Total Tellurium (Te)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	6064752
Total Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Titanium (Ti)	ug/L	<5.0	7.5	20	<5.0	11	5.1	5.0	6064752
Total Tungsten (W)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6064752

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		JJY981	JJY982	JJY983	JJY984	JJY985	JJY986		
Sampling Date		2019/04/08 10:15	2019/04/08 11:30	2019/04/08 12:25	2019/04/08 13:00	2019/04/08 13:15	2019/04/08 13:25		
COC Number		709779-01-01	709779-01-01	709779-01-01	709779-01-01	709779-01-01	709779-01-01		
	UNITS	**SW-1**	**SW-2**	**SW-3**	**SW-4**	**SW-5**	**SW-6**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	<0.50	<0.50	0.95	<0.50	0.65	<0.50	0.50	6064752
Total Zinc (Zn)	ug/L	8.0	6.6	<5.0	8.4	6.8	9.1	5.0	6064752
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6064752

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

Maxxam ID: JJY981
Sample ID: SW-1
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6060815	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061549	2019/04/09	2019/04/10	Nilam Borole

Maxxam ID: JJY982
Sample ID: SW-2
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6060815	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061100	2019/04/09	2019/04/10	Massarat Jan

Maxxam ID: JJY983
Sample ID: SW-3
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6060815	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061100	2019/04/09	2019/04/10	Massarat Jan

Maxxam ID: JJY983 Dup
Sample ID: SW-3
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai

Maxxam ID: JJY984
Sample ID: SW-4
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

Maxxam ID: JJY984
Sample ID: SW-4
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6060815	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061549	2019/04/09	2019/04/10	Nilam Borole

Maxxam ID: JJY985
Sample ID: SW-5
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6062713	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061100	2019/04/09	2019/04/10	Massarat Jan

Maxxam ID: JJY986
Sample ID: SW-6
Matrix: Water

Collected: 2019/04/08
Shipped:
Received: 2019/04/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6064757	N/A	2019/04/11	Deonarine Ramnarine
Total Metals Analysis by ICPMS	ICP/MS	6064752	N/A	2019/04/11	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6060815	N/A	2019/04/10	Chandra Nandlal
pH	AT	6060871	2019/04/09	2019/04/09	Surinder Rai
Orthophosphate	KONE	6064767	N/A	2019/04/12	Deonarine Ramnarine
Sulphate by Automated Colourimetry	KONE	6064764	N/A	2019/04/11	Deonarine Ramnarine
Low Level Total Suspended Solids	BAL	6061549	2019/04/09	2019/04/10	Nilam Borole

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	2.7°C

Results relate only to the items tested.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B991645
Report Date: 2019/04/15

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6060815	Nitrate (N)	2019/04/10	98	80 - 120	100	80 - 120	<0.10	mg/L	NC	20		
6060815	Nitrite (N)	2019/04/10	101	80 - 120	102	80 - 120	<0.010	mg/L	2.5	20		
6060871	pH	2019/04/09			102	98 - 103			0.68	N/A		
6061100	Total Suspended Solids	2019/04/10					<1	mg/L	18	25	100	85 - 115
6061549	Total Suspended Solids	2019/04/10					<1	mg/L	3.8	25	98	85 - 115
6062713	Nitrate (N)	2019/04/10	102	80 - 120	106	80 - 120	<0.10	mg/L	5.5	20		
6062713	Nitrite (N)	2019/04/10	106	80 - 120	106	80 - 120	<0.010	mg/L	NC	20		
6064752	Total Aluminum (Al)	2019/04/11	115	80 - 120	98	80 - 120	<5.0	ug/L				
6064752	Total Antimony (Sb)	2019/04/11	101	80 - 120	98	80 - 120	<0.50	ug/L				
6064752	Total Arsenic (As)	2019/04/11	97	80 - 120	95	80 - 120	<1.0	ug/L				
6064752	Total Barium (Ba)	2019/04/11	95	80 - 120	94	80 - 120	<2.0	ug/L				
6064752	Total Beryllium (Be)	2019/04/11	98	80 - 120	96	80 - 120	<0.50	ug/L				
6064752	Total Bismuth (Bi)	2019/04/11	87	80 - 120	87	80 - 120	<1.0	ug/L				
6064752	Total Boron (B)	2019/04/11	NC	80 - 120	95	80 - 120	<10	ug/L	2.2	20		
6064752	Total Cadmium (Cd)	2019/04/11	95	80 - 120	95	80 - 120	<0.10	ug/L				
6064752	Total Calcium (Ca)	2019/04/11	NC	80 - 120	98	80 - 120	<200	ug/L				
6064752	Total Chromium (Cr)	2019/04/11	93	80 - 120	92	80 - 120	<5.0	ug/L				
6064752	Total Cobalt (Co)	2019/04/11	92	80 - 120	91	80 - 120	<0.50	ug/L				
6064752	Total Copper (Cu)	2019/04/11	93	80 - 120	94	80 - 120	<1.0	ug/L				
6064752	Total Iron (Fe)	2019/04/11	92	80 - 120	91	80 - 120	<100	ug/L	14	20		
6064752	Total Lead (Pb)	2019/04/11	89	80 - 120	89	80 - 120	<0.50	ug/L				
6064752	Total Lithium (Li)	2019/04/11	97	80 - 120	95	80 - 120	<5.0	ug/L				
6064752	Total Magnesium (Mg)	2019/04/11	92	80 - 120	93	80 - 120	<50	ug/L				
6064752	Total Manganese (Mn)	2019/04/11	91	80 - 120	90	80 - 120	<2.0	ug/L				
6064752	Total Molybdenum (Mo)	2019/04/11	98	80 - 120	95	80 - 120	<0.50	ug/L				
6064752	Total Nickel (Ni)	2019/04/11	89	80 - 120	89	80 - 120	<1.0	ug/L				
6064752	Total Potassium (K)	2019/04/11	93	80 - 120	93	80 - 120	<200	ug/L				
6064752	Total Selenium (Se)	2019/04/11	100	80 - 120	99	80 - 120	<2.0	ug/L				
6064752	Total Silicon (Si)	2019/04/11	94	80 - 120	93	80 - 120	<50	ug/L				
6064752	Total Silver (Ag)	2019/04/11	93	80 - 120	92	80 - 120	<0.10	ug/L				
6064752	Total Sodium (Na)	2019/04/11	NC	80 - 120	92	80 - 120	<100	ug/L				
6064752	Total Strontium (Sr)	2019/04/11	NC	80 - 120	92	80 - 120	<1.0	ug/L				

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B991645
Report Date: 2019/04/15

QUALITY ASSURANCE REPORT(CONT'D)

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6064752	Total Tellurium (Te)	2019/04/11	97	80 - 120	98	80 - 120	<1.0	ug/L				
6064752	Total Thallium (Tl)	2019/04/11	90	80 - 120	89	80 - 120	<0.050	ug/L				
6064752	Total Tin (Sn)	2019/04/11	98	80 - 120	95	80 - 120	<1.0	ug/L				
6064752	Total Titanium (Ti)	2019/04/11	99	80 - 120	95	80 - 120	<5.0	ug/L				
6064752	Total Tungsten (W)	2019/04/11	95	80 - 120	93	80 - 120	<1.0	ug/L				
6064752	Total Uranium (U)	2019/04/11	87	80 - 120	86	80 - 120	<0.10	ug/L				
6064752	Total Vanadium (V)	2019/04/11	95	80 - 120	93	80 - 120	<0.50	ug/L				
6064752	Total Zinc (Zn)	2019/04/11	93	80 - 120	94	80 - 120	<5.0	ug/L	6.9	20		
6064752	Total Zirconium (Zr)	2019/04/11	100	80 - 120	97	80 - 120	<1.0	ug/L				
6064757	Dissolved Chloride (Cl-)	2019/04/11	114	80 - 120	102	80 - 120	<1.0	mg/L	0.033	20		
6064764	Dissolved Sulphate (SO4)	2019/04/11	110	75 - 125	102	80 - 120	<1.0	mg/L	1.9	20		
6064767	Orthophosphate (P)	2019/04/12	106	75 - 125	101	80 - 120	<0.010	mg/L	NC	25		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B991645
Report Date: 2019/04/15

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Eva Pranjic
CHARTERED
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683
Attention:	Accounts Payable	Attention:	Marta Lopez-Egea	P.O. #:	
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	1895639 (3000/3005)
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	(905) 567-4444 Ext: 2060 Fax:	Project Name:	
Email:	AP_CustomerService@golder.com	Email:	Marta_Lopez-Egea@golder.com	Site #:	
				Sampled By:	

Laboratory Use Only:

Maxxam Job #:	Bottle Order #:
	709779
COC #:	Project Manager:
C#709779-01-01	Ema Gitej

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)	Other Regulations	Special Instructions
☐ Table 1 ☐ Res/Park ☐ Medium/Fine	☐ CCME ☐ Sanitary Sewer Bylaw	
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ Reg 558. ☐ Storm Sewer Bylaw	
☐ Table 3 ☐ Agri/Other ☐ For RSC	☐ MISA Municipality	
☐ Table ___	☒ PWQO	
	☐ Other	

Include Criteria on Certificate of Analysis (Y/N)? ______

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ______ Time Required: ______
Rush Confirmation Number: ______ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Total Metals Analysis by ICPMS	pH	Chloride, Sulphate, Nitrate, Nitrite, Orthophosphate	Low Level TSS						# of Bottles	Comments
1	SID#437574	SW-1	2019/04/08	10:15	SW		✓	✓	✓	✓						3	
2	SID#437575	SW-2		11:30			✓	✓	✓	✓						3	
3	SID#437576	SW-3		12:25			✓	✓	✓	✓						3	
4	SID#437577	SW-4		13:00			✓	✓	✓	✓						3	
5	SID#437578	SW-5		13:15			✓	✓	✓	✓						3	
6	SID#437579	SW-6		13:25			✓	✓	✓	✓						3	
7																	
8																	
9																	
10																	

08-Apr-19 17:11
Ema Gitej
B991645
THP ENV-1368

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Kevin Whitten	19/04/08	17:10	HARAID UDMAN	2019/04/08	17:11	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
	3/3/2 ice	Present		✓
		Intact		✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxa Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 722108-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/07/03
Report #: R5781765
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: B9H0140
Received: 2019/06/20, 19:20

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride by Automated Colourimetry	6	N/A	2019/06/24	CAM SOP-00463	SM 4500-Cl E m
Hardness (calculated as CaCO3)	6	N/A	2019/07/02	CAM SOP 00102/00408/00447	SM 2340 B
Total Metals Analysis by ICPMS	6	N/A	2019/06/25	CAM SOP-00447	EPA 6020B m
Nitrate (NO3) and Nitrite (NO2) in Water (1)	6	N/A	2019/06/24	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	6	2019/06/22	2019/06/24	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	6	N/A	2019/06/24	CAM SOP-00461	EPA 365.1 m
Sulphate by Automated Colourimetry	6	N/A	2019/06/24	CAM SOP-00464	EPA 375.4 m
Low Level Total Suspended Solids	6	2019/06/22	2019/06/24	CAM SOP-00428	SM 23 2540D m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 722108-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/07/03
Report #: R5781765
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: B9H0140
Received: 2019/06/20, 19:20

Encryption Key

Ema Gitej
Senior Project Manager
03 Jul 2019 17:39:47

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: Ema.Gitej@bvlabs.com
Phone# (905)817-5829
==
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF WATER

BV Labs ID		KBK292		KBK293	KBK294			KBK294		
Sampling Date		2019/06/20 11:20		2019/06/20 13:00	2019/06/20 13:30			2019/06/20 13:30		
COC Number		722108-01-01		722108-01-01	722108-01-01			722108-01-01		
	UNITS	**SW-1**	**RDL**	**SW-2**	**SW-3**	**RDL**	**QC Batch**	**SW-3 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters										
Hardness (CaCO3)	mg/L	4.0	1.0	6.3	7.0	1.0	6199947			
Inorganics										
Orthophosphate (P)	mg/L	<0.010	0.010	<0.010	<0.010	0.010	6191892			
pH	pH	4.63		6.21	6.39		6191953			
Total Suspended Solids	mg/L	<1	1	2	5	1	6191788	5	1	6191788
Dissolved Sulphate (SO4)	mg/L	<1.0	1.0	<1.0	2.9	1.0	6191889			
Dissolved Chloride (Cl-)	mg/L	2.5	1.0	3.6	<1.0	1.0	6191888			
Nitrite (N)	mg/L	<0.050	0.050	<0.010	<0.010	0.010	6191895			
Nitrate (N)	mg/L	<0.50	0.50	<0.10	<0.10	0.10	6191895			
Nitrate + Nitrite (N)	mg/L	<0.50	0.50	<0.10	<0.10	0.10	6191895			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

BV Labs ID		KBK295			KBK295		KBK296		
Sampling Date		2019/06/20 14:15			2019/06/20 14:15		2019/06/20 14:50		
COC Number		722108-01-01			722108-01-01		722108-01-01		
	UNITS	**SW-4**	**RDL**	**QC Batch**	**SW-4 Lab-Dup**	**QC Batch**	**SW-5**	**RDL**	**QC Batch**
Calculated Parameters									
Hardness (CaCO3)	mg/L	3.5	1.0	6199947			6.6	1.0	6199947
Inorganics									
Orthophosphate (P)	mg/L	<0.010	0.010	6191892			<0.010	0.010	6191892
pH	pH	5.57		6191953	5.45	6191953	5.96		6191953
Total Suspended Solids	mg/L	<1	1	6191788			10	1	6191788
Dissolved Sulphate (SO4)	mg/L	2.0	1.0	6191889			<1.0	1.0	6191889
Dissolved Chloride (Cl-)	mg/L	<1.0	1.0	6191888			3.2	1.0	6191888
Nitrite (N)	mg/L	<0.010	0.010	6191895			0.012	0.010	6192035
Nitrate (N)	mg/L	<0.10	0.10	6191895			<0.10	0.10	6192035
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	6191895			<0.10	0.10	6192035

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

BV Labs Job #: B9H0140
Report Date: 2019/07/03

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: AK

RESULTS OF ANALYSES OF WATER

BV Labs ID		KBK296			KBK297		
Sampling Date		2019/06/20 14:50			2019/06/20 14:35		
COC Number		722108-01-01			722108-01-01		
	UNITS	**SW-5 Lab-Dup**	**RDL**	**QC Batch**	**SW-6**	**RDL**	**QC Batch**
Calculated Parameters							
Hardness (CaCO3)	mg/L				3.2	1.0	6199947
Inorganics							
Orthophosphate (P)	mg/L				<0.010	0.010	6191892
pH	pH				6.17		6191953
Total Suspended Solids	mg/L				1	1	6191788
Dissolved Sulphate (SO4)	mg/L				<1.0	1.0	6191889
Dissolved Chloride (Cl-)	mg/L				1.7	1.0	6191888
Nitrite (N)	mg/L	0.011	0.010	6192035	<0.010	0.010	6191895
Nitrate (N)	mg/L	<0.10	0.10	6192035	<0.10	0.10	6191895
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	6192035	<0.10	0.10	6191895

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		KBK292	KBK293	KBK294	KBK294	KBK295	KBK296		
Sampling Date		2019/06/20 11:20	2019/06/20 13:00	2019/06/20 13:30	2019/06/20 13:30	2019/06/20 14:15	2019/06/20 14:50		
COC Number		722108-01-01	722108-01-01	722108-01-01	722108-01-01	722108-01-01	722108-01-01		
	UNITS	**SW-1**	**SW-2**	**SW-3**	**SW-3 Lab-Dup**	**SW-4**	**SW-5**	**RDL**	**QC Batch**
Metals									
Total Aluminum (Al)	ug/L	530	220	90	84	150	300	5.0	6193302
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6193302
Total Arsenic (As)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Barium (Ba)	ug/L	16	13	12	11	15	14	2.0	6193302
Total Beryllium (Be)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6193302
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Boron (B)	ug/L	<10	<10	<10	<10	<10	<10	10	6193302
Total Cadmium (Cd)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6193302
Total Calcium (Ca)	ug/L	1200	1900	2100	2000	1000	1900	200	6193302
Total Chromium (Cr)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6193302
Total Cobalt (Co)	ug/L	0.54	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6193302
Total Copper (Cu)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Iron (Fe)	ug/L	680	690	150	150	<100	770	100	6193302
Total Lead (Pb)	ug/L	1.6	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6193302
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6193302
Total Magnesium (Mg)	ug/L	270	400	370	360	200	430	50	6193302
Total Manganese (Mn)	ug/L	19	32	15	15	10	37	2.0	6193302
Total Molybdenum (Mo)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6193302
Total Nickel (Ni)	ug/L	1.5	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Potassium (K)	ug/L	<200	<200	270	270	<200	<200	200	6193302
Total Selenium (Se)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	6193302
Total Silicon (Si)	ug/L	1600	680	3800	3700	2500	680	50	6193302
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6193302
Total Sodium (Na)	ug/L	800	2100	940	910	580	2100	100	6193302
Total Strontium (Sr)	ug/L	12	19	22	22	13	19	1.0	6193302
Total Tellurium (Te)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	6193302
Total Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Titanium (Ti)	ug/L	7.2	5.1	<5.0	<5.0	<5.0	9.6	5.0	6193302
Total Tungsten (W)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6193302

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		KBK292	KBK293	KBK294	KBK294	KBK295	KBK296		
Sampling Date		2019/06/20 11:20	2019/06/20 13:00	2019/06/20 13:30	2019/06/20 13:30	2019/06/20 14:15	2019/06/20 14:50		
COC Number		722108-01-01	722108-01-01	722108-01-01	722108-01-01	722108-01-01	722108-01-01		
	UNITS	**SW-1**	**SW-2**	**SW-3**	**SW-3 Lab-Dup**	**SW-4**	**SW-5**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	<0.50	0.67	0.80	0.90	<0.50	0.72	0.50	6193302
Total Zinc (Zn)	ug/L	13	5.8	<5.0	<5.0	8.2	5.3	5.0	6193302
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6193302

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		KBK297		
Sampling Date		2019/06/20 14:35		
COC Number		722108-01-01		
	UNITS	**SW-6**	**RDL**	**QC Batch**
Metals				
Total Aluminum (Al)	ug/L	210	5.0	6193302
Total Antimony (Sb)	ug/L	<0.50	0.50	6193302
Total Arsenic (As)	ug/L	<1.0	1.0	6193302
Total Barium (Ba)	ug/L	11	2.0	6193302
Total Beryllium (Be)	ug/L	<0.50	0.50	6193302
Total Bismuth (Bi)	ug/L	<1.0	1.0	6193302
Total Boron (B)	ug/L	<10	10	6193302
Total Cadmium (Cd)	ug/L	<0.10	0.10	6193302
Total Calcium (Ca)	ug/L	920	200	6193302
Total Chromium (Cr)	ug/L	<5.0	5.0	6193302
Total Cobalt (Co)	ug/L	<0.50	0.50	6193302
Total Copper (Cu)	ug/L	<1.0	1.0	6193302
Total Iron (Fe)	ug/L	160	100	6193302
Total Lead (Pb)	ug/L	<0.50	0.50	6193302
Total Lithium (Li)	ug/L	<5.0	5.0	6193302
Total Magnesium (Mg)	ug/L	200	50	6193302
Total Manganese (Mn)	ug/L	10	2.0	6193302
Total Molybdenum (Mo)	ug/L	<0.50	0.50	6193302
Total Nickel (Ni)	ug/L	<1.0	1.0	6193302
Total Potassium (K)	ug/L	<200	200	6193302
Total Selenium (Se)	ug/L	<2.0	2.0	6193302
Total Silicon (Si)	ug/L	1700	50	6193302
Total Silver (Ag)	ug/L	<0.10	0.10	6193302
Total Sodium (Na)	ug/L	1100	100	6193302
Total Strontium (Sr)	ug/L	8.2	1.0	6193302
Total Tellurium (Te)	ug/L	<1.0	1.0	6193302
Total Thallium (Tl)	ug/L	<0.050	0.050	6193302
Total Tin (Sn)	ug/L	<1.0	1.0	6193302
Total Titanium (Ti)	ug/L	<5.0	5.0	6193302
Total Tungsten (W)	ug/L	<1.0	1.0	6193302
Total Uranium (U)	ug/L	<0.10	0.10	6193302

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		KBK297		
Sampling Date		2019/06/20 14:35		
COC Number		722108-01-01		
	UNITS	**SW-6**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	<0.50	0.50	6193302
Total Zinc (Zn)	ug/L	6.1	5.0	6193302
Total Zirconium (Zr)	ug/L	<1.0	1.0	6193302

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

BV Labs ID: KBK292
Sample ID: SW-1
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6191895	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

BV Labs ID: KBK293
Sample ID: SW-2
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6191895	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

BV Labs ID: KBK294
Sample ID: SW-3
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6191895	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

BV Labs ID: KBK294 Dup
Sample ID: SW-3
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

TEST SUMMARY

BV Labs ID: KBK295
Sample ID: SW-4
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6191895	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

BV Labs ID: KBK295 Dup
Sample ID: SW-4
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai

BV Labs ID: KBK296
Sample ID: SW-5
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6192035	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

BV Labs ID: KBK296 Dup
Sample ID: SW-5
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6192035	N/A	2019/06/24	Chandra Nandlal

BV Labs ID: KBK297
Sample ID: SW-6
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6191888	N/A	2019/06/24	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6199947	N/A	2019/07/02	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6193302	N/A	2019/06/25	Thao Nguyen
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6191895	N/A	2019/06/24	Chandra Nandlal
pH	AT	6191953	2019/06/22	2019/06/24	Surinder Rai

TEST SUMMARY

BV Labs ID: KBK297
Sample ID: SW-6
Matrix: Water

Collected: 2019/06/20
Shipped:
Received: 2019/06/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Orthophosphate	KONE	6191892	N/A	2019/06/24	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6191889	N/A	2019/06/24	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6191788	2019/06/22	2019/06/24	Nilam Borole

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	17.3°C

Revised report (2019/07/03): Hardness analysis is included for all samples as requested.

Sample KBK292 [SW-1] : Nitrite/Nitrate: Due to colour interferences, sample required dilution. Detection limit was adjusted accordingly.

Results relate only to the items tested.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BUREAU VERITAS

BV Labs Job #: B9H0140
Report Date: 2019/07/03

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: AK

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6191788	Total Suspended Solids	2019/06/24					<1	mg/L	0	25	96	85 - 115
6191888	Dissolved Chloride (Cl-)	2019/06/24	NC	80 - 120	100	80 - 120	<1.0	mg/L	0.19	20		
6191889	Dissolved Sulphate (SO4)	2019/06/24	NC	75 - 125	103	80 - 120	<1.0	mg/L	2.1	20		
6191892	Orthophosphate (P)	2019/06/24	105	75 - 125	101	80 - 120	<0.010	mg/L	NC	25		
6191895	Nitrate (N)	2019/06/24	85	80 - 120	101	80 - 120	<0.10	mg/L	8.4	20		
6191895	Nitrite (N)	2019/06/24	104	80 - 120	100	80 - 120	<0.010	mg/L	NC	20		
6191953	pH	2019/06/24			102	98 - 103			2.1	N/A		
6192035	Nitrate (N)	2019/06/24	90	80 - 120	92	80 - 120	<0.10	mg/L	NC	20		
6192035	Nitrite (N)	2019/06/24	104	80 - 120	104	80 - 120	<0.010	mg/L	4.3	20		
6193302	Total Aluminum (Al)	2019/06/25	105	80 - 120	100	80 - 120	<5.0	ug/L	6.1	20		
6193302	Total Antimony (Sb)	2019/06/25	101	80 - 120	97	80 - 120	<0.50	ug/L	NC	20		
6193302	Total Arsenic (As)	2019/06/25	99	80 - 120	96	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Barium (Ba)	2019/06/25	93	80 - 120	91	80 - 120	<2.0	ug/L	2.3	20		
6193302	Total Beryllium (Be)	2019/06/25	96	80 - 120	93	80 - 120	<0.50	ug/L	NC	20		
6193302	Total Bismuth (Bi)	2019/06/25	93	80 - 120	90	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Boron (B)	2019/06/25	98	80 - 120	97	80 - 120	<10	ug/L	NC	20		
6193302	Total Cadmium (Cd)	2019/06/25	97	80 - 120	94	80 - 120	<0.10	ug/L	NC	20		
6193302	Total Calcium (Ca)	2019/06/25	102	80 - 120	100	80 - 120	<200	ug/L	3.2	20		
6193302	Total Chromium (Cr)	2019/06/25	98	80 - 120	95	80 - 120	<5.0	ug/L	NC	20		
6193302	Total Cobalt (Co)	2019/06/25	97	80 - 120	95	80 - 120	<0.50	ug/L	NC	20		
6193302	Total Copper (Cu)	2019/06/25	97	80 - 120	94	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Iron (Fe)	2019/06/25	101	80 - 120	98	80 - 120	<100	ug/L	2.7	20		
6193302	Total Lead (Pb)	2019/06/25	95	80 - 120	92	80 - 120	<0.50	ug/L	NC	20		
6193302	Total Lithium (Li)	2019/06/25	97	80 - 120	95	80 - 120	<5.0	ug/L	NC	20		
6193302	Total Magnesium (Mg)	2019/06/25	100	80 - 120	97	80 - 120	<50	ug/L	1.8	20		
6193302	Total Manganese (Mn)	2019/06/25	97	80 - 120	94	80 - 120	<2.0	ug/L	2.8	20		
6193302	Total Molybdenum (Mo)	2019/06/25	99	80 - 120	96	80 - 120	<0.50	ug/L	NC	20		
6193302	Total Nickel (Ni)	2019/06/25	98	80 - 120	94	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Potassium (K)	2019/06/25	99	80 - 120	95	80 - 120	<200	ug/L	1.9	20		
6193302	Total Selenium (Se)	2019/06/25	106	80 - 120	104	80 - 120	<2.0	ug/L	NC	20		
6193302	Total Silicon (Si)	2019/06/25	98	80 - 120	95	80 - 120	<50	ug/L	3.0	20		
6193302	Total Silver (Ag)	2019/06/25	98	80 - 120	94	80 - 120	<0.10	ug/L	NC	20		

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6193302	Total Sodium (Na)	2019/06/25	99	80 - 120	96	80 - 120	<100	ug/L	3.5	20		
6193302	Total Strontium (Sr)	2019/06/25	94	80 - 120	92	80 - 120	<1.0	ug/L	0.0046	20		
6193302	Total Tellurium (Te)	2019/06/25	97	80 - 120	95	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Thallium (Tl)	2019/06/25	93	80 - 120	91	80 - 120	<0.050	ug/L	NC	20		
6193302	Total Tin (Sn)	2019/06/25	97	80 - 120	94	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Titanium (Ti)	2019/06/25	96	80 - 120	95	80 - 120	<5.0	ug/L	NC	20		
6193302	Total Tungsten (W)	2019/06/25	98	80 - 120	97	80 - 120	<1.0	ug/L	NC	20		
6193302	Total Uranium (U)	2019/06/25	97	80 - 120	95	80 - 120	<0.10	ug/L	NC	20		
6193302	Total Vanadium (V)	2019/06/25	97	80 - 120	95	80 - 120	<0.50	ug/L	13	20		
6193302	Total Zinc (Zn)	2019/06/25	101	80 - 120	97	80 - 120	<5.0	ug/L	NC	20		
6193302	Total Zirconium (Zr)	2019/06/25	99	80 - 120	96	80 - 120	<1.0	ug/L	NC	20		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

CHARTERED
Eva Pranjic
CHEMIST

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

IMMEDIATE

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:	REPORT TO:	PROJECT INFORMATION:	Laboratory Use Only:
Company Name: #1326 Golder Associates Ltd	Company Name:	Quotation #: B80683	BV Labs Job #:
Attention: Accounts Payable	Attention: Marta Lopez-Egea	P.O. #:	Bottle Order #: 722108
Address: 6925 Century Ave Suite 100, Mississauga ON L5N 7K2	Address:	Project: 1895639 (3000/3005)	COC #: C#722108-01-01
Tel: (905) 567-4444 Fax: (905) 567-6561	Tel: (905) 567-4444 Ext: 2060 Fax:	Project Name:	Project Manager: Ema Gitej
Email: AP_CustomerService@golder.com	Email: Marta_Lopez-Egea@golder.com	Site #:	
		Sampled By: AK/KN	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): Table 1, Table 2, Table 3, Table ___; Res/Park, Ind/Comm, Agri/Other; Medium/Fine, Coarse, For RSC

Other Regulations: CCME, Reg 558, MISA, ☑ PWQO, Other; Sanitary Sewer Bylaw, Storm Sewer Bylaw, Municipality ___

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required: Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___
Rush Confirmation Number: ___ (call lab for #)

#	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Total Metals Analysis by ICPMS	pH	Chloride, Sulphate, Nitrate, Nitrite, Orthophosphate	Low Level TSS	# of Bottles	Comments
1	SID#437574	SW-1	19/06/20	11:20	SW	No	✓	✓	✓	✓	3	
2	SID#437575	SW-2	↓	13:00	↓	↓	✓	✓	✓	✓	3	
3	SID#437576	SW-3	↓	13:30	↓	↓	✓	✓	✓	✓	3	
4	SID#437577	SW-4	↓	14:15	↓	↓	✓	✓	✓	✓	3	
5	SID#437578	SW-5	↓	14:50	↓	↓	✓	✓	✓	✓	3	
6	SID#437579	SW-6	↓	14:35	↓	↓	✓	✓	✓	✓	3	
7												
8												
9												
10												

20-Jun-19 19:20
Ema Gitej
B9H0140
KFL ENV-1418

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Helen Kennedy	19/06/20	19:20	DIPIKA SINGH	2019/06/20	19:20	

Laboratory Use Only: Time Sensitive; Temperature (°C) on Recei: 17/18/17; Custody Seal Present: Yes ✓; Intact: Yes ✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Ice Present

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 731760-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/09/04
Report #: R5866095
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9O1921
Received: 2019/08/29, 16:42

Sample Matrix: Surface Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	4	N/A	2019/08/31	CAM SOP-00448	SM 23 2320 B m
Chloride by Automated Colourimetry	4	N/A	2019/09/04	CAM SOP-00463	SM 4500-Cl E m
Hardness (calculated as CaCO3)	4	N/A	2019/09/03	CAM SOP 00102/00408/00447	SM 2340 B
Total Metals Analysis by ICPMS	4	N/A	2019/09/03	CAM SOP-00447	EPA 6020B m
Nitrate (NO3) and Nitrite (NO2) in Water (1)	4	N/A	2019/09/01	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	4	2019/08/30	2019/08/31	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	4	N/A	2019/09/03	CAM SOP-00461	EPA 365.1 m
Sulphate by Automated Colourimetry	4	N/A	2019/09/03	CAM SOP-00464	EPA 375.4 m
Low Level Total Suspended Solids	2	2019/08/30	2019/08/31	CAM SOP-00428	SM 23 2540D m
Low Level Total Suspended Solids	2	2019/08/31	2019/09/03	CAM SOP-00428	SM 23 2540D m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 731760-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/09/04
Report #: R5866095
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9O1921
Received: 2019/08/29, 16:42

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key AUTHORIZED REPORT RAPPORT AUTORISÉ

Bureau Veritas Laboratories
04 Sep 2019 14:59:52

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: Ema.Gitej@bvlabs.com
Phone# (905)817-5829
==
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BV Labs Job #: B9O1921
Report Date: 2019/09/04

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

RESULTS OF ANALYSES OF SURFACE WATER

BV Labs ID		KQQ792	KQQ793		KQQ794			KQQ794		
Sampling Date		2019/08/29 11:10	2019/08/29 12:15		2019/08/29 12:45			2019/08/29 12:45		
COC Number		731760-01-01	731760-01-01		731760-01-01			731760-01-01		
	UNITS	**SW-1**	**SW-2**	**QC Batch**	**SW-3**	**RDL**	**QC Batch**	**SW-3 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters										
Hardness (CaCO3)	mg/L	9.7	12	6306460	8.0	1.0	6306460			
Inorganics										
Orthophosphate (P)	mg/L	<0.010	<0.010	6310908	<0.010	0.010	6310915	<0.010	0.010	6310915
pH	pH	5.73	7.03	6307784	6.80		6307784			
Total Suspended Solids	mg/L	2	<1	6310661	5	1	6308738			
Dissolved Sulphate (SO4)	mg/L	<1.0	2.2	6310910	3.3	1.0	6310929	3.3	1.0	6310929
Alkalinity (Total as CaCO3)	mg/L	<1.0	7.0	6307780	4.4	1.0	6307780			
Dissolved Chloride (Cl-)	mg/L	5.6	1.7	6310907	<1.0	1.0	6310917	<1.0	1.0	6310917
Nitrite (N)	mg/L	<0.010	<0.010	6308955	<0.010	0.010	6308955			
Nitrate (N)	mg/L	<0.10	<0.10	6308955	<0.10	0.10	6308955			
Nitrate + Nitrite (N)	mg/L	<0.10	<0.10	6308955	<0.10	0.10	6308955			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

BV Labs ID		KQQ796		
Sampling Date		2019/08/29 02:15		
COC Number		731760-01-01		
	UNITS	**SW-5**	**RDL**	**QC Batch**
Calculated Parameters				
Hardness (CaCO3)	mg/L	14	1.0	6306460
Inorganics				
Orthophosphate (P)	mg/L	<0.010	0.010	6310908
pH	pH	7.03		6307784
Total Suspended Solids	mg/L	3	1	6308738
Dissolved Sulphate (SO4)	mg/L	1.7	1.0	6310910
Alkalinity (Total as CaCO3)	mg/L	9.7	1.0	6307780
Dissolved Chloride (Cl-)	mg/L	2.7	1.0	6310907
Nitrite (N)	mg/L	<0.010	0.010	6308949
Nitrate (N)	mg/L	<0.10	0.10	6308949
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	6308949

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SURFACE WATER)

BV Labs ID		KQQ792	KQQ793	KQQ794	KQQ796		
Sampling Date		2019/08/29 11:10	2019/08/29 12:15	2019/08/29 12:45	2019/08/29 02:15		
COC Number		731760-01-01	731760-01-01	731760-01-01	731760-01-01		
	UNITS	SW-1	SW-2	SW-3	SW-5	RDL	QC Batch
Metals							
Total Aluminum (Al)	ug/L	170	66	84	110	5.0	6311615
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	6311615
Total Arsenic (As)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615
Total Barium (Ba)	ug/L	20	9.4	9.1	12	2.0	6311615
Total Beryllium (Be)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	6311615
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615
Total Boron (B)	ug/L	<10	<10	<10	<10	10	6311615
Total Cadmium (Cd)	ug/L	<0.10	<0.10	<0.10	<0.10	0.10	6311615
Total Calcium (Ca)	ug/L	2200	2700	2000	3300	200	6311615
Total Chromium (Cr)	ug/L	<5.0	<5.0	<5.0	<5.0	5.0	6311615
Total Cobalt (Co)	ug/L	0.60	<0.50	<0.50	<0.50	0.50	6311615
Total Copper (Cu)	ug/L	<1.0	<1.0	<1.0	1.3	1.0	6311615
Total Iron (Fe)	ug/L	550	490	250	930	100	6311615
Total Lead (Pb)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	6311615
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	5.0	6311615
Total Magnesium (Mg)	ug/L	580	820	370	1000	50	6311615
Total Manganese (Mn)	ug/L	35	27	11	45	2.0	6311615
Total Molybdenum (Mo)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	6311615
Total Nickel (Ni)	ug/L	<1.0	<1.0	1.0	<1.0	1.0	6311615
Total Potassium (K)	ug/L	<200	350	230	460	200	6311615
Total Selenium (Se)	ug/L	<2.0	<2.0	<2.0	<2.0	2.0	6311615
Total Silicon (Si)	ug/L	1400	3100	4000	3100	50	6311615
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	0.10	6311615
Total Sodium (Na)	ug/L	1700	1900	990	2400	100	6311615
Total Strontium (Sr)	ug/L	36	31	23	36	1.0	6311615
Total Tellurium (Te)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	0.050	6311615
Total Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615
Total Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	<5.0	5.0	6311615
Total Tungsten (W)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10	<0.10	0.10	6311615

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SURFACE WATER)

BV Labs ID		KQQ792	KQQ793	KQQ794	KQQ796		
Sampling Date		2019/08/29 11:10	2019/08/29 12:15	2019/08/29 12:45	2019/08/29 02:15		
COC Number		731760-01-01	731760-01-01	731760-01-01	731760-01-01		
	UNITS	SW-1	SW-2	SW-3	SW-5	RDL	QC Batch
Total Vanadium (V)	ug/L	0.58	0.68	0.83	0.98	0.50	6311615
Total Zinc (Zn)	ug/L	14	<5.0	<5.0	22	5.0	6311615
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	6311615

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

BV Labs Job #: B9O1921
Report Date: 2019/09/04

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

BV Labs ID: KQQ792
Sample ID: SW-1
Matrix: Surface Water

Collected: 2019/08/29
Shipped:
Received: 2019/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6307780	N/A	2019/08/31	Surinder Rai
Chloride by Automated Colourimetry	KONE	6310907	N/A	2019/09/04	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6306460	N/A	2019/09/03	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6311615	N/A	2019/09/03	Matthew Ritenburg
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6308955	N/A	2019/09/01	Amanpreet Sappal
pH	AT	6307784	2019/08/30	2019/08/31	Surinder Rai
Orthophosphate	KONE	6310908	N/A	2019/09/03	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6310910	N/A	2019/09/03	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6310661	2019/08/31	2019/09/03	Nilam Borole

BV Labs ID: KQQ793
Sample ID: SW-2
Matrix: Surface Water

Collected: 2019/08/29
Shipped:
Received: 2019/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6307780	N/A	2019/08/31	Surinder Rai
Chloride by Automated Colourimetry	KONE	6310907	N/A	2019/09/04	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6306460	N/A	2019/09/03	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6311615	N/A	2019/09/03	Matthew Ritenburg
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6308955	N/A	2019/09/01	Amanpreet Sappal
pH	AT	6307784	2019/08/30	2019/08/31	Surinder Rai
Orthophosphate	KONE	6310908	N/A	2019/09/03	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6310910	N/A	2019/09/03	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6310661	2019/08/31	2019/09/03	Nilam Borole

BV Labs ID: KQQ794
Sample ID: SW-3
Matrix: Surface Water

Collected: 2019/08/29
Shipped:
Received: 2019/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6307780	N/A	2019/08/31	Surinder Rai
Chloride by Automated Colourimetry	KONE	6310917	N/A	2019/09/04	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6306460	N/A	2019/09/03	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6311615	N/A	2019/09/03	Matthew Ritenburg
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6308955	N/A	2019/09/01	Amanpreet Sappal
pH	AT	6307784	2019/08/30	2019/08/31	Surinder Rai
Orthophosphate	KONE	6310915	N/A	2019/09/03	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6310929	N/A	2019/09/03	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6308738	2019/08/30	2019/08/31	Nilam Borole

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BUREAU VERITAS

BV Labs Job #: B9O1921
Report Date: 2019/09/04

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

BV Labs ID: KQQ794 Dup
Sample ID: SW-3
Matrix: Surface Water

Collected: 2019/08/29
Shipped:
Received: 2019/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	6310917	N/A	2019/09/04	Deonarine Ramnarine
Orthophosphate	KONE	6310915	N/A	2019/09/03	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6310929	N/A	2019/09/03	Alina Dobreanu

BV Labs ID: KQQ796
Sample ID: SW-5
Matrix: Surface Water

Collected: 2019/08/29
Shipped:
Received: 2019/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6307780	N/A	2019/08/31	Surinder Rai
Chloride by Automated Colourimetry	KONE	6310907	N/A	2019/09/04	Deonarine Ramnarine
Hardness (calculated as CaCO3)		6306460	N/A	2019/09/03	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6311615	N/A	2019/09/03	Matthew Ritenburg
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6308949	N/A	2019/09/01	Amanpreet Sappal
pH	AT	6307784	2019/08/30	2019/08/31	Surinder Rai
Orthophosphate	KONE	6310908	N/A	2019/09/03	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6310910	N/A	2019/09/03	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6308738	2019/08/30	2019/08/31	Nilam Borole

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	1.0°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6307780	Alkalinity (Total as CaCO3)	2019/08/31			97	85 - 115	<1.0	mg/L	5.9	20		
6307784	pH	2019/08/31			102	98 - 103			1.0	N/A		
6308738	Total Suspended Solids	2019/08/31					<1	mg/L	NC	25	100	85 - 115
6308949	Nitrate (N)	2019/09/01	96	80 - 120	96	80 - 120	<0.10	mg/L	NC	20		
6308949	Nitrite (N)	2019/09/01	105	80 - 120	104	80 - 120	<0.010	mg/L	NC	20		
6308955	Nitrate (N)	2019/09/01	95	80 - 120	96	80 - 120	<0.10	mg/L	1.1	20		
6308955	Nitrite (N)	2019/09/01	110	80 - 120	103	80 - 120	<0.010	mg/L	NC	20		
6310661	Total Suspended Solids	2019/09/03					<1	mg/L	22	25	98	85 - 115
6310907	Dissolved Chloride (Cl-)	2019/09/04	NC	80 - 120	102	80 - 120	<1.0	mg/L	0.12	20		
6310908	Orthophosphate (P)	2019/09/03	107	75 - 125	100	80 - 120	<0.010	mg/L	NC	25		
6310910	Dissolved Sulphate (SO4)	2019/09/03	NC	75 - 125	103	80 - 120	<1.0	mg/L	0.51	20		
6310915	Orthophosphate (P)	2019/09/03	106	75 - 125	100	80 - 120	<0.010	mg/L	NC	25		
6310917	Dissolved Chloride (Cl-)	2019/09/04	110	80 - 120	104	80 - 120	<1.0	mg/L	NC	20		
6310929	Dissolved Sulphate (SO4)	2019/09/03	113	75 - 125	102	80 - 120	<1.0	mg/L	0.46	20		
6311615	Total Aluminum (Al)	2019/09/03	104	80 - 120	100	80 - 120	<5.0	ug/L	0.0066	20		
6311615	Total Antimony (Sb)	2019/09/03	102	80 - 120	99	80 - 120	<0.50	ug/L	NC	20		
6311615	Total Arsenic (As)	2019/09/03	102	80 - 120	95	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Barium (Ba)	2019/09/03	97	80 - 120	96	80 - 120	<2.0	ug/L	1.7	20		
6311615	Total Beryllium (Be)	2019/09/03	105	80 - 120	101	80 - 120	<0.50	ug/L	NC	20		
6311615	Total Bismuth (Bi)	2019/09/03	93	80 - 120	93	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Boron (B)	2019/09/03	93	80 - 120	97	80 - 120	<10	ug/L	NC	20		
6311615	Total Cadmium (Cd)	2019/09/03	99	80 - 120	97	80 - 120	<0.10	ug/L	NC	20		
6311615	Total Calcium (Ca)	2019/09/03	NC	80 - 120	99	80 - 120	<200	ug/L	0.65	20		
6311615	Total Chromium (Cr)	2019/09/03	97	80 - 120	96	80 - 120	<5.0	ug/L	NC	20		
6311615	Total Cobalt (Co)	2019/09/03	98	80 - 120	96	80 - 120	<0.50	ug/L	NC	20		
6311615	Total Copper (Cu)	2019/09/03	99	80 - 120	98	80 - 120	<1.0	ug/L	2.4	20		
6311615	Total Iron (Fe)	2019/09/03	99	80 - 120	98	80 - 120	<100	ug/L	NC	20		
6311615	Total Lead (Pb)	2019/09/03	96	80 - 120	95	80 - 120	<0.50	ug/L	NC	20		
6311615	Total Lithium (Li)	2019/09/03	101	80 - 120	99	80 - 120	<5.0	ug/L	NC	20		
6311615	Total Magnesium (Mg)	2019/09/03	98	80 - 120	95	80 - 120	<50	ug/L	3.4	20		
6311615	Total Manganese (Mn)	2019/09/03	98	80 - 120	95	80 - 120	<2.0	ug/L	0.28	20		

BV Labs Job #: B9O1921
Report Date: 2019/09/04

QUALITY ASSURANCE REPORT(CONT'D)

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6311615	Total Molybdenum (Mo)	2019/09/03	103	80 - 120	99	80 - 120	<0.50	ug/L	2.6	20		
6311615	Total Nickel (Ni)	2019/09/03	97	80 - 120	96	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Potassium (K)	2019/09/03	96	80 - 120	93	80 - 120	<200	ug/L	2.2	20		
6311615	Total Selenium (Se)	2019/09/03	103	80 - 120	102	80 - 120	<2.0	ug/L	7.6	20		
6311615	Total Silicon (Si)	2019/09/03	95	80 - 120	95	80 - 120	<50	ug/L	0.76	20		
6311615	Total Silver (Ag)	2019/09/03	99	80 - 120	97	80 - 120	<0.10	ug/L	NC	20		
6311615	Total Sodium (Na)	2019/09/03	97	80 - 120	95	80 - 120	<100	ug/L	2.1	20		
6311615	Total Strontium (Sr)	2019/09/03	99	80 - 120	95	80 - 120	<1.0	ug/L	2.8	20		
6311615	Total Tellurium (Te)	2019/09/03	100	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Thallium (Tl)	2019/09/03	97	80 - 120	95	80 - 120	<0.050	ug/L	NC	20		
6311615	Total Tin (Sn)	2019/09/03	102	80 - 120	98	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Titanium (Ti)	2019/09/03	93	80 - 120	102	80 - 120	<5.0	ug/L	NC	20		
6311615	Total Tungsten (W)	2019/09/03	100	80 - 120	97	80 - 120	<1.0	ug/L	NC	20		
6311615	Total Uranium (U)	2019/09/03	92	80 - 120	91	80 - 120	<0.10	ug/L	10	20		
6311615	Total Vanadium (V)	2019/09/03	98	80 - 120	97	80 - 120	<0.50	ug/L	1.1	20		
6311615	Total Zinc (Zn)	2019/09/03	101	80 - 120	98	80 - 120	<5.0	ug/L	NC	20		
6311615	Total Zirconium (Zr)	2019/09/03	103	80 - 120	100	80 - 120	<1.0	ug/L	NC	20		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: B9O1921
Report Date: 2019/09/04

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:	REPORT TO:	PROJECT INFORMATION:	Laboratory Use Only:
Company Name: #1326 Golder Associates Ltd	Company Name:	Quotation #: B80683	BV Labs Job #: / Bottle Order #: 731760
Attention: Accounts Payable	Attention: Marta Lopez-Egea	P.O. #:	
Address: 6925 Century Ave Suite 100, Mississauga ON L5N 7K2	Address:	Project: 1895639 (3000/3005)	COC #: C#731760-01-01
Tel: (905) 567-4444 Fax: (905) 567-6561	Tel: (905) 567-4444 Ext: 2060 Fax:	Project Name:	Project Manager: Ema Gitej
Email: AP_CustomerService@golder.com	Email: Marta_Lopez-Egea@golder.com	Site #:	
		Sampled By:	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ____

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ____ ☒ PWQO ☐ Other ____

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ____

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ____ Time Required: ____
Rush Confirmation Number: ____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Total Metals Analysis by ICPMS	pH	Chloride, Sulphate, Nitrate, Nitrite, Orthophosphate	Low Level TSS	Alkalinity, Hardness					# of Bottles	Comments
1		SW-1	Aug 29/19	~~10:45~~ 11:10	SW		✓	✓	✓	✓	✓					3	
2		SW-2	19/08/29	12:15	SW		✓	✓	✓	✓	✓					3	
3		SW-3	19/08/29	12:45	SW		✓	✓	✓	✓	✓					3	
4		~~SW-4~~															
5		SW-5	19/08/29	2:15	SW		✓	✓	✓	✓	✓					3	
6		~~SW-6~~															
7																	
8																	
9																	
10																	

29-Aug-19 16:42
Ema Gitej
B9O1921
GK1 ENV-658

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only
[signature] / Kevin Whitz	19/08/29	16:30	[signature]	2019/08/29	16:42			Temperature (°C) on Recei 1/0/1; Custody Seal Present / Intact — Yes / No ✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 739912-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/11/29
Report #: R5985634
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9X2127
Received: 2019/11/25, 16:05

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	6	N/A	2019/11/27	CAM SOP-00448	SM 23 2320 B m
Chloride by Automated Colourimetry	6	N/A	2019/11/27	CAM SOP-00463	SM 23 4500-Cl E m
Hardness (calculated as CaCO3)	6	N/A	2019/11/29	CAM SOP 00102/00408/00447	SM 2340 B
Total Metals Analysis by ICPMS	6	N/A	2019/11/29	CAM SOP-00447	EPA 6020B m
Nitrate (NO3) and Nitrite (NO2) in Water (1)	1	N/A	2019/11/27	CAM SOP-00440	SM 23 4500-NO3I/NO2B
Nitrate (NO3) and Nitrite (NO2) in Water (1)	5	N/A	2019/11/28	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	6	2019/11/26	2019/11/27	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	6	N/A	2019/11/27	CAM SOP-00461	EPA 365.1 m
Sulphate by Automated Colourimetry	6	N/A	2019/11/27	CAM SOP-00464	EPA 375.4 m
Low Level Total Suspended Solids	5	2019/11/26	2019/11/27	CAM SOP-00428	SM 23 2540D m
Low Level Total Suspended Solids	1	2019/11/27	2019/11/28	CAM SOP-00428	SM 23 2540D m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Your Project #: 1895639 (3000/3005)
Your C.O.C. #: 739912-01-01

Attention: Marta Lopez-Egea

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/11/29
Report #: R5985634
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9X2127

Received: 2019/11/25, 16:05

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Ema Gitej
Senior Project Manager
29 Nov 2019 17:18:09

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: Ema.Gitej@bvlabs.com
Phone# (905)817-5829

==

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF WATER

BV Labs ID		LKB892		LKB893		LKB894		
Sampling Date		2019/11/25 11:10		2019/11/25 11:50		2019/11/25 12:10		
COC Number		739912-01-01		739912-01-01		739912-01-01		
	UNITS	SW-1	QC Batch	SW-2	QC Batch	SW-3	RDL	QC Batch
Calculated Parameters								
Hardness (CaCO3)	mg/L	9.5	6462993	11	6462993	9.0	1.0	6462993
Inorganics								
Orthophosphate (P)	mg/L	<0.010	6464674	<0.010	6464674	<0.010	0.010	6464674
pH	pH	4.47	6463707	6.21	6463707	6.70		6463707
Total Suspended Solids	mg/L	1	6463385	1	6463385	24	1	6464111
Dissolved Sulphate (SO4)	mg/L	<1.0	6464668	1.6	6464668	4.1	1.0	6464668
Alkalinity (Total as CaCO3)	mg/L	<1.0	6463701	2.3	6463701	5.4	1.0	6463701
Dissolved Chloride (Cl-)	mg/L	2.4	6464657	5.6	6464657	<1.0	1.0	6464657
Nitrite (N)	mg/L	<0.010	6466561	<0.010	6464619	<0.010	0.010	6462202
Nitrate (N)	mg/L	<0.10	6466561	0.11	6464619	<0.10	0.10	6462202
Nitrate + Nitrite (N)	mg/L	<0.10	6466561	0.11	6464619	<0.10	0.10	6462202

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

BV Labs ID		LKB894			LKB895			LKB895		
Sampling Date		2019/11/25 12:10			2019/11/25 12:50			2019/11/25 12:50		
COC Number		739912-01-01			739912-01-01			739912-01-01		
	UNITS	SW-3 Lab-Dup	RDL	QC Batch	SW-4	RDL	QC Batch	SW-4 Lab-Dup	RDL	QC Batch
Calculated Parameters										
Hardness (CaCO3)	mg/L				4.6	1.0	6462993			
Inorganics										
Orthophosphate (P)	mg/L	<0.010	0.010	6464674	<0.010	0.010	6464674			
pH	pH	6.64		6463707	5.51		6463707			
Total Suspended Solids	mg/L				<1	1	6464111	<1	1	6464111
Dissolved Sulphate (SO4)	mg/L	4.1	1.0	6464668	2.7	1.0	6464668			
Alkalinity (Total as CaCO3)	mg/L	4.9	1.0	6463701	<1.0	1.0	6463701			
Dissolved Chloride (Cl-)	mg/L	<1.0	1.0	6464657	<1.0	1.0	6464657			
Nitrite (N)	mg/L				<0.010	0.010	6464619			
Nitrate (N)	mg/L				0.15	0.10	6464619			
Nitrate + Nitrite (N)	mg/L				0.15	0.10	6464619			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RESULTS OF ANALYSES OF WATER

BV Labs ID		LKB896		LKB897		
Sampling Date		2019/11/25 13:35		2019/11/25 13:10		
COC Number		739912-01-01		739912-01-01		
	UNITS	**SW-5**	**QC Batch**	**SW-6**	**RDL**	**QC Batch**
Calculated Parameters						
Hardness (CaCO3)	mg/L	11	6462993	10	1.0	6462993
Inorganics						
Orthophosphate (P)	mg/L	<0.010	6464674	<0.010	0.010	6464674
pH	pH	6.12	6463707	5.26		6463707
Total Suspended Solids	mg/L	5	6464111	<1	1	6466892
Dissolved Sulphate (SO4)	mg/L	1.8	6464668	7.5	1.0	6464668
Alkalinity (Total as CaCO3)	mg/L	2.4	6463701	<1.0	1.0	6463701
Dissolved Chloride (Cl-)	mg/L	6.1	6464657	3.0	1.0	6464657
Nitrite (N)	mg/L	<0.010	6464619	<0.010	0.010	6463758
Nitrate (N)	mg/L	0.11	6464619	0.12	0.10	6463758
Nitrate + Nitrite (N)	mg/L	0.11	6464619	0.12	0.10	6463758

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

BV Labs Job #: B9X2127
Report Date: 2019/11/29

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		LKB892	LKB893	LKB894	LKB895	LKB896	LKB897		
Sampling Date		2019/11/25 11:10	2019/11/25 11:50	2019/11/25 12:10	2019/11/25 12:50	2019/11/25 13:35	2019/11/25 13:10		
COC Number		739912-01-01	739912-01-01	739912-01-01	739912-01-01	739912-01-01	739912-01-01		
	UNITS	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6	RDL	QC Batch
Metals									
Total Aluminum (Al)	ug/L	400	190	410	130	490	190	5.0	6467788
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6467788
Total Arsenic (As)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Barium (Ba)	ug/L	27	16	11	16	20	29	2.0	6467788
Total Beryllium (Be)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6467788
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Boron (B)	ug/L	<10	<10	<10	<10	<10	<10	10	6467788
Total Cadmium (Cd)	ug/L	0.12	<0.10	<0.10	<0.10	<0.10	0.18	0.10	6467788
Total Calcium (Ca)	ug/L	2300	2700	2600	1000	2800	2700	200	6467788
Total Chromium (Cr)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6467788
Total Cobalt (Co)	ug/L	0.74	<0.50	<0.50	<0.50	0.52	<0.50	0.50	6467788
Total Copper (Cu)	ug/L	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Iron (Fe)	ug/L	310	330	550	<100	640	<100	100	6467788
Total Lead (Pb)	ug/L	0.94	<0.50	0.74	<0.50	0.70	<0.50	0.50	6467788
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	6467788
Total Magnesium (Mg)	ug/L	580	630	470	230	720	540	50	6467788
Total Manganese (Mn)	ug/L	40	27	11	9.0	42	110	2.0	6467788
Total Molybdenum (Mo)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	6467788
Total Nickel (Ni)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Potassium (K)	ug/L	<200	270	350	<200	310	<200	200	6467788
Total Selenium (Se)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	6467788
Total Silicon (Si)	ug/L	3100	2500	4300	2000	2900	2500	50	6467788
Total Silver (Ag)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6467788
Total Sodium (Na)	ug/L	1300	3400	1200	480	3600	1600	100	6467788
Total Strontium (Sr)	ug/L	25	28	29	14	30	25	1.0	6467788
Total Tellurium (Te)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	6467788
Total Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Titanium (Ti)	ug/L	<5.0	<5.0	21	<5.0	27	<5.0	5.0	6467788
Total Tungsten (W)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	6467788

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BUREAU VERITAS

BV Labs Job #: B9X2127
Report Date: 2019/11/29

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		LKB892	LKB893	LKB894	LKB895	LKB896	LKB897		
Sampling Date		2019/11/25 11:10	2019/11/25 11:50	2019/11/25 12:10	2019/11/25 12:50	2019/11/25 13:35	2019/11/25 13:10		
COC Number		739912-01-01	739912-01-01	739912-01-01	739912-01-01	739912-01-01	739912-01-01		
	UNITS	**SW-1**	**SW-2**	**SW-3**	**SW-4**	**SW-5**	**SW-6**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	0.70	<0.50	1.8	<0.50	1.4	<0.50	0.50	6467788
Total Zinc (Zn)	ug/L	23	7.8	<5.0	10	9.8	18	5.0	6467788
Total Zirconium (Zr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6467788

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		LKB897		
Sampling Date		2019/11/25 13:10		
COC Number		739912-01-01		
	UNITS	SW-6 Lab-Dup	RDL	QC Batch
Metals				
Total Aluminum (Al)	ug/L	190	5.0	6467788
Total Antimony (Sb)	ug/L	<0.50	0.50	6467788
Total Arsenic (As)	ug/L	<1.0	1.0	6467788
Total Barium (Ba)	ug/L	29	2.0	6467788
Total Beryllium (Be)	ug/L	<0.50	0.50	6467788
Total Bismuth (Bi)	ug/L	<1.0	1.0	6467788
Total Boron (B)	ug/L	<10	10	6467788
Total Cadmium (Cd)	ug/L	0.18	0.10	6467788
Total Calcium (Ca)	ug/L	2700	200	6467788
Total Chromium (Cr)	ug/L	<5.0	5.0	6467788
Total Cobalt (Co)	ug/L	<0.50	0.50	6467788
Total Copper (Cu)	ug/L	<1.0	1.0	6467788
Total Iron (Fe)	ug/L	<100	100	6467788
Total Lead (Pb)	ug/L	<0.50	0.50	6467788
Total Lithium (Li)	ug/L	<5.0	5.0	6467788
Total Magnesium (Mg)	ug/L	560	50	6467788
Total Manganese (Mn)	ug/L	110	2.0	6467788
Total Molybdenum (Mo)	ug/L	<0.50	0.50	6467788
Total Nickel (Ni)	ug/L	<1.0	1.0	6467788
Total Potassium (K)	ug/L	<200	200	6467788
Total Selenium (Se)	ug/L	<2.0	2.0	6467788
Total Silicon (Si)	ug/L	2500	50	6467788
Total Silver (Ag)	ug/L	<0.10	0.10	6467788
Total Sodium (Na)	ug/L	1600	100	6467788
Total Strontium (Sr)	ug/L	26	1.0	6467788
Total Tellurium (Te)	ug/L	<1.0	1.0	6467788
Total Thallium (Tl)	ug/L	<0.050	0.050	6467788
Total Tin (Sn)	ug/L	<1.0	1.0	6467788
Total Titanium (Ti)	ug/L	<5.0	5.0	6467788
Total Tungsten (W)	ug/L	<1.0	1.0	6467788
Total Uranium (U)	ug/L	<0.10	0.10	6467788

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

BV Labs ID		LKB897		
Sampling Date		2019/11/25 13:10		
COC Number		739912-01-01		
	UNITS	**SW-6 Lab-Dup**	**RDL**	**QC Batch**
Total Vanadium (V)	ug/L	<0.50	0.50	6467788
Total Zinc (Zn)	ug/L	18	5.0	6467788
Total Zirconium (Zr)	ug/L	<1.0	1.0	6467788

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

TEST SUMMARY

BV Labs ID: LKB892
Sample ID: SW-1
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6466561	N/A	2019/11/28	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6463385	2019/11/26	2019/11/27	Mandeep Kaur

BV Labs ID: LKB893
Sample ID: SW-2
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6464619	N/A	2019/11/28	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6463385	2019/11/26	2019/11/27	Mandeep Kaur

BV Labs ID: LKB894
Sample ID: SW-3
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6462202	N/A	2019/11/27	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6464111	2019/11/26	2019/11/27	Mandeep Kaur

BV Labs Job #: B9X2127
Report Date: 2019/11/29

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

BV Labs ID: LKB894 Dup
Sample ID: SW-3
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu

BV Labs ID: LKB895
Sample ID: SW-4
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6464619	N/A	2019/11/28	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6464111	2019/11/26	2019/11/27	Mandeep Kaur

BV Labs ID: LKB895 Dup
Sample ID: SW-4
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Low Level Total Suspended Solids	BAL	6464111	2019/11/26	2019/11/27	Mandeep Kaur

BV Labs ID: LKB896
Sample ID: SW-5
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6464619	N/A	2019/11/28	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6464111	2019/11/26	2019/11/27	Mandeep Kaur

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: B9X2127
Report Date: 2019/11/29

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

TEST SUMMARY

BV Labs ID: LKB897
Sample ID: SW-6
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	6463701	N/A	2019/11/27	Surinder Rai
Chloride by Automated Colourimetry	KONE	6464657	N/A	2019/11/27	Alina Dobreanu
Hardness (calculated as CaCO3)		6462993	N/A	2019/11/29	Automated Statchk
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	6463758	N/A	2019/11/28	Chandra Nandlal
pH	AT	6463707	2019/11/26	2019/11/27	Surinder Rai
Orthophosphate	KONE	6464674	N/A	2019/11/27	Alina Dobreanu
Sulphate by Automated Colourimetry	KONE	6464668	N/A	2019/11/27	Alina Dobreanu
Low Level Total Suspended Solids	BAL	6466892	2019/11/27	2019/11/28	Mandeep Kaur

BV Labs ID: LKB897 Dup
Sample ID: SW-6
Matrix: Water

Collected: 2019/11/25
Shipped:
Received: 2019/11/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Metals Analysis by ICPMS	ICP/MS	6467788	N/A	2019/11/29	Arefa Dabhad

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	0.7°C

Results relate only to the items tested.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6462202	Nitrate (N)	2019/11/27	104	80 - 120	103	80 - 120	<0.10	mg/L	NC	20		
6462202	Nitrite (N)	2019/11/27	112	80 - 120	111	80 - 120	<0.010	mg/L	NC	20		
6463385	Total Suspended Solids	2019/11/27					<1	mg/L	8.0	25	98	85 - 115
6463701	Alkalinity (Total as CaCO3)	2019/11/27			97	85 - 115	<1.0	mg/L	9.9	20		
6463707	pH	2019/11/27			102	98 - 103			0.90	N/A		
6463758	Nitrate (N)	2019/11/28	99	80 - 120	104	80 - 120	<0.10	mg/L	11	20		
6463758	Nitrite (N)	2019/11/28	104	80 - 120	111	80 - 120	<0.010	mg/L				
6464111	Total Suspended Solids	2019/11/27					<1	mg/L	NC	25	95	85 - 115
6464619	Nitrate (N)	2019/11/28	103	80 - 120	105	80 - 120	<0.10	mg/L	1.6	20		
6464619	Nitrite (N)	2019/11/28	109	80 - 120	111	80 - 120	<0.010	mg/L	NC	20		
6464657	Dissolved Chloride (Cl-)	2019/11/27	109	80 - 120	103	80 - 120	<1.0	mg/L	NC	20		
6464668	Dissolved Sulphate (SO4)	2019/11/27	116	75 - 125	103	80 - 120	<1.0	mg/L	0.28	20		
6464674	Orthophosphate (P)	2019/11/27	112	75 - 125	100	80 - 120	<0.010	mg/L	NC	25		
6466561	Nitrate (N)	2019/11/28	NC	80 - 120	104	80 - 120	<0.10	mg/L	0.089	20		
6466561	Nitrite (N)	2019/11/28	108	80 - 120	110	80 - 120	<0.010	mg/L				
6466892	Total Suspended Solids	2019/11/28					<1	mg/L	0	25	102	85 - 115
6467788	Total Aluminum (Al)	2019/11/29	92	80 - 120	97	80 - 120	<5.0	ug/L	2.8	20		
6467788	Total Antimony (Sb)	2019/11/29	98	80 - 120	100	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Arsenic (As)	2019/11/29	100	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Barium (Ba)	2019/11/29	99	80 - 120	98	80 - 120	<2.0	ug/L	0.49	20		
6467788	Total Beryllium (Be)	2019/11/29	103	80 - 120	103	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Bismuth (Bi)	2019/11/29	96	80 - 120	99	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Boron (B)	2019/11/29	100	80 - 120	104	80 - 120	<10	ug/L	NC	20		
6467788	Total Cadmium (Cd)	2019/11/29	98	80 - 120	101	80 - 120	<0.10	ug/L	2.3	20		
6467788	Total Calcium (Ca)	2019/11/29	96	80 - 120	100	80 - 120	<200	ug/L	0.38	20		
6467788	Total Chromium (Cr)	2019/11/29	95	80 - 120	97	80 - 120	<5.0	ug/L	NC	20		
6467788	Total Cobalt (Co)	2019/11/29	100	80 - 120	100	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Copper (Cu)	2019/11/29	96	80 - 120	97	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Iron (Fe)	2019/11/29	100	80 - 120	101	80 - 120	<100	ug/L	NC	20		
6467788	Total Lead (Pb)	2019/11/29	96	80 - 120	99	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Lithium (Li)	2019/11/29	107	80 - 120	103	80 - 120	<5.0	ug/L	NC	20		

BUREAU VERITAS

BV Labs Job #: B9X2127
Report Date: 2019/11/29

QUALITY ASSURANCE REPORT(CONT'D)

Golder Associates Ltd
Client Project #: 1895639 (3000/3005)
Sampler Initials: KW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
6467788	Total Magnesium (Mg)	2019/11/29	98	80 - 120	98	80 - 120	<50	ug/L	3.5	20		
6467788	Total Manganese (Mn)	2019/11/29	98	80 - 120	100	80 - 120	<2.0	ug/L	5.2	20		
6467788	Total Molybdenum (Mo)	2019/11/29	100	80 - 120	102	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Nickel (Ni)	2019/11/29	99	80 - 120	99	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Potassium (K)	2019/11/29	95	80 - 120	95	80 - 120	<200	ug/L	NC	20		
6467788	Total Selenium (Se)	2019/11/29	101	80 - 120	102	80 - 120	<2.0	ug/L	NC	20		
6467788	Total Silicon (Si)	2019/11/29	94	80 - 120	96	80 - 120	<50	ug/L	0.55	20		
6467788	Total Silver (Ag)	2019/11/29	99	80 - 120	100	80 - 120	<0.10	ug/L	NC	20		
6467788	Total Sodium (Na)	2019/11/29	99	80 - 120	99	80 - 120	<100	ug/L	0.62	20		
6467788	Total Strontium (Sr)	2019/11/29	99	80 - 120	97	80 - 120	<1.0	ug/L	4.4	20		
6467788	Total Tellurium (Te)	2019/11/29	99	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Thallium (Tl)	2019/11/29	98	80 - 120	101	80 - 120	<0.050	ug/L	NC	20		
6467788	Total Tin (Sn)	2019/11/29	96	80 - 120	99	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Titanium (Ti)	2019/11/29	93	80 - 120	95	80 - 120	<5.0	ug/L	NC	20		
6467788	Total Tungsten (W)	2019/11/29	98	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
6467788	Total Uranium (U)	2019/11/29	98	80 - 120	102	80 - 120	<0.10	ug/L	NC	20		
6467788	Total Vanadium (V)	2019/11/29	100	80 - 120	101	80 - 120	<0.50	ug/L	NC	20		
6467788	Total Zinc (Zn)	2019/11/29	102	80 - 120	102	80 - 120	<5.0	ug/L	3.4	20		
6467788	Total Zirconium (Zr)	2019/11/29	100	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.
For Service Group specific validation please refer to the Validation Signature Page.

IMMEDIATE

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free 800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683	BV Labs Job #:	Bottle Order #: 739912
Attention:	Accounts Payable	Attention:	Marta Lopez-Egea	P.O. #:			
Address:	6925 Century Ave Suite 100, Mississauga ON L5N 7K2	Address:		Project:	1895639 (3000/3005)	COC #: C#739912-01-01	Project Manager: Ema Gitej
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	(905) 567-4444 Ext: 2060 Fax:	Project Name:			
Email:	AP_CustomerService@golder.com	Email:	Marta_Lopez-Egea@golder.com	Site #:			
				Sampled By:			

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558. ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☒ PWQO ☐ Other ___

Special Instructions:

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required: Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Total Metals Analysis by ICPMS	pH	Chloride, Sulphate, Nitrate, Nitrite, Orthophosphate	Low Level TSS	Alkalinity, Hardness						# of Bottles	Comments
1		SW-1	Nov25/19	11:10	SW		✓	✓	✓	✓	✓						3	
2		SW-2		11:50			✓	✓	✓	✓	✓							
3		SW-3		12:10			✓	✓	✓	✓	✓							
4		SW-4		12:50			✓	✓	✓	✓	✓							
5		SW-5		13:35			✓	✓	✓	✓	✓							
6		SW-6		13:10			✓	✓	✓	✓	✓							
7																		
8																		
9																		
10																		

25-Nov-19 16:05
Ema Gitej
B9X2127
JCC ENV-612

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only			
Kevin Whitton / [signature]	19/11/25	16:00	[signature] - COLENE CURATTO	2019/11/25	16:05			Temperature (°C) on Recei: 1/1/0 ice	Custody Seal Present / Intact	Yes	No ✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

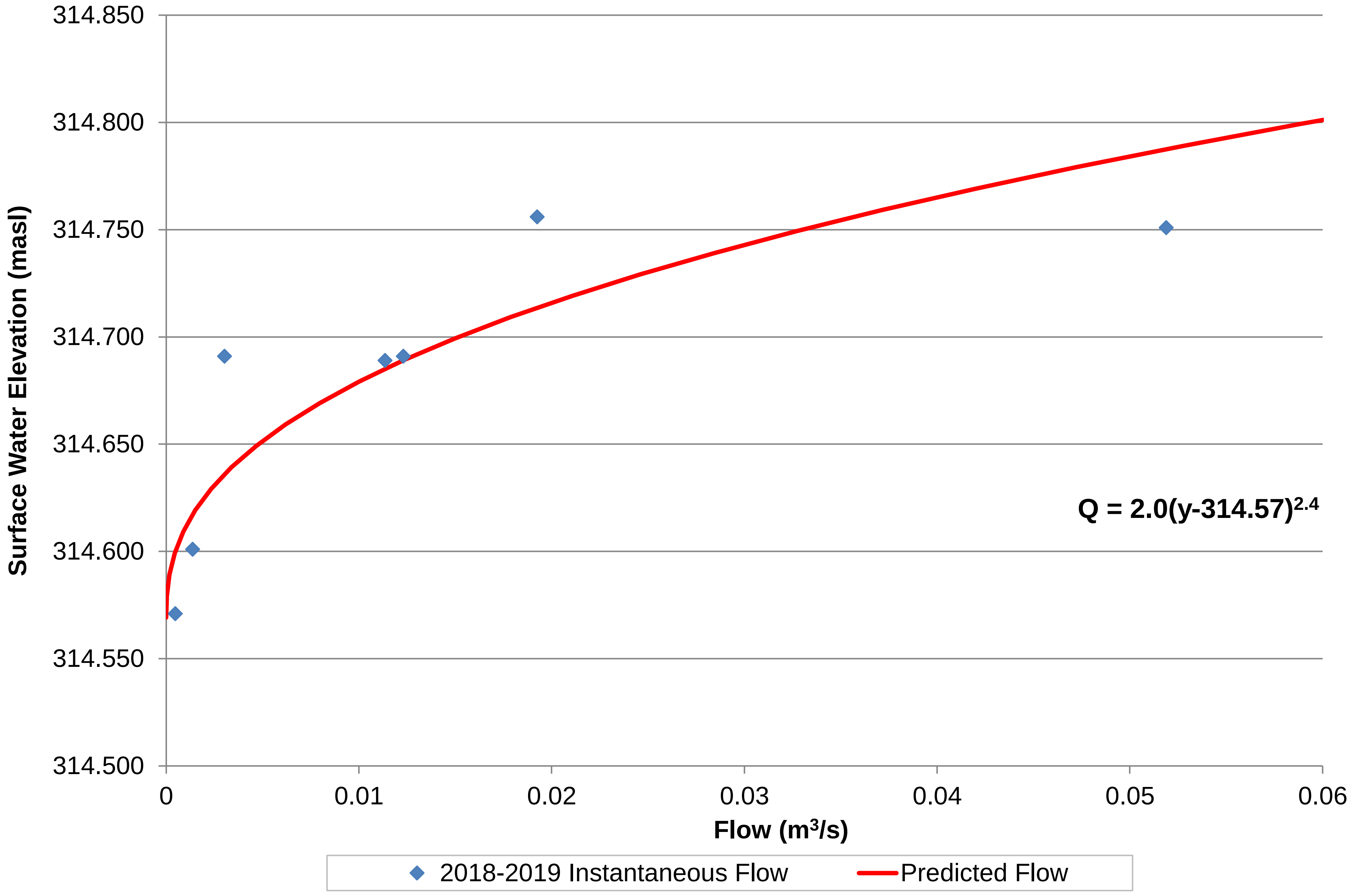
SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

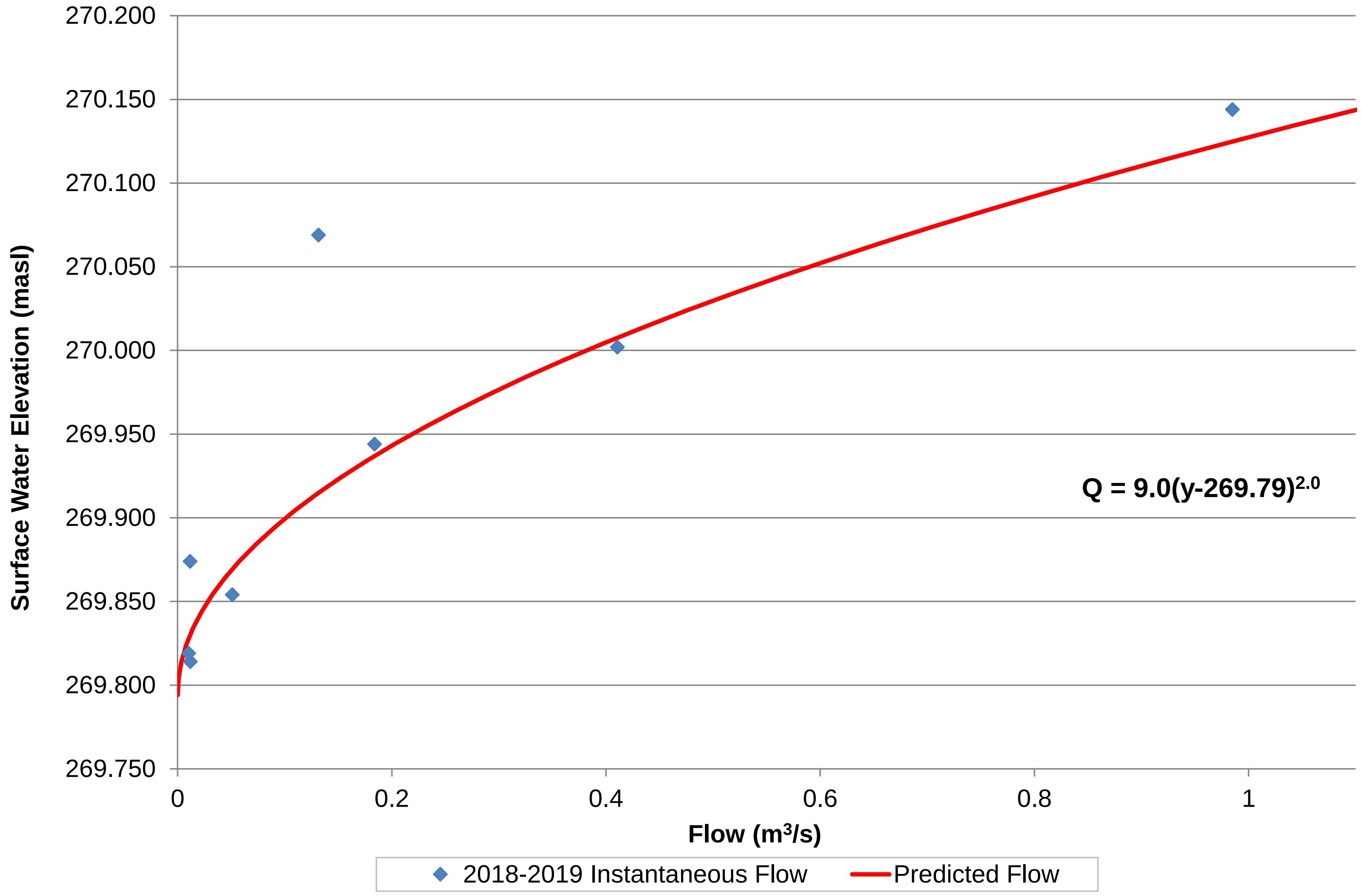
APPENDIX I

Rating Curves



CLIENT FOWLER CONSTRUCTION COMPANY LIMITED	PROJECT CHILD'S PIT/QUARRY, BRACEBRIDGE, ONTARIO
CONSULTANT GOLDER YYYY-MM-DD 2020-04-27 PREPARED NP DESIGN NP REVIEW MLE APPROVED KAM	TITLE SW1 ESTIMATED FLOW RATING CURVE PROJECT No. 1895639 Rev.

FIGURE I-1



CLIENT
FOWLER CONSTRUCTION COMPANY LIMITED

PROJECT
CHILD'S PIT/QUARRY, BRACEBRIDGE, ONTARIO

CONSULTANT

GOLDER

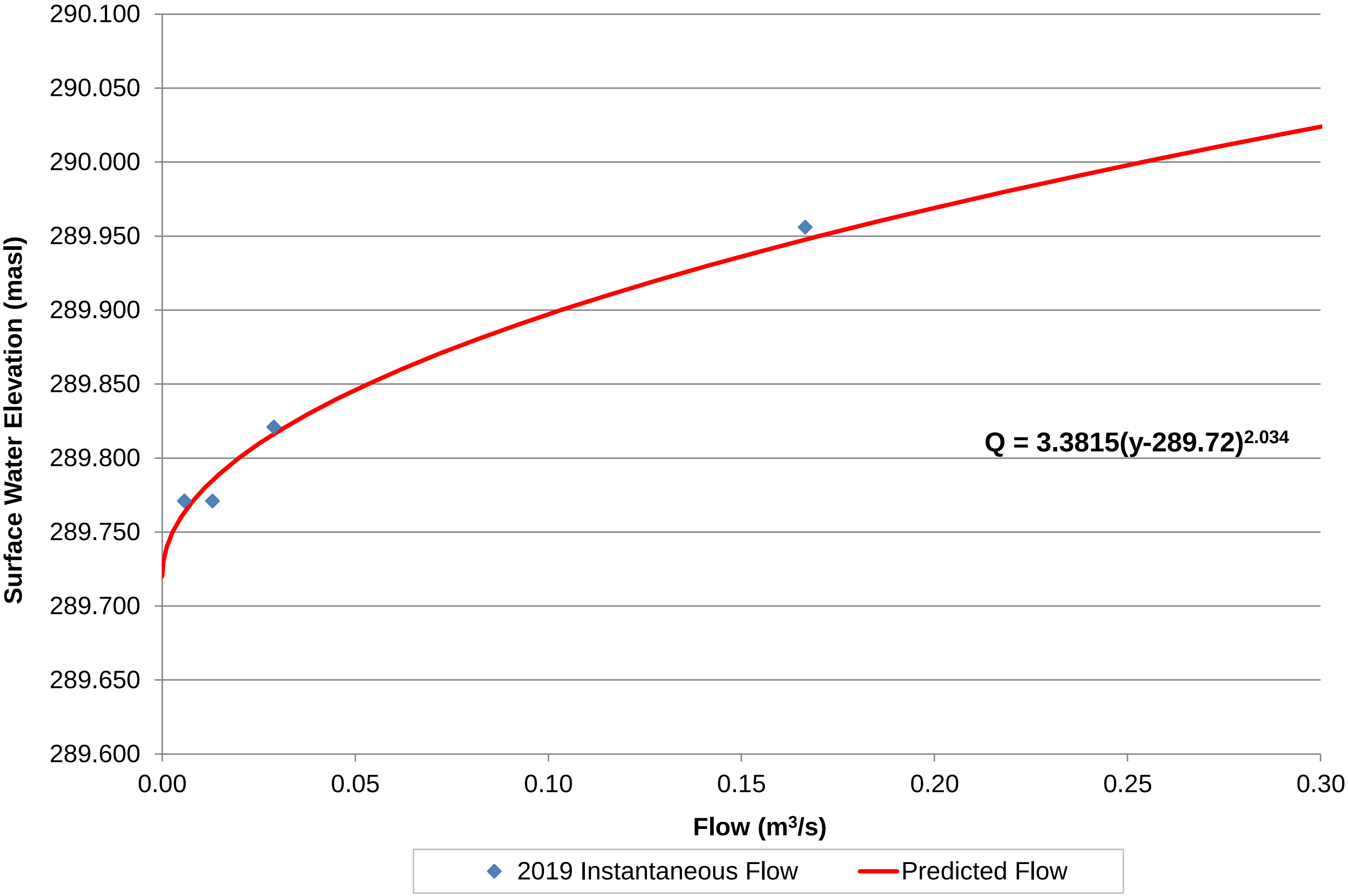
YYYY-MM-DD	2020-04-27
PREPARED	NP
DESIGN	NP
REVIEW	MLE
APPROVED	KAM

TITLE
SW2 ESTIMATED FLOW RATING CURVE

PROJECT No. 1895639

Rev.

FIGURE I-2



CLIENT FOWLER CONSTRUCTION COMPANY LIMITED		PROJECT CHILD'S PIT/QUARRY, BRACEBRIDGE, ONTARIO	
CONSULTANT GOLDER	YYYY-MM-DD: 2020-04-27 PREPARED: NP DESIGN: NP REVIEW: MLE APPROVED: KAM	TITLE SW5 ESTIMATED FLOW RATING CURVE	
		PROJECT No. 1895639	Rev.

FIGURE I-3

APPENDIX J

Water Balance Results

Table J-0: Water Budget (Based on Beatrice Climate Station Daily Data)

Month	Mean Temperature (°C)	Rainfall (mm)	Precipitation (mm)	Potential Evapotrans-piration (mm)	Actual Evapotranspiration (mm)							Surplus (mm)						
					3 mm	10 mm	100 mm	125 mm	250 mm	400 mm	90% precip	3 mm	10 mm	100 mm	125 mm	250 mm	400 mm	Precip - PET
January	-10	22	107	1	1	1	1	1	1	1	0	42	42	41	41	40	40	106
February	-9	18	78	1	1	1	1	1	1	1	0	41	41	41	41	41	41	77
March	-4	42	77	6	6	6	6	6	6	6	1	138	138	138	138	136	135	71
April	4	78	85	29	28	29	29	29	29	29	6	168	168	168	168	168	168	56
May	11	93	93	73	66	68	73	73	73	73	15	29	29	29	29	29	29	20
June	16	93	93	104	83	86	103	104	104	104	22	11	10	9	9	9	9	-11
July	18	88	88	121	83	86	112	116	121	121	26	6	4	1	1	1	1	-33
August	17	100	100	107	86	87	97	100	106	107	23	13	12	7	7	7	7	-7
September	13	108	108	71	67	68	70	70	71	71	15	39	36	16	16	16	16	37
October	7	118	119	35	35	35	35	35	35	35	7	84	82	58	54	50	50	84
November	0	84	116	10	10	10	10	10	10	10	2	90	90	83	80	73	72	106
December	-6	37	121	2	2	2	2	2	2	2	0	56	56	56	56	55	54	119
Total		**882**	**1,186**	**560**	**468**	**479**	**539**	**547**	**559**	**560**	**119**	**717**	**708**	**647**	**640**	**625**	**622**	**626**

Notes:

Climatic Water Budget: Water Budget Means for the Period 1980 to 2018 using Beatrice Climate (Climate ID: 6115525) for 2005 to 2019 and Beatrice 2 (Climate ID: 6110606) for period 1980 to 2005

Table J-1: Child's Pit/Quarry High-Level Water Balance Assessment – Scenario 1

DRAINING TO AP-1 (MUSKOKA RIVER)

Surficial Geology					Soil Type B									Any		
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			Swamp/Marsh/OpenWater		
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	PRECIP-PET	
Total Area (m^2)					Total Area (m^2)	330,496		Total Area (m^2)	268,173		Total Area (m^2)	408,947		Total Area (m^2)	11,143	
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	330,496		GW Catchment Area (m^2)	228,856		GW Catchment Area (m^2)	408,947		GW Catchment Area (m^2)	11,143	
Infiltration Factor (%)					Infiltrat. Factor	0.25		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0	
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)
January	31	-10	107	1	1	42	13,881	1	40	10,727	1	40	16,358	1	106	1,185
February	28	-9	78	1	1	41	13,550	1	41	10,995	1	41	16,767	1	77	853
March	31	-4	77	6	6	138	45,608	6	136	36,472	6	135	55,208	6	71	795
April	30	4	85	29	29	168	55,523	29	168	45,053	29	168	68,703	29	56	624
May	31	11	93	73	68	29	9,584	73	29	7,777	73	29	11,859	73	20	228
June	30	16	93	104	86	10	3,305	104	9	2,414	104	9	3,681	104	-11	-120
July	31	18	88	121	86	4	1,322	121	1	268	121	1	409	121	-33	-362
August	31	17	100	107	87	12	3,966	106	7	1,877	107	7	2,863	107	-7	-82
September	30	13	108	71	68	36	11,898	71	16	4,291	71	16	6,543	71	37	408
October	31	7	119	35	35	82	27,101	35	50	13,409	35	50	20,447	35	84	941
November	30	0	116	10	10	90	29,745	10	73	19,577	10	72	29,444	10	106	1,182
December	31	-6	121	2	2	56	18,508	2	55	14,750	2	54	22,083	2	119	1,328
Total			***1,186***	***560***	***479***	***708***	***233,991***	***559***	***625***	***167,608***	***560***	***622***	***254,365***	***560***	***626***	***6,979***

Surficial Geology	Any																	
Land Use	Mineral Thicket Swamp			Wetland			Extraction			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Muskoka River [5]	Infiltration within GW Catchment [6]	Recharge	Interflow outside GW capture zone	Total Discharge to Point of Analysis (including GW contribution to Muskoka River) [7]
Surplus Estimation Method	WHC	PRECIP-PET		WHC	PRECIP-PET		WHC	10 mm										
Total Area (m^2)	Total Area (m^2)	9,574		Total Area (m^2)	14,426		Total Area (m^2)	2,023,703		Total Area (m^2)		3,066,462	Daily Inflow (m^3/day)	Daily Inflow (m^3/day)				
Area within Groundwater Catchment (m^2)	GW Catchment Area (m^2)	9,574		GW Catchment Area (m^2)	14,426		GW Catchment Area (m^2)	2,023,703		GW Catchment Area (m^2)		3,027,145	1176.0	1923.0				
Infiltration Factor (%)	Infiltrat. Factor	0.0		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0					Contribution	Contribution				
Month	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%	100%				
	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	1	106	1,018	1	106	1,534	1	42	84,996	129,697	19,158	110,539	35,770	58,491	18,057	420	681	222,858
February	1	77	733	1	77	1,104	1	41	82,972	126,974	19,468	107,506	35,770	58,491	18,339	420	708	220,106
March	6	71	683	6	71	1,030	6	138	279,271	419,067	64,536	354,531	35,770	58,491	60,793	420	3,323	509,585
April	29	56	536	29	56	807	29	168	339,982	511,228	79,769	431,459	35,770	58,491	75,146	420	4,204	600,866
May	73	20	196	73	20	295	68	29	58,687	88,628	13,770	74,858	35,770	58,491	12,972	420	378	182,091
June	104	-11	-103	104	-11	-155	86	10	20,237	29,258	4,356	24,902	35,770	58,491	4,108	420	-172	123,272
July	121	-33	-311	121	-33	-469	86	4	8,095	8,951	723	8,229	35,770	58,491	695	420	-392	103,185
August	107	-7	-71	107	-7	-107	87	12	24,284	32,730	3,737	28,993	35,770	58,491	3,544	420	-227	126,799
September	71	37	350	71	37	528	68	36	72,853	96,871	9,250	87,621	35,770	58,491	8,809	420	20	190,692
October	35	84	809	35	84	1,219	35	82	165,944	229,869	26,385	203,484	35,770	58,491	25,009	420	956	322,754
November	10	106	1,016	10	106	1,531	10	90	182,133	264,627	35,862	228,766	35,770	58,491	33,853	420	1,589	356,880
December	2	119	1,141	2	119	1,719	2	56	113,327	172,856	25,993	146,863	35,770	58,491	24,479	420	1,094	265,604
Total	***560***	***626***	***5,997***	***560***	***626***	***9,035***	***479***	***708***	***1,432,782***	***2,110,757***	***303,006***	***1,807,751***	***429,240***	***701,895***	***285,805***	***5,039***	***12,162***	***3,224,691***

DRAINING TO AP-2 (SAGE RIVER)

Surficial Geology					Soil Type B															
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Sage Creek [5]	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm								
Total Area (m^2)					Total Area (m^2)	704,151		Total Area (m^2)	27,829		Total Area (m^2)	179,289		Total Area (m^2)		911,270	Daily Inflow (m^3/day)	Daily Inflow (m^3/day)		
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	306,809		GW Catchment Area (m^2)	1,418		GW Catchment Area (m^2)	30,832		GW Catchment Area (m^2)		339,058	1176.0	467.0		
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	Contribution	Contribution		
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]					0%	100%		
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	29,574	1	40	1,113	1	40	7,172	37,859	11,759	26,101	0	14,205	3,551	43,856
February	28	-9	78	1	1	41	28,870	1	41	1,141	1	41	7,351	37,362	11,692	25,670	0	14,205	3,544	43,419
March	31	-4	77	6	6	138	97,173	6	136	3,785	6	135	24,204	125,162	39,045	86,117	0	14,205	21,914	122,236
April	30	4	85	29	29	168	118,297	29	168	4,675	29	168	30,121	153,093	47,907	105,186	0	14,205	27,935	147,326
May	31	11	93	73	68	29	20,420	73	29	807	73	29	5,199	26,427	8,270	18,157	0	14,205	1,240	33,602
June	30	16	93	104	86	10	7,042	104	9	250	104	9	1,614	8,906	2,743	6,163	0	14,205	-2,502	17,866
July	31	18	88	121	86	4	2,817	121	1	28	121	1	179	3,024	813	2,210	0	14,205	-3,840	12,575
August	31	17	100	107	87	12	8,450	106	7	195	107	7	1,255	9,900	2,876	7,023	0	14,205	-2,489	18,739
September	30	13	108	71	68	36	25,349	71	16	445	71	16	2,869	28,663	8,083	20,580	0	14,205	730	35,514
October	31	7	119	35	35	82	57,740	35	50	1,391	35	50	8,964	68,096	19,891	48,205	0	14,205	8,452	70,861
November	30	0	116	10	10	90	63,374	10	73	2,032	10	72	12,909	78,314	23,720	54,594	0	14,205	11,305	80,103
December	31	-6	121	2	2	56	39,432	2	55	1,531	2	54	9,682	50,645	15,770	34,874	0	14,205	6,258	55,337
Total			***1,186***	***560***	***479***	***708***	***498,539***	***559***	***625***	***17,393***	***560***	***622***	***111,518***	***627,450***	***192,569***	***434,881***	***0***	***170,455***	***76,099***	***681,435***

Notes:

1. Surplus calculated (on a monthly basis) by Surplus **(m^3) = [('Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]**
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry or Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Quarry or Point of Discharge (m3) = Σ['Days' × Linear Regression of 1176.0, 1923.0, or 467.0 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated according to Eq [4] and Eq [5]

Table J-2: Child's Pit/Quarry High-Level Water Balance Assessment – Scenario 2

DRAINING TO AP-1 (MUSKOKA RIVER)

Surficial Geology					Soil Type B									Any																				
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			Swamp/Marsh/OpenWater			Mineral Thicket Swamp			Wetland			Extraction			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Muskoka River [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	PRECIP-PET		WHC	PRECIP-PET		WHC	PRECIP-PET		WHC	10 mm										
Total Area (m²)					Total Area (m²)	47,369		Total Area (m²)	265,895		Total Area (m²)	24,816		Total Area (m²)	97		Total Area (m²)	8,451		Total Area (m²)	888		Total Area (m²)	2,731,619		Total Area (m²)		3,079,135	Daily Inflow (m³/day)	Daily Inflow (m³/day)				
Area within Groundwater Catchment (m²)					GW Catchment Area (m²)	47,369		GW Catchment Area (m²)	226,578		GW Catchment Area (m²)	24,816		GW Catchment Area (m²)	97		GW Catchment Area (m²)	8,451		GW Catchment Area (m²)	888		GW Catchment Area (m²)	2,731,619		GW Catchment Area (m²)		3,039,818	1364.0	1892.0				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0					Contribution	Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)
January	31	-10	107	1	1	42	1,990	1	40	10,636	1	40	993	1	106	10	1	106	898	1	106	94	1	42	114,728	129,349	8,439	120,910	41,488	57,548	7,338	420	681	229,067
February	28	-9	78	1	1	41	1,942	1	41	10,902	1	41	1,017	1	77	7	1	77	647	1	77	68	1	41	111,996	126,580	8,625	117,954	41,488	57,548	7,497	420	708	226,325
March	31	-4	77	6	6	138	6,537	6	136	36,162	6	135	3,350	6	71	7	6	71	603	6	71	63	6	138	376,963	423,686	28,623	395,063	41,488	57,548	24,880	420	3,323	526,045
April	30	4	85	29	29	168	7,958	29	168	44,670	29	168	4,169	29	56	5	29	56	473	29	56	50	29	168	458,912	516,237	35,343	480,894	41,488	57,548	30,720	420	4,204	619,478
May	31	11	93	73	68	29	1,374	73	29	7,711	73	29	720	73	20	2	73	20	173	73	20	18	68	29	79,217	89,214	6,101	83,114	41,488	57,548	5,303	420	378	188,629
June	30	16	93	104	86	10	474	104	9	2,393	104	9	223	104	-11	-1	104	-11	-91	104	-11	-10	86	10	27,316	30,305	1,905	28,400	41,488	57,548	1,658	420	-172	129,169
July	31	18	88	121	86	4	189	121	1	266	121	1	25	121	-33	-3	121	-33	-275	121	-33	-29	86	4	10,926	11,100	246	10,854	41,488	57,548	218	420	-392	109,744
August	31	17	100	107	87	12	568	106	7	1,861	107	7	174	107	-7	-1	107	-7	-63	107	-7	-7	87	12	32,779	35,313	1,532	33,781	41,488	57,548	1,339	420	-227	134,122
September	30	13	108	71	68	36	1,705	71	16	4,254	71	16	397	71	37	4	71	37	309	71	37	32	68	36	98,338	105,040	3,603	101,437	41,488	57,548	3,163	420	20	204,097
October	31	7	119	35	35	82	3,884	35	50	13,295	35	50	1,241	35	84	8	35	84	714	35	84	75	35	82	223,993	243,210	10,898	232,312	41,488	57,548	9,522	420	956	343,202
November	30	0	116	10	10	90	4,263	10	73	19,410	10	72	1,787	10	106	10	10	106	897	10	106	94	10	90	245,846	272,307	15,546	256,761	41,488	57,548	13,537	420	1,589	372,933
December	31	-6	121	2	2	56	2,653	2	55	14,624	2	54	1,340	2	119	12	2	119	1,007	2	119	106	2	56	152,971	172,712	11,570	161,142	41,488	57,548	10,056	420	1,094	272,843
Total			***1,186***	***560***	***479***	***708***	***33,537***	***559***	***625***	***166,184***	***560***	***622***	***15,435***	***560***	***626***	***61***	***560***	***626***	***5,293***	***560***	***626***	***556***	***479***	***708***	***1,933,986***	***2,155,053***	***132,431***	***2,022,622***	***497,860***	***690,580***	***115,230***	***5,039***	***12,162***	***3,355,655***

DRAINING TO AP-2 (SAGE RIVER)

Surficial Geology					Soil Type B									Any											
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			Extraction			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Sage Creek [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	10 mm										
Total Area (m²)					Total Area (m²)	147,575		Total Area (m²)	7,585		Total Area (m²)	19,599		Total Area (m²)	723,849		Total Area (m²)		898,608	Daily Inflow (m³/day)	Daily Inflow (m³/day)				
Area within Groundwater Catchment (m²)					GW Catchment Area (m²)	20,203		GW Catchment Area (m²)	3,225		GW Catchment Area (m²)	8,660		GW Catchment Area (m²)	714,893		GW Catchment Area (m²)		746,982	1364.0	371.0				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.1					Contribution	Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	0%	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(mm)	(mm)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)	(m³)
January	31	-10	107	1	1	42	6,198	1	40	303	1	40	784	1	42	30,402	37,687	5,194	32,493	0	11,285	3,478	1,147	569	44,346
February	28	-9	78	1	1	41	6,051	1	41	311	1	41	804	1	41	29,678	36,843	5,100	31,743	0	11,285	3,408	1,147	544	43,572
March	31	-4	77	6	6	138	20,365	6	136	1,032	6	135	2,646	6	138	99,891	123,934	17,125	106,808	0	11,285	11,454	1,147	4,524	122,617
April	30	4	85	29	29	168	24,793	29	168	1,274	29	168	3,293	29	168	121,607	150,966	20,897	130,069	0	11,285	13,965	1,147	5,784	147,138
May	31	11	93	73	68	29	4,280	73	29	220	73	29	568	68	29	20,992	26,060	3,607	22,452	0	11,285	2,411	1,147	49	33,786
June	30	16	93	104	86	10	1,476	104	9	68	104	9	176	86	10	7,238	8,959	1,229	7,730	0	11,285	825	1,147	-743	18,271
July	31	18	88	121	86	4	590	121	1	8	121	1	20	86	4	2,895	3,513	452	3,061	0	11,285	313	1,147	-1,008	13,337
August	31	17	100	107	87	12	1,771	106	7	53	107	7	137	87	12	8,686	10,647	1,417	9,230	0	11,285	965	1,147	-695	19,820
September	30	13	108	71	68	36	5,313	71	16	121	71	16	314	68	36	26,059	31,806	4,176	27,630	0	11,285	2,861	1,147	168	39,083
October	31	7	119	35	35	82	12,101	35	50	379	35	50	980	35	82	59,356	72,816	9,716	63,100	0	11,285	6,606	1,147	1,963	76,348
November	30	0	116	10	10	90	13,282	10	73	554	10	72	1,411	10	90	65,146	80,393	10,928	69,465	0	11,285	7,365	1,147	2,416	83,165
December	31	-6	121	2	2	56	8,264	2	55	417	2	54	1,058	2	56	40,536	50,275	6,941	43,334	0	11,285	4,644	1,147	1,149	55,768
Total			***1,186***	***560***	***479***	***708***	***104,483***	***559***	***625***	***4,741***	***560***	***622***	***12,191***	***479***	***708***	***512,485***	***633,899***	***86,783***	***547,116***	***0***	***135,415***	***58,295***	***13,767***	***14,721***	***697,252***

Notes:

1. Surplus calculated (on a monthly basis) by Surplus **(m^3) = [('Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]**
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry or Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Quarry Point of Discharge (m3) = Σ['Days' × Linear Regression of 1364.0, 1892.0, or 371.0 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated according to Eq [4] and Eq [5]

Table J-3: Child's Pit/Quarry High-Level Water Balance Assessment – Scenario 3

DRAINING TO AP-1 (MUSKOKA RIVER)

Surficial Geology					Soil Type B												Any																	
Land Use					Forest - Precambrian Bedrock			Vegetated			Forest - Alluvial			Forest - Till/Organics			Swamp/Marsh/OpenWater			Mineral Thicket Swamp			Flooded Quarry			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Muskoka River [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	PRECIP-PET		WHC	PRECIP-PET		WHC	PRECIP-PET										
Total Area (m^2)					Total Area (m^2)	42,455		Total Area (m^2)	538,726		Total Area (m^2)	268,050		Total Area (m^2)	19,255		Total Area (m^2)	97		Total Area (m^2)	8,005		Total Area (m^2)	2,202,548		Total Area (m^2)		3,079,135	Daily Inflow (m^3/day)	Daily Inflow (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	42,455		GW Catchment Area (m^2)	538,726		GW Catchment Area (m^2)	228,732		GW Catchment Area (m^2)	19,255		GW Catchment Area (m^2)	97		GW Catchment Area (m^2)	8,005		GW Catchment Area (m^2)	2,202,548		GW Catchment Area (m^2)		3,039,818	330.0	2669.0				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.2		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0					Contribution	Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	1,783	1	42	22,626	1	42	11,258	1	40	770	1	106	10	1	106	851	1	106	234,153	271,453	13,237	258,216	10,038	81,182	12,081	420	736	363,408
February	28	-9	78	1	1	41	1,741	1	41	22,088	1	41	10,990	1	41	789	1	77	7	1	77	613	1	77	168,563	204,791	12,940	191,850	10,038	81,182	11,812	420	708	296,719
March	31	-4	77	6	6	138	5,859	6	138	74,344	6	138	36,991	6	135	2,599	6	71	7	6	71	571	6	71	157,188	277,560	43,527	234,033	10,038	81,182	39,729	420	3,378	372,158
April	30	4	85	29	29	168	7,132	29	168	90,506	29	168	45,032	29	168	3,235	29	56	5	29	56	448	29	56	123,252	269,611	53,024	216,587	10,038	81,182	48,401	420	4,204	365,035
May	31	11	93	73	68	29	1,231	68	29	15,623	68	29	7,773	73	29	558	73	20	2	73	20	164	73	20	45,101	70,453	9,153	61,300	10,038	81,182	8,355	420	378	162,051
June	30	16	93	104	86	10	425	86	10	5,387	86	10	2,680	104	9	173	104	-11	-1	104	-11	-86	104	-11	-23,675	-15,096	3,147	-18,243	10,038	81,182	2,871	420	-145	75,979
July	31	18	88	121	86	4	170	86	4	2,155	86	4	1,072	121	1	19	121	-33	-3	121	-33	-260	121	-33	-71,600	-68,447	1,234	-69,681	10,038	81,182	1,124	420	-310	22,463
August	31	17	100	107	87	12	509	87	12	6,465	87	12	3,217	107	7	135	107	-7	-1	107	-7	-59	107	-7	-16,305	-6,039	3,739	-9,778	10,038	81,182	3,409	420	-90	85,091
September	30	13	108	71	68	36	1,528	68	36	19,394	68	36	9,650	71	16	308	71	37	4	71	37	293	71	37	80,585	111,762	11,170	100,592	10,038	81,182	10,179	420	571	203,552
October	31	7	119	35	35	82	3,481	35	82	44,176	35	82	21,980	35	50	963	35	84	8	35	84	676	35	84	186,059	257,343	25,573	231,770	10,038	81,182	23,316	420	1,837	350,399
November	30	0	116	10	10	90	3,821	10	90	48,485	10	90	24,124	10	72	1,386	10	106	10	10	106	849	10	106	233,690	312,367	28,233	284,134	10,038	81,182	25,756	420	2,057	405,644
December	31	-6	121	2	2	56	2,377	2	56	30,169	2	56	15,011	2	54	1,040	2	119	12	2	119	954	2	119	262,493	312,055	17,656	294,400	10,038	81,182	16,114	420	1,121	404,396
Total			***1,186***	***560***	***479***	***708***	***30,058***	***479***	***708***	***381,418***	***479***	***708***	***189,779***	***560***	***622***	***11,976***	***560***	***626***	***61***	***560***	***626***	***5,014***	***560***	***626***	***1,379,506***	***1,997,813***	***222,632***	***1,775,181***	***120,450***	***974,185***	***203,146***	***5,039***	***14,446***	***3,106,894***

DRAINING TO AP-2 (SAGE RIVER)

Surficial Geology					Soil Type B												Any											
Land Use					Forest - Precambrian Bedrock			Vegetated			Forest - Alluvial			Forest - Till/Organics			Flooded Quarry			TOTALS			Groundwater Inflow Into Quarry [5]	Groundwater Discharge to Sage Creek [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis 7
Surplus Estimation Method					WHC	10 mm		WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	PRECIP-PET										
Total Area (m^2)					Total Area (m^2)	147,571		Total Area (m^2)	723,856		Total Area (m^2)	7,583		Total Area (m^2)	19,597		Total Area (m^2)	0		Total Area (m^2)		898,608	Daily Inflow (m^3/day)	Daily Inflow (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	20,200		GW Catchment Area (m^2)	714,899		GW Catchment Area (m^2)	3,224		GW Catchment Area (m^2)	8,658		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)		746,980	330.0	392.0				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.2		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0					Contribution	Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	0%	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	6,198	1	42	30,402	1	40	303	1	40	784	1	106	0	37,687	8,234	29,453	0	11,923	6,481	1,147	606	41,983
February	28	-9	78	1	1	41	6,050	1	41	29,678	1	41	311	1	41	803	1	77	0	36,843	8,068	28,775	0	11,923	6,339	1,147	581	41,280
March	31	-4	77	6	6	138	20,365	6	138	99,892	6	136	1,031	6	135	2,646	6	71	0	123,934	27,114	96,820	0	11,923	21,319	1,147	4,648	113,391
April	30	4	85	29	29	168	24,792	29	168	121,608	29	168	1,274	29	168	3,292	29	56	0	150,966	33,058	117,909	0	11,923	25,975	1,147	5,935	135,767
May	31	11	93	73	68	29	4,280	68	29	20,992	73	29	220	73	29	568	73	20	0	26,060	5,706	20,353	0	11,923	4,484	1,147	75	32,352
June	30	16	93	104	86	10	1,476	86	10	7,239	104	9	68	104	9	176	104	-11	0	8,959	1,953	7,006	0	11,923	1,540	1,147	-734	18,195
July	31	18	88	121	86	4	590	86	4	2,895	121	1	8	121	1	20	121	-33	0	3,513	742	2,771	0	11,923	599	1,147	-1,004	13,690
August	31	17	100	107	87	12	1,771	87	12	8,686	106	7	53	107	7	137	107	-7	0	10,647	2,286	8,362	0	11,923	1,822	1,147	-684	19,601
September	30	13	108	71	68	36	5,313	68	36	26,059	71	16	121	71	16	314	71	37	0	31,806	6,782	25,025	0	11,923	5,434	1,147	200	37,148
October	31	7	119	35	35	82	12,101	35	82	59,356	35	50	379	35	50	980	35	84	0	72,816	15,652	57,164	0	11,923	12,468	1,147	2,037	71,124
November	30	0	116	10	10	90	13,281	10	90	65,147	10	73	554	10	72	1,411	10	106	0	80,393	17,443	62,950	0	11,923	13,799	1,147	2,496	77,370
December	31	-6	121	2	2	56	8,264	2	56	40,536	2	55	417	2	54	1,058	2	119	0	50,275	10,994	39,281	0	11,923	8,648	1,147	1,199	52,404
Total			***1,186***	***560***	***479***	***708***	***104,480***	***479***	***708***	***512,490***	***559***	***625***	***4,740***	***560***	***622***	***12,189***	***560***	***626***	***0***	***633,899***	***138,031***	***495,869***	***0***	***143,080***	***108,908***	***13,768***	***15,355***	***654,304***

Notes:

1. Surplus calculated (on a monthly basis) by Surplus **(m^3) = [('Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]**
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry or Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Quarry or Point of Discharge (m3) = Σ['Days' × Linear Regression of 330.0, 2669.0 or 392.0 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated according to Eq [4] and Eq [5]

Table J-4: Child's Pit/Quarry Detailed Water Balance Assessment – Scenario 1

DRAINING TO AP-3 (MR-NORTH)

Surficial Geology					Soil Type B									Any													
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			Swamp/Marsh/OpenWater			Mineral Thicket Swamp			TOTALS			Groundwater Discharge to Point of Assessment [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	PRECIP-PET		WHC	PRECIP-PET									
Total Area (m^2)					Total Area (m^2)	266,122		Total Area (m^2)	1,335		Total Area (m^2)	227,404		Total Area (m^2)	10,526		Total Area (m^2)	1,123		Total Area (m^2)		506,510	Daily Discharge (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	266,122		GW Catchment Area (m^2)	1,335		GW Catchment Area (m^2)	227,404		GW Catchment Area (m^2)	10,526		GW Catchment Area (m^2)	1,123		GW Catchment Area (m^2)		506,510	5.4				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0		Infiltrat. Factor	0.0					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	11,177	1	40	53	1	40	9,096	1	106	1,119	1	106	119	21,565	7,380	14,185	167	7,380	0	0	14,353
February	28	-9	78	1	1	41	10,911	1	41	55	1	41	9,324	1	77	806	1	77	86	21,181	7,428	13,753	151	7,428	0	0	13,904
March	31	-4	77	6	6	138	36,725	6	136	182	6	135	30,700	6	71	751	6	71	80	68,437	24,658	43,779	167	24,658	0	0	43,947
April	30	4	85	29	29	168	44,709	29	168	224	29	168	38,204	29	56	589	29	56	63	83,789	30,436	53,352	162	30,436	0	0	53,514
May	31	11	93	73	68	29	7,718	73	29	39	73	29	6,595	73	20	216	73	20	23	14,590	5,254	9,336	167	5,254	0	0	9,503
June	30	16	93	104	86	10	2,661	104	9	12	104	9	2,047	104	-11	-113	104	-11	-12	4,595	1,697	2,898	162	1,697	0	0	3,060
July	31	18	88	121	86	4	1,064	121	1	1	121	1	227	121	-33	-342	121	-33	-37	915	381	534	167	381	0	0	701
August	31	17	100	107	87	12	3,193	106	7	9	107	7	1,592	107	-7	-78	107	-7	-8	4,708	1,601	3,108	167	1,601	0	0	3,275
September	30	13	108	71	68	36	9,580	71	16	21	71	16	3,638	71	37	385	71	37	41	13,666	4,229	9,437	162	4,229	0	0	9,599
October	31	7	119	35	35	82	21,822	35	50	67	35	50	11,370	35	84	889	35	84	95	34,243	11,187	23,056	167	11,187	0	0	23,223
November	30	0	116	10	10	90	23,951	10	73	97	10	72	16,373	10	106	1,117	10	106	119	41,657	14,243	27,415	162	14,243	0	0	27,577
December	31	-6	121	2	2	56	14,903	2	55	73	2	54	12,280	2	119	1,254	2	119	134	28,644	9,917	18,727	167	9,917	0	0	18,895
Total			**1,186**	**560**	**479**	**708**	**188,414**	**559**	**625**	**834**	**560**	**622**	**141,446**	**560**	**626**	**6,592**	**560**	**626**	**704**	**337,990**	**118,410**	**219,580**	**1,971**	**118,410**	**0**	**0**	**221,551**

DRAINING TO AP-4 (SC-3)

Surficial Geology					Soil Type B						Any										
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Extraction			TOTALS			Groundwater Discharge to Point of Assessment [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	10 mm									
Total Area (m^2)					Total Area (m^2)	163,253		Total Area (m^2)	11,297		Total Area (m^2)	0		Total Area (m^2)		174,549	Daily Discharge (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	117,659		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)		117,659	12.2				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.1					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	6,857	1	40	452	1	42	0	7,308	2,030	5,278	378	1,235	782	13	5,669
February	28	-9	78	1	1	41	6,693	1	41	463	1	41	0	7,157	1,998	5,159	342	1,206	782	9	5,510
March	31	-4	77	6	6	138	22,529	6	136	1,536	6	138	0	24,065	6,708	17,358	378	4,059	782	1,866	19,602
April	30	4	85	29	29	168	27,426	29	168	1,898	29	168	0	29,324	8,185	21,139	366	4,942	782	2,461	23,966
May	31	11	93	73	68	29	4,734	73	29	328	68	29	0	5,062	1,413	3,649	378	853	782	-222	3,805
June	30	16	93	104	86	10	1,633	104	9	102	86	10	0	1,734	479	1,255	366	294	782	-597	1,024
July	31	18	88	121	86	4	653	121	1	11	86	4	0	664	171	493	378	118	782	-729	143
August	31	17	100	107	87	12	1,959	106	7	79	87	12	0	2,038	545	1,493	378	353	782	-590	1,281
September	30	13	108	71	68	36	5,877	71	16	181	68	36	0	6,058	1,596	4,462	366	1,059	782	-245	4,583
October	31	7	119	35	35	82	13,387	35	50	565	35	82	0	13,952	3,742	10,209	378	2,412	782	548	11,136
November	30	0	116	10	10	90	14,693	10	73	825	10	90	0	15,517	4,250	11,267	366	2,647	782	821	12,454
December	31	-6	121	2	2	56	9,142	2	55	621	2	56	0	9,763	2,720	7,043	378	1,647	782	291	7,712
Total			**1,186**	**560**	**479**	**708**	**115,583**	**559**	**625**	**7,060**	**479**	**708**	**0**	**122,643**	**33,838**	**88,805**	**4,453**	**20,826**	**9,387**	**3,625**	**96,884**

DRAINING TO AP-5 (SC-6)

Surficial Geology																					
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			TOTALS			Groundwater Discharge to Point of Assessment [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm									
Total Area (m^2)					Total Area (m^2)	179,681		Total Area (m^2)	12,702		Total Area (m^2)	86,631		Total Area (m^2)		279,013	Daily Discharge (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	43,604		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	30,804		GW Catchment Area (m^2)		74,408	58.7				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	100%				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	7,547	1	40	508	1	40	3,465	11,520	3,975	7,545	1,820	1,074	1,924	977	10,342
February	28	-9	78	1	1	41	7,367	1	41	521	1	41	3,552	11,440	3,982	7,457	1,644	1,078	1,924	980	10,081
March	31	-4	77	6	6	138	24,796	6	136	1,727	6	135	11,695	38,219	13,256	24,963	1,820	3,584	1,924	7,748	34,531
April	30	4	85	29	29	168	30,186	29	168	2,134	29	168	14,554	46,874	16,317	30,557	1,761	4,419	1,924	9,975	42,293
May	31	11	93	73	68	29	5,211	73	29	368	73	29	2,512	8,091	2,817	5,275	1,820	763	1,924	130	7,225
June	30	16	93	104	86	10	1,797	104	9	114	104	9	780	2,691	919	1,772	1,761	248	1,924	-1,252	2,280
July	31	18	88	121	86	4	719	121	1	13	121	1	87	818	232	586	1,820	59	1,924	-1,751	655
August	31	17	100	107	87	12	2,156	106	7	89	107	7	606	2,851	904	1,947	1,820	239	1,924	-1,258	2,509
September	30	13	108	71	68	36	6,468	71	16	203	71	16	1,386	8,058	2,452	5,605	1,761	639	1,924	-110	7,256
October	31	7	119	35	35	82	14,734	35	50	635	35	50	4,332	19,700	6,294	13,407	1,820	1,664	1,924	2,706	17,932
November	30	0	116	10	10	90	16,171	10	73	927	10	72	6,237	23,336	7,811	15,525	1,761	2,090	1,924	3,797	21,083
December	31	-6	121	2	2	56	10,062	2	55	699	2	54	4,678	15,439	5,344	10,095	1,820	1,442	1,924	1,978	13,893
Total			**1,186**	**560**	**479**	**708**	**127,214**	**559**	**625**	**7,939**	**560**	**622**	**53,885**	**189,037**	**64,303**	**124,734**	**21,426**	**17,298**	**23,085**	**23,920**	**170,079**

Notes:
1. Surplus calculated (on a monthly basis) by **Surplus (m^3) = [('Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]**
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry or Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Point of Assessment (m3) = Σ['Days' × Linear Regression of 5.4, 12.2 or 58.7 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated **calculated according to Eq [4] and Eq [5]**

Table J-5: Child's Pit/Quarry Detailed Water Balance Assessment – Scenario 2

DRAINING TO AP-3 (MR-NORTH)

Surficial Geology					Soil Type B						Any										
Land Use					Forest - Precambrian Bedrock			Forest - Till/Organics			Extraction			TOTALS			Groundwater Inflow into Quarry [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	400 mm		WHC	10 mm									
Total Area (m^2)					Total Area (m^2)	0		Total Area (m^2)	0		Total Area (m^2)	707,916		Total Area (m^2)		**707,916**	Daily Inflow (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	707,916		GW Catchment Area (m^2)		**707,916**	**180.0**				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.5		Infiltrat. Factor	0.0					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	**100%**				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	0	1	40	0	1	42	29,732	29,732	0	29,732	5,475	0	0	0	35,207
February	28	-9	78	1	1	41	0	1	41	0	1	41	29,025	29,025	0	29,025	5,475	0	0	0	34,500
March	31	-4	77	6	6	138	0	6	135	0	6	138	97,692	97,692	0	97,692	5,475	0	0	0	103,167
April	30	4	85	29	29	168	0	29	168	0	29	168	118,930	118,930	0	118,930	5,475	0	0	0	124,405
May	31	11	93	73	68	29	0	73	29	0	68	29	20,530	20,530	0	20,530	5,475	0	0	0	26,005
June	30	16	93	104	86	10	0	104	9	0	86	10	7,079	7,079	0	7,079	5,475	0	0	0	12,554
July	31	18	88	121	86	4	0	121	1	0	86	4	2,832	2,832	0	2,832	5,475	0	0	0	8,307
August	31	17	100	107	87	12	0	107	7	0	87	12	8,495	8,495	0	8,495	5,475	0	0	0	13,970
September	30	13	108	71	68	36	0	71	16	0	68	36	25,485	25,485	0	25,485	5,475	0	0	0	30,960
October	31	7	119	35	35	82	0	35	50	0	35	82	58,049	58,049	0	58,049	5,475	0	0	0	63,524
November	30	0	116	10	10	90	0	10	72	0	10	90	63,712	63,712	0	63,712	5,475	0	0	0	69,187
December	31	-6	121	2	2	56	0	2	54	0	2	56	39,643	39,643	0	39,643	5,475	0	0	0	45,118
Total			***1,186***	***560***	***479***	***708***	***0***	***560***	***622***	***0***	***479***	***708***	***501,205***	***501,205***	***0***	***501,205***	***65,700***	***0***	***0***	***0***	***566,905***

DRAINING TO AP-4 (SC-3)

Surficial Geology					Soil Type B						Any										
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Extraction			TOTALS			Groundwater Discharge to Point of Assessment [5]	Infiltration within GW Catchment [6]	Recharge outside GW Catchment Divide	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	10 mm									
Total Area (m^2)					Total Area (m^2)	94,036		Total Area (m^2)	11,295		Total Area (m^2)	120,165		Total Area (m^2)		**225,497**	Daily Discharge (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	2,855		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	119,575		GW Catchment Area (m^2)		**122,430**	**0.2**				
Infiltration Factor (%)					Infiltrat. Factor	0.25		Infiltrat. Factor	0.7		Infiltrat. Factor	0.1					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	**100%**				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	3,950	1	40	452	1	42	5,047	9,448	1,808	7,640	6	532	1,417	-141	7,505
February	28	-9	78	1	1	41	3,855	1	41	463	1	41	4,927	9,245	1,781	7,465	6	520	1,417	-156	7,314
March	31	-4	77	6	6	138	12,977	6	136	1,536	6	138	16,583	31,096	5,978	25,118	6	1,749	1,417	2,812	27,936
April	30	4	85	29	29	168	15,798	29	168	1,898	29	168	20,188	37,883	7,297	30,587	6	2,129	1,417	3,751	34,343
May	31	11	93	73	68	29	2,727	73	29	328	68	29	3,485	6,539	1,260	5,280	6	367	1,417	-525	4,761
June	30	16	93	104	86	10	940	104	9	102	86	10	1,202	2,244	426	1,817	6	127	1,417	-1,117	706
July	31	18	88	121	86	4	376	121	1	11	86	4	481	868	150	718	6	51	1,417	-1,318	-594
August	31	17	100	107	87	12	1,128	106	7	79	87	12	1,442	2,649	482	2,168	6	152	1,417	-1,088	1,086
September	30	13	108	71	68	36	3,385	71	16	181	68	36	4,326	7,892	1,405	6,487	6	456	1,417	-468	6,025
October	31	7	119	35	35	82	7,711	35	50	565	35	82	9,854	18,129	3,308	14,821	6	1,039	1,417	852	15,679
November	30	0	116	10	10	90	8,463	10	73	825	10	90	10,815	20,103	3,774	16,328	6	1,140	1,417	1,217	17,551
December	31	-6	121	2	2	56	5,266	2	55	621	2	56	6,729	12,617	2,424	10,192	6	710	1,417	298	10,496
Total			***1,186***	***560***	***479***	***708***	***66,577***	***559***	***625***	***7,060***	***479***	***708***	***85,077***	***158,714***	***30,094***	***128,620***	***73***	***8,971***	***17,006***	***4,117***	***132,810***

DRAINING TO AP-5 (SC-6)

Surficial Geology					Soil Type B																			
Land Use					Forest - Precambrian Bedrock			Forest - Alluvial			Forest - Till/Organics			Extraction			TOTALS			Groundwater Discharge to Point of Assessment [5]	Infiltration within GW Catchment [6]	Recharge	Interflow	Total Discharge to Point of Analysis [7]
Surplus Estimation Method					WHC	10 mm		WHC	250 mm		WHC	400 mm		WHC	10 mm									
Total Area (m^2)					Total Area (m^2)	36,660		Total Area (m^2)	12,702		Total Area (m^2)	7,664		Total Area (m^2)	252,619		Total Area (m^2)		**309,645**	Daily Discharge (m^3/day)				
Area within Groundwater Catchment (m^2)					GW Catchment Area (m^2)	1,209		GW Catchment Area (m^2)	355		GW Catchment Area (m^2)	0		GW Catchment Area (m^2)	249,496		GW Catchment Area (m^2)		**251,060**	**30.3**				
Infiltration Factor (%)					Infiltrat. Factor	0.3		Infiltrat. Factor	0.7		Infiltrat. Factor	0.5		Infiltrat. Fact	0.1					Contribution				
Month	Days	Temp	Precipit.	Potential Evapotransp.	Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Actual Evapotransp.	Surplus [1]		Net Surplus [2]	Infiltrat. [3]	SW Runoff [4]	**100%**				
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
January	31	-10	107	1	1	42	1,540	1	40	508	1	40	307	1	42	10,610	12,964	1,955	11,009	939	1,071	551	334	12,282
February	28	-9	78	1	1	41	1,503	1	41	521	1	41	314	1	41	10,357	12,695	1,933	10,762	848	1,046	551	337	11,947
March	31	-4	77	6	6	138	5,059	6	136	1,727	6	135	1,035	6	138	34,861	42,683	6,477	36,205	939	3,519	551	2,408	39,553
April	30	4	85	29	29	168	6,159	29	168	2,134	29	168	1,288	29	168	42,440	52,020	7,921	44,099	909	4,284	551	3,086	48,094
May	31	11	93	73	68	29	1,063	73	29	368	73	29	222	68	29	7,326	8,980	1,367	7,612	939	740	551	77	8,629
June	30	16	93	104	86	10	367	104	9	114	104	9	69	86	10	2,526	3,076	459	2,617	909	255	551	-347	3,179
July	31	18	88	121	86	4	147	121	1	13	121	1	8	86	4	1,010	1,177	150	1,027	939	101	551	-502	1,465
August	31	17	100	107	87	12	440	106	7	89	107	7	54	87	12	3,031	3,614	502	3,112	939	305	551	-353	3,698
September	30	13	108	71	68	36	1,320	71	16	203	71	16	123	68	36	9,094	10,740	1,443	9,297	909	913	551	-21	10,185
October	31	7	119	35	35	82	3,006	35	50	635	35	50	383	35	82	20,715	24,739	3,459	21,280	939	2,083	551	825	23,045
November	30	0	116	10	10	90	3,299	10	73	927	10	72	552	10	90	22,736	27,514	4,023	23,491	909	2,291	551	1,182	25,582
December	31	-6	121	2	2	56	2,053	2	55	699	2	54	414	2	56	14,147	17,312	2,624	14,688	939	1,428	551	645	16,273
Total			***1,186***	***560***	***479***	***708***	***25,955***	***559***	***625***	***7,939***	***560***	***622***	***4,767***	***479***	***708***	***178,854***	***217,515***	***32,315***	***185,200***	***11,060***	***18,034***	***6,610***	***7,671***	***203,931***

Notes:

1. Surplus calculated (on a monthly basis) by Surplus **(m^3) = [('Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]**
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry or Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Quarry or Point of Discharge (m3) = Σ['Days' × Linear Regression of 1364.0, 0.2 or 30.3 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated calculated according to Eq [4] and Eq [5]

Table J-6: Child's Pit/Quarry Detailed Water Balance Assessment – Scenario 3

DRAINING TO AP-3 (MR-NORTH)

Surficial Geology	Soil Type B		Soil Type B		Soil Type B		Any		TOTALS		Groundwater Discharge to Point of Assessment [5]
Land Use	Forest - Precambrian Bedrock		Vegetated		Forest - Till/Organics		Flooded Quarry				
Surplus Estimation Method	WHC	10 mm	WHC	10 mm	WHC	400 mm	WHC	PRECIP-PET			
Total Area (m^2)	Total Area (m^2)	0	Total Area (m^2)	0	Total Area (m^2)	0	Total Area (m^2)	0	Total Area (m^2)	0	Daily Discharge (m^3/day)
Area within Groundwater Catchment (m^2)	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	0	0.0
Infiltration Factor (%)	Infiltrat. Factor	0.3	Infiltrat. Factor	0.2	Infiltrat. Factor	0.5	Infiltrat. Factor	0.0			Contribution
											100%

Month	Days	Temp (°C)	Precip. (mm)	Potential Evapotransp. (mm)	Forest - Precambrian Bedrock: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Vegetated: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Forest - Till/Organics: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Flooded Quarry: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Net Surplus [2] (m^3)	Infiltrat. [3] (m^3)	SW Runoff [4] (m^3)	Groundwater Discharge (m^3)	Infiltration within GW Catchment [6] (m^3)	Recharge (m^3)	Interflow (m^3)	Total Discharge to Point of Analysis [7] (m^3)
January	31	-10	107	1	1	42	0	1	40	0	1	40	0	1	106	0	0	0	0	0	0	0	0	0
February	28	-9	78	1	1	41	0	1	41	0	1	41	0	1	77	0	0	0	0	0	0	0	0	0
March	31	-4	77	6	6	138	0	6	136	0	6	135	0	6	71	0	0	0	0	0	0	0	0	0
April	30	4	85	29	29	168	0	29	168	0	29	168	0	29	56	0	0	0	0	0	0	0	0	0
May	31	11	93	73	68	29	0	73	29	0	73	29	0	73	20	0	0	0	0	0	0	0	0	0
June	30	16	93	104	86	10	0	104	9	0	104	9	0	104	-11	0	0	0	0	0	0	0	0	0
July	31	18	88	121	86	4	0	121	1	0	121	1	0	121	-33	0	0	0	0	0	0	0	0	0
August	31	17	100	107	87	12	0	106	7	0	107	7	0	107	-7	0	0	0	0	0	0	0	0	0
September	30	13	108	71	68	36	0	71	16	0	71	16	0	71	37	0	0	0	0	0	0	0	0	0
October	31	7	119	35	35	82	0	35	50	0	35	50	0	35	84	0	0	0	0	0	0	0	0	0
November	30	0	116	10	10	90	0	10	73	0	10	72	0	10	106	0	0	0	0	0	0	0	0	0
December	31	-6	121	2	2	56	0	2	55	0	2	54	0	2	119	0	0	0	0	0	0	0	0	0
Total			***1,186***	***560***	***479***	***708***	***0***	***559***	***625***	***0***	***560***	***622***	***0***	***560***	***626***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

DRAINING TO AP-4 (SC-3)

Surficial Geology	Soil Type B		Soil Type B		Soil Type B		TOTALS		Groundwater Discharge to Point of Assessment [5]
Land Use	Forest - Precambrian Bedrock		Vegetated		Forest - Alluvial				
Surplus Estimation Method	WHC	10 mm	WHC	10 mm	WHC	250 mm			
Total Area (m^2)	Total Area (m^2)	94,036	Total Area (m^2)	120,165	Total Area (m^2)	11,295	Total Area (m^2)	225,497	Daily Discharge (m^3/day)
Area within Groundwater Catchment (m^2)	GW Catchment Area (m^2)	2,855	GW Catchment Area (m^2)	119,575	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	122,430	16.9
Infiltration Factor (%)	Infiltrat. Factor	0.3	Infiltrat. Factor	0.2	Infiltrat. Factor	0.7			Contribution
									100%

Month	Days	Temp (°C)	Precip. (mm)	Potential Evapotransp. (mm)	Forest - Precambrian Bedrock: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Vegetated: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Forest - Alluvial: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Net Surplus [2] (m^3)	Infiltrat. [3] (m^3)	SW Runoff [4] (m^3)	Groundwater Discharge (m^3)	Infiltration within GW Catchment [6] (m^3)	Recharge outside GW Catchment Divide (m^3)	Interflow (m^3)	Total Discharge to Point of Analysis [7] (m^3)
January	31	-10	107	1	1	42	3,950	1	42	5,047	1	40	452	9,448	2,313	7,135	524	1,034	1,417	-139	7,521
February	28	-9	78	1	1	41	3,855	1	41	4,927	1	41	463	9,245	2,273	6,972	473	1,010	1,417	-154	7,292
March	31	-4	77	6	6	138	12,977	6	138	16,583	6	136	1,536	31,096	7,636	23,460	524	3,399	1,417	2,820	26,804
April	30	4	85	29	29	168	15,798	29	168	20,188	29	168	1,898	37,883	9,315	28,568	507	4,138	1,417	3,761	32,836
May	31	11	93	73	68	29	2,727	68	29	3,485	73	29	328	6,539	1,608	4,931	524	714	1,417	-523	4,932
June	30	16	93	104	86	10	940	86	10	1,202	104	9	102	2,244	547	1,697	507	246	1,417	-1,117	1,087
July	31	18	88	121	86	4	376	86	4	481	121	1	11	868	198	670	524	99	1,417	-1,318	-124
August	31	17	100	107	87	12	1,128	87	12	1,442	106	7	79	2,649	626	2,024	524	296	1,417	-1,087	1,461
September	30	13	108	71	68	36	3,385	68	36	4,326	71	16	181	7,892	1,838	6,054	507	887	1,417	-466	6,095
October	31	7	119	35	35	82	7,711	35	82	9,854	35	50	565	18,129	4,294	13,835	524	2,020	1,417	857	15,216
November	30	0	116	10	10	90	8,463	10	90	10,815	10	73	825	20,103	4,856	15,247	507	2,217	1,417	1,222	16,976
December	31	-6	121	2	2	56	5,266	2	56	6,729	2	55	621	12,617	3,097	9,519	524	1,379	1,417	301	10,344
Total			***1,186***	***560***	***479***	***708***	***66,577***	***479***	***708***	***85,077***	***559***	***625***	***7,060***	***158,714***	***38,602***	***120,113***	***6,169***	***17,437***	***17,006***	***4,158***	***130,439***

DRAINING TO AP-5 (SC-6)

Surficial Geology	Soil Type B		Soil Type B		Soil Type B		Soil Type B		TOTALS		Groundwater Discharge to Point of Assessment [5]
Land Use	Forest - Precambrian Bedrock		Vegetated		Forest - Alluvial		Forest - Till/Organics				
Surplus Estimation Method	WHC	10 mm	WHC	10 mm	WHC	250 mm	WHC	400 mm			
Total Area (m^2)	Total Area (m^2)	36,658	Total Area (m^2)	252,620	Total Area (m^2)	12,702	Total Area (m^2)	7,664	Total Area (m^2)	309,645	Daily Discharge (m^3/day)
Area within Groundwater Catchment (m^2)	GW Catchment Area (m^2)	1,209	GW Catchment Area (m^2)	249,496	GW Catchment Area (m^2)	0	GW Catchment Area (m^2)	355	GW Catchment Area (m^2)	251,060	42.3
Infiltration Factor (%)	Infiltrat. Factor	0.3	Infiltrat. Factor	0.2	Infiltrat. Factor	0.7	Infiltrat. Factor	0.5			Contribution
											100%

Month	Days	Temp (°C)	Precip. (mm)	Potential Evapotransp. (mm)	Forest - Precambrian Bedrock: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Vegetated: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Forest - Alluvial: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Forest - Till/Organics: Actual Evapotransp. (mm)	Surplus [1] (mm)	Surplus [1] (m^3)	Net Surplus [2] (m^3)	Infiltrat. [3] (m^3)	SW Runoff [4] (m^3)	Groundwater Discharge (m^3)	Infiltration within GW Catchment [6] (m^3)	Recharge (m^3)	Interflow (m^3)	Total Discharge to Point of Analysis [7] (m^3)
January	31	-10	107	1	1	42	1,540	1	42	10,610	1	40	508	1	40	307	12,964	3,016	9,948	1,311	2,116	551	349	11,609
February	28	-9	78	1	1	41	1,503	1	41	10,357	1	41	521	1	41	314	12,695	2,969	9,727	1,184	2,066	551	353	11,263
March	31	-4	77	6	6	138	5,059	6	138	34,862	6	136	1,727	6	135	1,035	42,683	9,964	32,719	1,311	6,952	551	2,461	36,491
April	30	4	85	29	29	168	6,159	29	168	42,440	29	168	2,134	29	168	1,288	52,020	12,165	39,855	1,269	8,464	551	3,151	44,275
May	31	11	93	73	68	29	1,063	68	29	7,326	73	29	368	73	29	222	8,980	2,100	6,880	1,311	1,461	551	88	8,279
June	30	16	93	104	86	10	367	86	10	2,526	104	9	114	104	9	69	3,076	711	2,365	1,269	504	551	-343	3,291
July	31	18	88	121	86	4	147	86	4	1,010	121	1	13	121	1	8	1,177	251	926	1,311	201	551	-500	1,737
August	31	17	100	107	87	12	440	87	12	3,031	106	7	89	107	7	54	3,614	805	2,809	1,311	604	551	-349	3,771
September	30	13	108	71	68	36	1,320	68	36	9,094	71	16	203	71	16	123	10,740	2,352	8,388	1,269	1,810	551	-9	9,648
October	31	7	119	35	35	82	3,006	35	82	20,715	35	50	635	35	50	383	24,739	5,531	19,209	1,311	4,125	551	854	21,374
November	30	0	116	10	10	90	3,299	10	90	22,736	10	73	927	10	72	552	27,514	6,297	21,217	1,269	4,531	551	1,215	23,701
December	31	-6	121	2	2	56	2,053	2	56	14,147	2	55	699	2	54	414	17,312	4,039	13,274	1,311	2,821	551	667	15,252
Total			***1,186***	***560***	***479***	***708***	***25,954***	***479***	***708***	***178,855***	***559***	***625***	***7,939***	***560***	***622***	***4,767***	***217,515***	***50,200***	***167,315***	***15,440***	***35,653***	***6,610***	***7,937***	***190,692***

Notes:

1. Surplus calculated (on a monthly basis) by Surplus (m^3) = [['Surplus'(mm) × 'Total Area'(m^2) ÷ 1000]
2. Net Surplus calculated as **Net Surplus (m^3) = Σ['Surplus'(m^3)]**
3. Infiltration calculated (on a monthly basis) by **Infiltration (m^3) = Σ['Surplus'(mm) × 'Total Area'(m^2) × 'Infiltration Factor'] ÷ 1000**
4. Surface Water Runoff calculated (on a monthly basis) by **SW Runoff (m^3) = Σ['Net Surplus'(mm) - 'Infiltration'(m^3)]**
5. Groundwater Inflow into Quarry into Point of Discharge calculated (on a monthly basis) by **Groundwater Inflow into Quarry or Point of Discharge (m3) = Σ['Days' × Linear Regression of 16.9 or 42.3 m^3/day estimated GW inflow for duration of catchment period (12 months)]**
6. Infiltration within groundwater catchment calculated (on a monthly basis by **Infiltration within GW Catchment (m^3) = Σ['Surplus'(mm) × Linear Regression of Area (m^2) within Groundwater Catchment × 'Infiltration Factor'] ÷ 1000**
7. Total Discharge calculated according to Eq [4] and Eq [5]

APPENDIX K

Water Supply Well Impact Assessment

Table K1
Supply Well Completion Details and Predicted Available Drawdown

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Location Name	**Water Well Record Number**	**Easting**	**Northing**	**Ground Surface Elevation (mASL)**	**Well Depth (m)**	**Well Bottom Elevation (mASL)**	**Static Water Elevation (mASL)**	**Source of Static Water Level**	**Drawdown - Scenario 1 - Development of Existing Childs Pit/Quarry to Interim Quarry Floor Elevations (m)**	**Drawdown - Scenario 2 - Full Development of Existing Childs Pit/Quarry to Interim Quarry Floor Elevations and the Extension Lands to Final Floor Elevations (m)**	**Predicted Additional Drawdown Resulting from Extracting the Extension Lands to the Final Floor Elevation (Scenario 2 minus Scenario 1) (m)**	**Available Drawdown (m) (calculated using the static water level measured during private well survey where available, or the static measured at time of drilling as per the water well record)**	**Predicted Available Drawdown Following Development of the Existing License to the Interim Quarry Floor and Extension Area to Final Floor Elevation (m) (available drawdown Column 13 minus Scenario 2 drawdown Column 11)**	**Drawdown - Scenario 3 - Rehabilitation**	**Predicted Available Drawdown Following Rehabilitation of the Existing Childs Pit/Quarry and the Extension Lands (m) (available drawdown Column 13 minus Scenario 3 drawdown Column 15)**
PW-4	4207859	635965	4998227	315.6	92.96	222.7	313.07	manually measured	1.3	2.5	1.3	90.4	87.9	2.5	87.9
PW-5	4207895	635881	4998400	321.5	135.64	185.9	314.45	manually measured	1.8	3.8	1.9	128.5	124.8	3.8	124.8
PW-7	7107640	635647	4998752	318.5	121.9	196.6	312.97	measured using data logger	3.8	7.7	3.9	116.4	108.7	6.7	109.6
PW-8	4208929	635759	4998785	311.3	36.57	274.7	309.67	measured using data logger	3.1	6.1	3.0	34.9	28.8	5.4	29.6
PW-9	- -	635718	4998874	313.5	91.44(1)	222.1	324.5	model - Scenario 0	3.6	6.7	3.1	102.4	95.7	5.8	96.7
PW-13	7154512	635598	4999198	321.1	97.5	223.6	319.91	measured using data logger	5.2	8.0	2.8	96.3	88.3	6.5	89.8
PW-14	4207168	635498	4999048	327	91.44	235.6	319.99	WWR	5.8	9.8	4.0	84.4	74.6	8.0	76.4
PW-15	4206320	635469	4999137	328.0	98.45	229.6	318.08	manually measured	6.3	10.1	3.8	88.5	78.4	8.1	80.5
PW-17	4207757	635495	4999355	326	92.96(1)	233.0	324.78	WWR	6.5	9.0	2.5	91.7	82.7	7.0	84.7
PW-18	- -	635388	4999660	329.3	121.9	207.4	326.43	measured using data logger	8.0	9.5	1.5	119.1	109.5	7.0	112.0
PW-19	7111466	635372	4999862	333.8	134.1	199.7	329.89	manually measured	7.7	8.7	1.0	130.2	121.5	6.3	123.9
PW-20	7051444	635279	4999964	327.4	135.6	191.8	325.04	manually measured	8.4	9.2	0.8	133.2	124.0	6.5	126.7
PW-21	4208992	635269	5000034	330.0	121.92	208.1	309.88	WWR	8.2	8.9	0.7	101.8	92.9	6.2	95.6
PW-22	- -	635165	5000097	329.5	121.92(1)	207.5	322.95	measured using data logger	9.0	9.6	0.6	115.4	105.8	6.6	108.8
PW-25	7045579	635164	5000284	327.0	99.97	227.0	320.59	manually measured	7.4	7.8	0.4	93.6	85.7	5.3	88.3
PW-27	7202334	635142	5000349	327.0	115.8	211.2	308.70	WWR	7.0	7.4	0.3	97.5	90.1	4.9	92.6
4209825	4209825	635370	4999340	329	123.4	205.6	322.90	WWR	8.2	11.1	2.9	117.3	106.2	8.5	108.8
7047910	7047910	634940	5000456	333.0	122	211.0	323.00	WWR	7.6	7.9	0.2	112.0	104.1	4.9	107.1
7211231	7211231	634805	5000900	325.0	121.92	203.1	320.43	WWR	3.4	3.5	0.1	117.4	113.8	1.9	115.4
7279477	7279477	633173	4997763	281.1	57.3	223.8	279.3	WWR	1.5	1.5	0.0	55.5	53.9	0.3	55.2

Notes:
(1) no water well record available, depth of well taken from completed private well survey

APPENDIX L

Qualifications and Experience of Report Authors

Education

M.A.Sc. Civil Engineering - Water Resources, University of Ottawa, Ontario, Canada, 2015

B.Eng. Civil Engineering, Universidad de Granada, Spain, 2011

Certifications

Canadian Dam Association (CDA) Annual Award – Research Scholarship, October 2014

First Prize – Civil Engineering Department, University of Ottawa, March 2014

Scholarship based on academic merits; University of Granada, Spain, 2006 to 2010

Languages

English – Fluent

Spanish – Fluent

Golder Associates Ltd. – Ottawa

Ms. Marta Lopez-Egea, M.A.Sc.

Marta Lopez Egea is a Water Resources Specialist at Golder Associates in Ottawa. Since joining Golder Associates, Marta has participated in several water resources and water quality modelling projects involving, river modelling, estimation of peak flows and runoff during extreme events, strategic water management assessments, development of regional hydrodynamic/thermodynamic models. Her experience extends to hydrotechnical reports, water balance studies involving recommendation and assessment of LID features, water source protection studies, stormwater management plans for subdivisions and aggregate clients and environmental permitting support. Her involvement on the projects extends to development of monitoring plans to data collection and analysis, quality assurance and reporting.

Employment History

Golder Associates Ltd. – GTA - Mississauga / Ottawa
Water Resources Specialist (2015 to Present)

Hydrodynamic and thermodynamic modelling involving CFD techniques (MIKE3, DELFT, FLOW 3D), hydrodynamic and water quality modelling of pit lakes (CE-QUAL), strategic water management assessment (GoldSim), hydraulic and hydrologic modelling experience including development of stage-discharge rating curves (HEC-RAS), estimation of peak flows and runoff during extreme events (HEC-HMS), mass-balance analysis in contaminated investigations and water budget calculations. Provided data collection, analysis, modelling and reporting of hydraulic, hydrology, and water quality studies to support Environmental Compliance Approvals, Permits to Take Water, aggregate licence applications and Water Handling Plans, Erosion and Sediment Control Plans, Source Water Protection Plans and Scour Analyses. Assisted with field work when required.

University of Ottawa – Ottawa, Ontario, Canada
Research and Teaching Assistant (2012 to 2014)

Research project at University of Ottawa in cooperation with DFO. Objectives included the experimental and numerical modelling (OpenFOAM) of hydraulic conditions forming at low-head dams. Design recommendations were provided to modify the current design of sea lamprey barriers to improve safety. In addition, completed duties as teaching assistant including in the following courses: Introduction to Fluid Mechanics, Hydraulics and Civil Engineering Graphics.

Algonquin College – Algonquin, Ontario, Canada
Part Time Professor (2012 to 2014)

Professor at the Civil Engineering department responsible of instructing the following courses: Environmental Engineering, Hydraulics, Structural Analysis, Strength of Materials and Statics.

PROJECT EXPERIENCE – WATER RESOURCES

Char River and Lower Landing Lake Study. Rankin Inlet, Nunavut, Canada	Developed a water balance of Lower Landing Lake and conducted the hydrological assessment of Char River using GoldSim to provide recommendation regarding supplementation during water shortage.
Supplementation Study of Lake Geraldine. Iqaluit, Nunavut, Canada	Developed a water balance of Lake Geraldine to investigate potential supplementation options for water supply to the City of Iqaluit to prevent water shortage during winter. A previously Golder developed GoldSim model was used to predict water deficit under several probabilistic scenarios of weather conditions and consumption rates.
Tomlinson/ Lafarge Flow Monitoring Report Findlay Creek. Ottawa, Ontario, Canada	Analysed field data of recent and historic observations (water level and flow hydrographs) at the receiver to understand flow pattern and evolution through time and to ultimately distinguish anthropogenic effects from those impacts on receiver associated with operations.
Several Clients - Water Balance Studies. Ontario, Canada	Developed water balance assessment to evaluate impacts on surplus, runoff and infiltration associated to development of quarry, pits and/or subdivisions. Evaluations of water management strategies and/or LID features to mitigate impacts on water resources.
Several Clients - Water Management Reports. Ontario, Canada	Developed water management studies for clients in the aggregate sector. Included an assessment of current water management operations, proposed water management features to meet water quantity and quality objectives (required from hydrologic model). Assessment of potential impacts regarding erosion and flooding.
Diamond Mines. Yellowknife NWT, Canada	Developed a 3D hydrodynamic and water quality model (MIKE3) of receiving lake. Conducted review of available data, created input series to represent past, current and future conditions, supported development of conceptual model, and conducted calibration and validation of model.
Bruce Power – Lake Huron. Ontario, Canada	Developed a 3D hydrodynamic and thermodynamic (MIKE3) model of Lake Huron, refined at the Bruce Power site to evaluate the thermal plumes at discharge locations to the receiving environment. Operational data were input in the model to ultimately assess impacts on the environment. This model is currently used to provide continuous support for regulatory purposes. The model is currently under development to incorporate future climatic predictions.
Agnico Eagle – Amaruq. Nunavut, Canada	Developed hydrodynamic and water quality model of Pit Lake using CEQUAL-W2 model to asses stratification and predict water quality over time, incorporating GoldSim model results. The model was used to inform client on closure options and filling alternatives.
Essakane – Pit Lake Model. Burkina Faso	Developed hydrodynamic and water quality model of Pit Lake using CEQUAL-W2 model to asses stratification and predict water quality based on different water management options at closure.

Baffinland Nunavut, Canada	Assisted with the development of a hydrodynamic model (DELFT) to predict currents and provide a quantitative assessment of sediment transport patterns comparing existing and proposed conditions.
Hidden Valley Bridge Replacement Project. Ontario, Canada	Reviewed the existing HEC-2 hydraulic model along with the current floodplain mapping to identify control sections and plan the field campaign. Updated HEC-RAS model
Gas Main Installation Hwy 89 & Sideroad 10. Ontario, Canada	Completed hydrological model to predict peak flows and runoff volumes (HEC-HMS) associated to rainfall and snowmelt events in support to permits application for the installation of a gas main and provided input on the design of the erosion and sediment control plan.
Mass Balance Analysis CN 109.5 Algonquin Park. Ontario, Canada	Completed a mass balance assessment of contaminants to evaluate the site remediation operational plan and predict completion of remediation activities

Education

B.A.Sc. Honours Geological Engineering (co-op), Faculty of Engineering, University of Waterloo, Ontario, 2006

M.Sc. Earth Science, Department of Earth and Environmental Sciences, University of Waterloo, Ontario, 2008

Golder Associates Ltd. – Ottawa

Employment History

Golder Associates Ltd. – Guelph/Ottawa, Ontario
Geological Engineer (2008 to Present)

Responsible for technical components of hydrogeological investigations relating to large-scale mine water balance studies, environmental impact assessments, groundwater resource and protection studies, and construction and infrastructure dewatering projects. Recent projects involved regional characterization of the hydrogeology and subsequent development of groundwater flow models to estimate groundwater flow and solute mass loadings for uranium mines in northern Saskatchewan. Mr. Bishop has also provided expertise in support of various hydrogeological studies involving proposed nuclear waste repositories and groundwater supply systems across Ontario, including Lanark, Simcoe, Waterloo, Wellington, Brant, and Grey Counties.

University of Waterloo – Waterloo, Ontario
Teaching Assistant (2007 to 2008)

Teaching assistant for university courses relating to engineering geology.

Golder Associates Ltd. – Ottawa, Ontario
Hydrogeological Engineering Assistant (May 2006 to August 2006)

Organized and prepared reports for numerous environmental investigations, including a major closed landfill assessment for the City of Toronto and a phase II environmental assessment at CFB Petawawa. This involved collecting and interpreting historical information, such as air photos, directories, and fire insurance plans. Other project work involved contouring and analyzing hydraulic head data at various sites to determine principal groundwater flow directions and database management for a township-scale groundwater well impact study.

Hemerra Envirochem Inc. – Vancouver, B.C.
Hydrogeological Engineering Assistant (August 2004 to December 2004)

Organized and prepared reports for several environmental site investigations. This involved interpretation of geological cross-sections and synthesizing historical data. Different field activities included supervising the removal of a gas tank removal in Delta, BC, conducting a two-day test pit program in Richmond, BC and long-term groundwater monitoring of a large permeable reactive barrier in North Vancouver.

XCG Consultants Ltd. – Kingston, Ontario
Hydrologist (2003 to May 2004)

Developed and programmed LFA 2004, a software package used to estimate the low flow value of any river given historical data. This program was completed and tested using client feedback. Additional projects involved groundwater modelling of a karst region in Florida using a MODFLOW processor and hydrodynamic modelling of the Ohio River at Cincinnati using EFDC. Various field activities included pumping tests, groundwater sampling and flow gauging for permit to take water applications.

City of Hamilton, Waste Management – Hamilton, Ontario
Field Technician (September 2002 to December 2002)

Collected surface water, groundwater, potable well and leachate samples as per landfill monitoring program requirements. In-office duties involved ranking consultant profiles for the 2003-2004 waste management roster and tracking of leachate volumes using shipping manifests.

City of St. Catharines, Environmental Services – St. Catharines, Ontario
Field Technician (January 2002 to April 2002)

Investigated public reports of environmental concern, usually relating dumping or surface water quality issues. Field activities included surface water sampling and sanitary sewer flow monitoring.

PROJECT EXPERIENCE – NUMERICAL MODELLING – QUARRIES

Cavanagh Henderson II Quarry
Ottawa, Ontario, Canada

Completed an assessment of groundwater inflows and drawdowns for a proposed quarry expansion in an area immediately adjacent to a provincially significant wetland. The hydrogeological analysis was completed using MODFLOW. Cumulative effects of neighbouring quarry properties were considered in this assessment. This work was reviewed by provincial regulators (MOECC and MNR).

Tackaberry Perth Quarry
Perth, Ontario, Canada

Following review of hydrogeological data a conceptual model was developed to form the basis of a numerical model. Constructed and calibrated a groundwater flow model to estimate groundwater inflows and drawdowns relating to a proposed quarry expansion. Results of the groundwater flow modelling were submitted as a part of a quarry license amendment, which was reviewed by provincial regulators.

Carden Plain Cumulative Impact Assessment, Carden, Ontario, Canada

Developed the conceptual hydrogeological model for the Carden Plain area based on information from 12 large bedrock quarries that operate in the area. Constructed 3D numerical groundwater flow models to evaluate the potential cumulative impacts of quarry dewatering across the regional setting, and determine possible implications to surface water and groundwater resources.

Flamborough Quarry
Flamborough, Ontario, Canada

Developed a MODFLOW groundwater flow model of the proposed quarry and used this model to evaluate the effectiveness of a well-injection system designed to maintain water levels within a wetland directly adjacent the quarry boundary, as per Ministry of Environment Permit-To-Take-Water requirements.

PROJECT EXPERIENCE – NUMERICAL MODELLING - CONSTRUCTION AND INFRASTRUCTURE

AECL Groundwater Capture Study - Spring B
Chalk River, ON, Canada

Completed groundwater flow modelling in support of conceptual designs of systems for treatment of water from Spring B at the Chalk River Laboratories facility. This involved a review of hydrogeological data, conceptual model development, and construction and calibration of a numerical groundwater flow model. Predictive simulations were completed using the groundwater flow model to evaluate the migration of solutes from Waste Management Area B to Spring B and potential for groundwater (plume) recovery using four alternative collection methods

CSST
Ottawa, ON, Canada

Developed three dimensional groundwater flow and solute transport model to using FEFLOW to estimate the drawdown and groundwater inflow to a proposed tunnel through downtown Ottawa. Modelling involved detailed incorporation of construction schedule into model boundary conditions.

NWMO Repository Design Development, Adaptive Phased Management Plan Engineering Support
Ontario, Canada

Developed a numerical model (using MODFLOW) to provide estimates of groundwater inflows to a proposed 500 m deep repository for used nuclear fuel situated in crystalline bedrock in Northern Ontario. The model incorporated the schedule for repository panel development. A total of twelve modelling scenarios were completed to provide a better understanding of the bounding conditions. An analytical solution was also used as an independent means of checking the results of the numerical model.

CNL Whiteshell Reactor 1 Decommissioning Assessment,
Pinawa, Manitoba

Completed hydrogeological components of the decommissioning safety assessment for CNL's Whiteshell Reactor #1 (WR-1). This involved review of a wide range of data (reactor design, building design, source chemistry, grout performance, hydrogeology, etc.). Following the data review groundwater flow and solute transport modelling was completed to simulate groundwater flow conditions under current and future (post-decommissioning) conditions. The fate and transport of metals and radionuclides following decommissioning of the reactor was estimated using a solute transport model. This work was subject to review by federal regulators.

CNL Near Surface Disposal Facility Assessment, Chalk River, Ontario

Completed hydrogeological characterization and groundwater flow modelling to support an assessment of the proposed near surface disposal facility (NSDF) at CNL's Chalk River Laboratories property. The model used in this assessment was calibrated to a large number of monitoring wells in addition to streamflows at the outlet of a wetland feature. Key to the evaluation was the completion of sensitivity analyses to establish the level of rigour in the design with respect to maintaining the base of the disposal facility above the anticipated long-term groundwater elevation. This work was subject to review by federal regulators.

Bruce Deep Geological Repository
Ontario, Canada

Developed three dimensional transient groundwater flow models using MODFLOW to estimate the groundwater seepage rates expected during construction of the Bruce Deep Geologic Repository. The models simulated the performance of grout to be applied during shaft construction, as well as the inflows to the repository at depth.

Vulcan Materials Hewitt Project
Los Angeles California

Completed analysis and interpretation of hydrogeological data, and groundwater flow modelling of a former waste disposal facility located in North Hollywood, California. Work was completed in support of litigation regarding contamination of public (LADWP) water supply wells.

Beckenridge Subdivision
Ontario, Canada

Developed three dimensional groundwater flow and solute transport model to using FEFLOW to estimate the potential for migration of contaminants from nearby contaminated lands following installation of residential pumping wells.

Dufferin Parking Garage,
Toronto, ON, Canada

Updated an existing MODFLOW groundwater flow model and used the model to predict groundwater inflows to the lower levels of a parking garage and to assess the degree of hydraulic connection between the actively pumped parking garage and a nearby groundwater interceptor trench. Modelling results were used to optimize the operating water level within the parking garage.

York Quay Rehabilitation Project
Toronto, ON, Canada

Constructed and used a MODFLOW groundwater flow model to simulate the groundwater inflows and extent of groundwater depressurization to a proposed excavation located at York Quay adjacent to Lake Ontario. The model tested various hydrogeological scenarios by comparing the results of several simulations where uncertain model input parameters (e.g. hydraulic conductivity, recharge) were varied.

Blue Mountains Landfill
Collingwood, Ontario, Canada

Evaluated the performance of various proposed landfill remediation options using MODFLOW coupled with the contaminant transport module MT3D. Multiple two-dimensional (cross-section) models were constructed to estimate the break-through of landfill impacted groundwater at environmental receptor locations. Advective and dispersive transport of multiple dissolved species was simulated using both a conservative (no decay) and reactive (first-order decay) approach.

PROJECT EXPERIENCE – WATER RESOURCES / HYDROGEOLOGY

Capital Region Resources Recovery Centre
Ottawa, Ontario Canada

Reviewed hydrogeological data in support of developing a site conceptual model, including groundwater flow directions, geological surfaces, and structural geology. This work was completed as a part of an environmental assessment for a proposed waste transfer facility, which involved a high degree of public engagement.

Capture Zone Delineation,
Nation Municipality, Ontario, Canada

Delineated groundwater capture zones for proposed groundwater supply wells in a major esker formation in eastern Ontario. This assessment was completed using numerical modelling techniques (with MODFLOW). Results of the assessment also were used in geotechnical analysis of the overlying clay formation.

Tier 3 Water Quantity Risk Assessment, City of Guelph
Guelph, Ontario, Canada

Compiled and analyzed groundwater well data used to develop a conceptual model of the regional aquifer/aquitard system. Project work will involve refinement of a FEFLOW groundwater model based on finalization of the conceptual model. Results of the FEFLOW model will be used to determine best management practices for the City of Guelph’s groundwater resources.

Source Water Protection Study, Village of Lanark
Lanark, Ontario, Canada

Completed the hydrogeological conceptualization of the Lanark Ontario area based on available groundwater well information and geotechnical reporting data. Built and calibrated a regional groundwater flow model and used the model to determine time-of-travel capture zones for proposed municipal supply wells.

Capture Zone Delineation, Lake Simcoe Region Conservation Authority
Simcoe County, Ontario, Canada

Constructed and updated numerous groundwater flow models based on various data sources for capture zone delineation of municipal and communal supply wells located in Simcoe County. Also responsible for evaluating the suitability of existing capture zones of other well systems located in Simcoe County based on regional groundwater equipotential maps. Well systems simulated using numerical models included: Horseshoe Valley, Warminster, Sugar Bush, Coldwater, Loretto, Tottenham, and Collingwood.

Capture Zone Delineation, Grand River Conservation Authority
Brant County and Grey County, Canada

Developed and/or updated groundwater flow models of various municipal water supply systems, including Dundalk (Grey County), Paris (Brant County), Mount Pleasant (Brant County), and Airport Road (Brant County). Used groundwater models to estimate the 2-year, 5-year, and 25-year time-of-travel capture zones for each municipal well under forecast pumping rates. Results of this work were used as a part of a vulnerability and threats assessment for municipal aquifers.

PROFESSIONAL AFFILIATIONS

Member of the Association of Professional Engineers of Ontario

Education

M.Sc. Civil Engineering: Hydrogeology
Queen's University
Kingston, Ontario, 2001

B.Sc. Environmental Science: Earth Sciences Stream, Honours
Brock University
St. Catharines, Ontario
1998

Certifications

Registered Professional Geoscientist Ontario

Golder Associates Ltd. – Ottawa

Senior Hydrogeologist

Jaime Oxtobee has over 18 years of broad experience in the field of physical hydrogeology that includes hydrogeological impact assessments in support of the licensing of pits and quarries under the *Aggregate Resources Act*, water supply development and regional scale groundwater studies.

Employment History

Golder Associates Ltd. – Ottawa
Associate and Senior Hydrogeologist (2001 to Present)

Jaime is responsible for project management, technical analysis and reporting for a variety of hydrogeological and environmental projects. Jaime is also often responsible for senior technical review of hydrogeological investigations.

Projects have included groundwater resources studies; hydrogeological investigation programs in support of licensing/permitting pits and quarries and in support of Permit to Take Water applications for local construction dewatering projects, ready-mix concrete plants, golf courses and quarries; communal water supply investigations; wellhead protection studies; contaminated site investigations; and, providing senior review for landfill, pit and quarry monitoring reports.

Queen's University – Kingston, Ontario
Teaching Assistant (2000 to 2001)

Teaching assistant for university courses relating to groundwater flow and contaminant transport in porous media and fractured rock environments.

Phase IV Bedrock Remediation Program – Smithville, Ontario
Project Manager (1999)

Coordinated and conducted a groundwater/surface water interaction study downgradient from the PCB-contaminated site in Smithville, Ontario. The study involved detailed numerical modelling, as well as an extensive field program including stream surveys, stream gauging, construction and installation of mini-piezometers, seepage meters and weirs, fracture mapping, groundwater and surface water sampling.

SELECTED PROJECT EXPERIENCE – AGGREGATE INDUSTRY

Hydrogeological and Hydrological Assessments for Quarry Licensing
Township of Drummond-North Elmsley, Ontario, Canada

Golder carried out the necessary hydrogeological, hydrological ecological and archaeological studies to support an application under the *Aggregate Resource Act* for licensing the extension of an existing quarry. The application was for two new below water quarries on either side of an existing below water quarry. Jaime led the hydrogeological and hydrological assessment component of the project, and was responsible for coordinating the multi-disciplinary team. Jaime was responsible for the development and execution of the hydrogeology field program, development of the site conceptual model and completion of the hydrogeological impact assessment/reporting. Jamie also provided input to the integration of the findings from the multiple disciplines.

Hydrogeological Assessments for Pit Licensing
Township of Lanark, Ontario, Canada

Golder carried out the necessary hydrogeological, ecological and archaeological studies to support an application under the *Aggregate Resource Act* for licensing a new pit above the water table. Jaime led the hydrogeological assessment component of the project and was responsible for coordinating the multi-disciplinary team. Jaime was responsible for the development and execution of the hydrogeology field program and preparing the required reporting.

Hydrogeological and Hydrological Assessments for Quarry Licensing
Ramara, Ontario, Canada

Golder carried out the necessary hydrogeological, hydrological and archaeological studies to support an application under the *Aggregate Resource Act* for licensing the extension of an existing quarry. The application was for one new below water quarry adjacent to an existing below water quarry. Jaime led the hydrogeological and hydrological assessment component of the project. Jaime was responsible for development and execution of the hydrogeology field program, development of the site conceptual model and completion of the hydrogeological impact assessment/reporting.

Hydrogeological Assessments for Pit Licensing
Township of Leeds and Thousand Islands, Ontario, Canada

Golder carried out the necessary hydrogeological studies to support an application under the *Aggregate Resource Act* for licensing a new pit below the water table. Jaime led the hydrogeological assessment component of the project. Jaime was responsible for the development and execution of the hydrogeology field program and completing the hydrogeological impact assessment/reporting.

Hydrogeological Assessment for Quarry Permitting
Township of Bomby

Golder carried out the necessary hydrogeological, ecological and archaeological studies to support an application under the *Aggregate Resource Act* for permitting a new quarry. The application was for a below water quarry located on Crown Land. Jaime led the hydrogeological assessment component of the project and was responsible for coordinating the multi-disciplinary team. Jaime was responsible for the development and execution of the hydrogeology field program, development of the site conceptual model and completion of the hydrogeological impact assessment/reporting. Jamie also provided input to the integration of the findings from the multiple disciplines.

Hydrogeological Assessment for Pit Permitting
District of Kenora, Ontario, Canada

Golder carried out the necessary hydrogeological, ecological and archaeological studies to support an application under the *Aggregate Resource Act* for permitting a new pit. The application was for a below water pit located on Crown Land. Jaime provided input to the hydrogeological assessment component of the project and was responsible for coordinating the multi-disciplinary team. Jaime was responsible for the development of the site conceptual model in the vicinity of the pit and completion of the hydrogeological impact assessment/reporting. Jamie also provided input to the integration of the findings from the multiple disciplines.

Hydrogeological Assessment for Quarry Permitting
District of Kenora, Ontario, Canada

Golder carried out the necessary hydrogeological, ecological and archaeological studies to support an application under the *Aggregate Resource Act* for permitting a new quarry. The application was for a below water quarry located on Crown Land. Jaime provided input to the hydrogeological assessment component of the project and was responsible for coordinating the multi-disciplinary team. Jaime was responsible for the development of the site conceptual model in the vicinity of the quarry and completion of the hydrogeological impact assessment/reporting. Jamie also provided input to the integration of the findings from the multiple disciplines.

Hydrogeological and Hydrological Assessment for Quarry Licensing
City of Kawartha Lakes, Ontario, Canada

Golder carried out the necessary hydrogeological, hydrological and ecological studies to support an application under the *Aggregate Resource Act* for licensing a new quarry. The application was for a below water quarry located adjacent to a provincially significant wetland. Jaime provided input to the hydrogeological assessment component of the project, which included the installation of over 80 monitoring intervals and the completing of three pumping tests. Jaime was involved in data analysis and the completion of the impact assessment and reporting for the hydrogeology assessment.

TRAINING

Beyond Data: Conceptual Site Models in Environmental Site Assessments
Golder U, 2011

Health and Safety Modules 1, 2, 3 and 4
Golder U, various years

Critical Thinking in Aquifer Test Interpretation
Golder U, 2011

HydroBench (Proprietary Aquifer Test Interpretation Software)
Golder U, 2011

Project Management
Golder U, 2007

Short course: Environmental Isotopes in Groundwater Resource and Contaminant Hydrogeology
2007

Short course: Hydrogeology of Fractured Rock – Characterization, Monitoring, Assessment and Remediation
2002

OSHA 40 Hour Hazardous Waste Site Worker Training
2002

PROFESSIONAL AFFILIATIONS

Member, Association of Professional Geoscientist of Ontario

Member, Ottawa Geotechnical Group

PUBLICATIONS

Conference Proceedings

West, A.L., K.A. Marentette and J.P.A. Oxtobee. 2009. *Quantifying Cumulative Effects of Multiple Rock Quarries on Aquifers*. 2009 Joint Assembly, May. Toronto, Canada.

Novakowski, K.S., P.A. Lapcivic, J.P.A. Oxtobee and L. Zanini. 2000. *Groundwater Flow in the Lockport Formation Underlying the Smithville Ontario Area*. 1st IAH-CNC and CGS Groundwater Specialty Conference, October. Montreal, Canada.

Oxtobee, J.P.A. and K.S. Novakowski. 2001. *A Study of groundwater/Surface Water Interaction in a Fractured Bedrock Environment*. Fractured Rock 2001 Conference, March. Toronto, Canada.

Journal Articles

Oxtobee, J.P.A. and K.S. Novakowski. Groundwater/Surface Water Interaction in a Fractured Rock Aquifer. *Journal of Ground Water*, 41(5) (2003), 667-681.

Oxtobee, J.P.A. and K.S. Novakowski. A Field Investigation of Groundwater/Surface Water Interaction in a Fractured Bedrock Environment. *Journal of Hydrology*, 269 (2002), 169-193.

Other

Oxtobee, J.P.A., 1998. Environmental Assessment of Grapeview, Francis and Richardson's Creeks, St. Catharines, Ontario. B.Sc. Thesis, Brock University, Earth Sciences Department pp.119.

Education

M.Sc. (Eng.) Water Resource Engineering, University of Guelph, Guelph, 1995

B.Sc. (Eng.) Water Resource Engineering, Minor: Environmental Engineering, University of Guelph, Guelph, 1993

Languages

English – Fluent

Golder Associates Ltd. – Cambridge

Employment History

Golder Associates Ltd. – Cambridge, Ontario
Water Resources Engineer, Principal (1997 to Present)

Responsible for management of water resources assessments including hydrology, hydraulics, upland and in stream erosion, water quality and water management for a wide variety of government, power generation, industrial, mining and aggregate producing clients. Being part of a comprehensive client service team for aggregate producers in Ontario has facilitated an excellent understanding of the aggregate business and how water management affects their operations. Water resources assessments have been completed in support of Environmental Assessments (EA) and Permitting and Approvals under Federal, provincial and international regulations. Peer reviewer for two Ontario Source Water Protection projects and water resources sections of a new international airport in Quito, Ecuador. Responsible for managing and implementing field data collection studies, including stream flow monitoring, meteorology and water quality. Other abilities include assessments of upland soil erosion, natural channel design and fluvial geomorphology.

University of Guelph – Guelph, Ontario
Hydrologist (1996 to 1996)

Responsible for collection and analysis of four large databases of rural hydrology parameters in Southern Ontario. Frequency distributions were found for event, daily and yearly runoff coefficients and detailed daily water budgets were synthesised for the duration of each record. Estimated evapo-transpiration in the absence of meteorological data required for the Penman equation.

University of Guelph – Guelph, Ontario
Research Assistant (1994 to 1996)

Responsible for designing and performing experiments concerning soil erosion by rainfall. Erosion rates from single drop impacts and 1.0 m^2 erosion plots were quantified and related to rainfall intensity and energy flux rate. A model of the inter-rill detachment process was developed for use in future large-scale erosion models.

University of Guelph – Guelph, Ontario
Teaching Assistant (1994 to 1996)

Taught weekly seminars on engineering mechanics (statics and dynamics) and on engineering design and report writing. Emphasis was placed on three-dimensional vector analysis and excellence in communicating technical information through text and verbal presentations.

PROJECT EXPERIENCE – HYDROLOGY/HYDRAULICS

Garson Mine Water Management and Inundation Study
Sudbury, Ontario

Senior review and technical advice for flood inundation study downstream of the Vale Garson Mine near Sudbury Ontario. The study included an options assessment, development of improved water management operating practices and conceptual design of reservoir retrofits.

International Falls Dam Rule Curve Cultural Study
Rainy River, Ontario

The effects of a recently updated operating rule curve at the International Falls Dam on water levels in Rainy River and the potential for changed water levels to affect locations of cultural significance are being investigated on behalf of the International Joint Commission on the Great Lakes.

Credit River Floodline Mapping
Mississauga, Ontario

Golder completed the most recent comprehensive update of the flood risk investigation and floodline mapping for the Credit River between Old Derry Road and Lake Ontario. This reach alternately flows through an entrenched bedrock valley and remnant beach plains adjacent to Lake Ontario in the most urbanised part of Mississauga. Mr. MacKenzie served as project staff on this project.

Water Quality Forecasting and Infrastructure
Annapolis Basin, Nova Scotia

Golder was part of a project team working with the Atlantic Innovation Fund / Applied Geomatics Research Group to develop a complex water quality forecasting tool for use by the shell fishing industry in the Digby Gut area. Real time weather forecasts were used to drive real time hydrology and database scenario models of runoff, water quality (bacteriological) and Bay of Fundy tidal fluctuations and their effects on contaminant movement in the Digby Gut. Hydrodynamic modelling was used to estimate contaminant movement and exposure of shell fishing areas to contamination. This information was packaged for use by shell fishers in order to minimize harvests of contaminated shellfish, thereby protecting the resource and minimizing post-harvest dupurification costs. Mr. MacKenzie was the hydrology and hydrometry technical lead for Golder on this project.

Brookfield Homes – Channel Rehabilitation
Brantford, Ontario

Assisted a channel rehabilitation/stabilization assessment and associated 'field fit' design for Brookfield at a tributary of Fairchild Creek to address debris removal and channel instability - responsible for field investigations and construction supervision/inspections.

River Diversion Design
Northern Ontario

Technical advisor for baseline channel hydraulics and fluvial geomorphic studies in support of a major mine development project in Northern Ontario to characterize baseline conditions at several stream channels, as well as to advance a conceptual design for a proposed diversion channel.

Borer's Creek Modelling and Restoration Design
Dundas, Ontario

HEC-RAS modelling and assessment of a failing reach of Borer's Creek that threatened to expose a high-pressure natural gas pipeline. Design of remedial measures for failing banks and restoration of the affected reach. Coordinated regulatory approvals. The project was successfully implemented before the spring freshet and significantly reduced the risk of damage to the pipeline.

Voisey's Bay Nickel Mine
Voisey's Bay, Labrador

A theoretical tailings dam breach was investigated using DAMBREAK to quantify potential impacts on an environmentally sensitive creek. Flood passage downstream of the breach was complicated by several small ponds and alternating sub and supercritical river reaches. Proposed mining operations at the Voisey's Bay nickel deposit require extensive management of surface waters. Five small dams were considered to safely convey clean water around the proposed tailings facility and to contain and treat tailings water. Modelling and design of the reservoirs and outflow structures was completed using GAWSER.

Plains Midstream – Dechlorination and Approval
Sarnia, Ontario

Technical advisor for the design and permitting of a dechlorination system for the Plains Midstream fractionation plant in Sarnia, Ontario. The system is being designed to reduce the free chlorine concentration in the wastewater discharge. Golder is also preparing the ECA (Industrial Sewage Works) amendment package for the facility, to include additional Limited Operational Flexibility (LOF) for the facility for the additional of the dechlorination system, and future sewage work modifications. LOF for the facility will grant future modifications to the works through the appropriate MOE reporting progress, if a professional engineer can demonstrate the modifications will not alter the process discharge quantity and quality limits established for the facility.

Channel Restoration Design
Algonquin Park, Ontario

Technical advisor for the hydraulic design of a stream re-alignment with associated grade controls at an historic train derailment site. Contaminated materials will be removed from the stream bed and banks and adjacent railway embankment. Removal of the contaminated materials will result in a net loss of stream substrate and a change to the fluvial geomorphology of the reach. Grade and stream bank controls were designed to minimize the risks of mobilizing residual contaminants and of significant channel migration.

Omya – Stormwater Management Design and Approvals
Perth, Ontario

A review of existing stormwater management infrastructure was completed for an industrial mineral processing site near Perth Ontario. As a result of incremental development of the site, parts of the stormwater management infrastructure were found to be inadequate. Additional stormwater management works were conceptualized and submitted to MOE for approval. Following approval, Golder provided liaison with the local Conservation Authority, completed basic design drawings suitable for design-build and applied for permitting under the Conservation Authorities Act.

OSSGA Carden Plain Cumulative Impact Assessment
Carden, Ontario

Due to the increased level of aggregate extraction activity in the Carden Plain area, the Ontario Ministry of the Environment (MOE) requested a multidisciplinary study and impact assessment to evaluate the potential cumulative impacts of quarry dewatering at multiple sites on groundwater, surface water and ecological receptors. Golder was retained by the Ontario Stone, Sand & Gravel Association to complete the required study. The project included extensive interaction with the MOE and the Ministry of Natural Resources (MNR). The objectives of the study were to screen out areas where cumulative impacts are unlikely, identify areas where cumulative impacts are likely, and to provide a preliminary assessment of the potential magnitude of predicted cumulative impacts. For the purpose of this study, a cumulative impact was defined as the additive effect of multiple quarry dewatering operations on groundwater, surface water and/or natural environment features. Golder was responsible for all aspects of this project including the development of the final field programs in consultation with personnel from the MOE. Mr. MacKenzie was the surface water lead for the project and participated in the public consultation aspects of the project.

Technical Reviewer Contaminated Site Channel Design Mississauga, Ontario

Golder was retained to review an options analysis and remedial channel design for a PCB contaminated channel in Mississauga. The remedial design included removal of the most contaminated material and design of a hardened channel lining to secure residual contaminants in-situ. Mr. MacKenzie reviewed the hydraulic channel analysis and design and provided a technical review report for consideration by the municipality and the channel designer.

Contaminated Site Channel Stability Analysis
Welland, Ontario

Golder recently completed Phase IV of an assessment of 12 sites in the Niagara River Area of Concern that were identified in the RAP Stage 1 Update as requiring further assessment. The Phase IV study is a detailed assessment of remedial alternatives for the site including passive and intervention options.
In support of the passive treatment options, Golder completed a detailed investigation of the complicated stream and wetland hydraulics of one of the sites on Lyon’s Creek. In the intervening years since the historic contamination, the site had developed into a wetland, which provided habitat for threatened plant and animal species. The hydraulic conditions were evaluated using one- and two-dimensional hydraulic models (HEC-RAS and RIVER-2D) to identify areas that are at risk for re-suspension of contaminated sediments and areas that are likely to accumulate new un-contaminated sediment with time. The results supported the passive treatment alternative. Mr. MacKenzie led the hydraulic investigation component of the Lyon’s Creek study.

Confidential Mine Site Closure
Eastern Ontario

Technical advisor for comprehensive surface water investigations in support of a risk assessment at two former uranium mines near Bancroft, Ontario. The studies included meteorology and flow monitoring, water column profiling with a particular focus on lake stratification and turnover, and water quality sampling.

Confidential Mine Site Closure
Northern Ontario

Technical advisor for surface water investigations, including streamflow studies, lake column profiling and water quality sampling, at a former nickel mine near Kenora, Ontario.

OPG Atikokan – Environmental Compliance Approval Northern Ontario

Technical advisor for the Environmental Compliance Approval ('ECA') Sewage (including Stormwater) amendment application for the Atikokan GS Biomass Conversion project. The study included a review of existing sewage works and associated ECA and MISA conditions. Implications from the proposed site changes to the sewage works, consisting of process streams (Furnace Ash Treatment Plant, Condenser Cooling Water), sanitary sewage system/lagoons and the coal pile runoff pond, along with their associated ECA conditions.

Confidential Manufacturing Client
Norval, Ontario

Baseline characterisation and impact assessment modelling of a proposed shale quarry in order to quantify and where necessary mitigate potential flow, water quality and thermal effects of the quarry on nearby watercourse and wetlands. Included conceptual design of mitigation measures and preparation of application materials for re-zoning and license under the Ontario Aggregate Resources Act.

Big Bay Point Water Balance
Barrie, Ontario

Monthly and annual water budgets were prepared using the Thornthwaite Water Budget method. This water budget assessment was performed to determine the rate of marina water pumping required from the proposed development area at Big Bay Point, to the golf course and Environmental Protection Area in support of detailed design of stormwater management facilities to meet post-development peak flow targets. Mr. MacKenzie provided technical advice and senior review for this project.

Baseline Hydrology Study for Proposed Mine
Ring of Fire, Northern Ontario

Technical advisor for baseline hydrology studies and effects evaluations in support of a major mine development project in Northern Ontario. Assessments were prepared as part of a multi-disciplinary Environmental Impact Statement (EIS) and Environmental Assessment (EA) under the Canadian Environmental Assessment Act (CEAA).

Quarry License Expansion Flamborough, Ontario

A level II hydrogeology study was completed in support of a rock quarry license expansion application. The surface water component of the study included establishment of eight continuous stream flow gauges and associated baseflow separation analysis. The baseflow separations were used to estimate mean annual recharge to groundwater. This information was provided to Golder hydrogeologists for use in estimating boundary conditions for the FEFLOW groundwater model. In addition, monthly and annual surface water balances were modelled using the Thornthwaite Water Budget method coupled to a GIS procedure. The fraction of surplus water that infiltrates was estimated using GIS and the method outlined in MOE 2003. The infiltration estimates were initially assumed to equal recharge. The resulting modelled groundwater levels were reviewed to identify areas of upward gradient or minimal downward gradient. This information was used in subsequent iterations to adjust the recharge estimates.

Quarry License Expansion
Northern Ontario

A level II hydrogeology study is underway in support of a rock quarry license expansion application. Surface water features in the area are characterized by shallow intermittent streams flowing on top of bedrock above a small escarpment running through the site. Below the escarpment, there is a line of small watercourses connecting a series of small lakes. The surface water study includes monitoring of several of the small intermittent watercourses and the outlet of two of the small lakes. Surface hydrological. The results of this analysis will form input to the groundwater modelling discipline. Recharge will initially be assumed to equal infiltration in the groundwater model; however, we expect this will cause mounding in parts of the model. Further iterations will be used to calibrate the recharge estimates subject to a mass balance at the surface.

Aggregate Site Water Use Study
Southern Ontario

Participated in a “typical water use” study for the aggregate industry. The study was initiated by the Aggregate Producers Association of Ontario (now the Ontario Stone Sand and Gravel Association) in preparation for planned changes, by the MOE, to the Permit to Take Water application process. Changes to the process were anticipated to include charges for water taking or use. The MOE was simultaneously working on new Source Water Protection legislation. As a result, the APAO felt it would be prudent to quantify actual water use versus maximum permitted water taking rate and to illustrate typical water use at aggregate sites.

Aggregate Site Permitting and Approvals
Southern Ontario

Application packages including MOE application forms and supporting studies and reports have been prepared for numerous aggregate sites across Southern Ontario. Applications have been completed for Permits to Take Water (PTTW) to allow quarry dewatering and for Environmental Compliance Approvals (ECA) under Section 53 of the Ontario Water Resources Act to allow offsite discharge of quarry and storm water.

Simcoe County Groundwater Studies
Simcoe County, Ontario

A base flow survey was conducted to quantify groundwater discharge in a series of watershed in Simcoe County. The project was conducted in two phases, one for North Simcoe and one for South Simcoe. Water budget and average annual infiltration calculations were completed in support of groundwater modelling. Surface-groundwater interactions were estimated throughout the region to provide a water balance.

Hydrology Studies for Quarry Developments
Ottawa Region, Ontario

A series of water resources investigations were completed for aggregate producing clients in the Ottawa area. The studies were completed in support of Certificate of Approval applications made under Section 53 of the Water Resources Act. Each study included a water balance analysis for the quarry and an estimate of future quarry discharge rates. These data were used to estimate the effects of quarry development on downstream water resources.

Water Supply Studies
Sudbury, Ontario

Two municipal water supplies were investigated as Groundwater Under Direct Influence of surface water (GUDI). Surficial water resources were investigated, and a water balance was prepared in support of groundwater modelling studies.

Pipeline Corridor Investigations
Timmins, Ontario

A pipeline was proposed to slurry tailing from the Kidd Metallurgical Site to the Kidd Mine, approximately 35 km away. The tailings are to be used for paste back-filling of depleted areas of the underground mine. An environmental review of water resources along the proposed pipeline corridor was completed. Larger watercourse crossings were mapped, and directional drilling was proposed to mitigate environmental effects.

Hydrological Effects Assessment Hagersville, Ontario	A long-term field monitoring programme was designed and implemented to track changes in flow regime resulting from closure of an underground Gypsum mine. Part of the mine was closed and allowed to flood. Three flow monitoring stations were established in Boston Creek, which flows over the mine. The stations were selected to represent background conditions upstream of the mines influence, conditions above the mine and downstream of the mine influence. Data loggers and transducers were installed to continuously (hourly) record water levels and flows in the creek.
GORO Nickel Mine New Caledonia	The GORO Nickel mine is located in an area of extreme precipitation. Hydrological and preliminary erosion assessments were completed in support of mine development planning and design. These data were used, by the multi-disciplinary project team, to design tailing basin capacities, diversion ditches and dams.
Round Lake Water Level Control Study Engelhart, Ontario	Flow exiting Round Lake flows down several kilometres of a very mild sloped reach of the Blanche River before cascading down a set of rapids at a rock outcrop. The rock outcrop was historically blasted to facilitate log driving practices. This modification has caused large fluctuations in water levels in Round Lake and the Blanche River. A hydrological and hydraulic study of the river and lake were completed and a fish-friendly rock-fill weir was designed to stabilise water levels.
Bruce Nuclear Generating Station Bruce County, Ontario	Participated in background water quality assessments in the surrounding environment. This work included water quality sampling in Baie du D'Or and Lake Huron. The data were used to assess potential effects of the generating station on the quality of surrounding water resources.
Pickering-A Nuclear Generating Station Pickering, Ontario	A multi-disciplinary environmental assessment was completed for the re-start of four CANDU reactors at the Pickering A generating station. A comprehensive review of existing water quantity and quality data was completed. Potential effects, of operating the station, on surrounding water resources were identified and evaluated.
Falconbridge Smelter Area Closure Falconbridge, Ontario	Performing a detailed analysis of water quantity and quality to address potential long-term impacts of the closure on the watersheds of Coniston and Emery Creeks. A daily water budget and reservoir routing model was implemented on a spreadsheet to investigate the efficiency of a variety of different closure scenarios. Also involved in hydrometry, automated water level monitoring, water quality sampling, hydrologic modelling.
Fire Water Intake Blind River, Ontario	Alternative designs for a fire water intake structure modification were assessed to minimise maintenance and sediment deposition and increase safety. Two-dimensional finite element flow modelling of the intake environment and one dimensional, coupled, unsteady, sediment and hydraulic modelling of the river reach was completed. Modelling results indicated that relocating the intake structure would reduce the risk of failure resulting from sediment accumulation.
Brimley Road Slope Failure Toronto, Ontario	Detailed statistical analysis of the rainfall amounts in the 30 days prior to a major slope failure. Historical records of rainfall and snowmelt were analysed and compared to the precipitation in the days preceding the failure.

Asacha Gold Mine
Russia

The Asacha gold mine lies close to the divide between a pristine watershed and a partially developed watershed. Hydrologically modelled areas potentially affected by mining operations to aid in developing a safe and detailed water management plan.

PROJECT EXPERIENCE – CLIMATE CHANGE

Goldcorp Sudbury Integrated Nickel Operations – East End Water Management
Sudbury, Ontario

Senior review and technical advisor for an assessment of potential climate change effects and vulnerabilities on a multi-site water management system including eight reservoirs, flooded underground mine works, an active smelter complex, a water treatment plant and associated dams and infrastructure. A Goldsim model of the water management system was constructed and validated. Ensemble Global Circulation Model (GCM) results, from approximately ninety model runs, were obtained for the 2050 horizon. Monte Carlo simulations were used to simulate daily weather patterns constrained by the GCM results and the same daily weather patterns were used to model a potential future range of water management scenarios using the Goldsim water management model.

Goldcorp Sudbury Integrated Nickel Operations – East End Infrastructure Assessment
Sudbury, Ontario

Evaluated climate change risks to several small flow conveyance structures including culverts, pipes and flow measurement structures. Peak flows from small sub-catchments are typically sensitive to short duration intense precipitation events. A trend analysis and curve fitting exercise was completed on observed maximum annual events, over recent site history, for a range of event durations ranging up to 24 hours. The trend analysis was used to estimate potential changes to Intensity-Duration-Frequency statistics at the 2050 horizon. This information was used to assess the capacity of existing flow conveyance infrastructure in small sub-catchments.

Meteorological Service of Canada – Environment Canada
Ottawa and across Canada

Participated on a national research team studying the effects of climate change on hydrological variables. Contribution to the study was to complete a regionalization study based on measured hydrologic variables from the Reference Hydrometric Basin Network (RHBN) including mean annual flow, lowest annual daily flow and peak annual daily flow. The data series were grouped according to their similarity using a cluster analysis routine. The homogeneous hydrologic regions identified by this method were compared to hydrologic regions identified in previous studies using meteorological and physiographic variables. Cluster analysis results consistently identified three homogeneous regions in the British Columbia mountains as well as several regions in Ontario, the Maritimes and along the St. Lawrence. The study demonstrated a significant lack of RHBN coverage in the northern part of the Prairie Provinces and the North West Territories, such that homogenous regions, if they exist in these areas, could not be identified by cluster analysis.

Infrastructure Ontario (Ontario Realty Corp.) – Infrastructure Climate Risk Assessment
Ontario

Completed the water resources and drainage components of a climate risk assessment on three typical buildings owned by Infrastructure Ontario. Risk was assessed using guidance provided in Engineers Canada’s PIEVC protocol. Co-led focus group workshops with building operators and subject matter experts to assess potential future risk.

Iqaluit Water Supply
Nunavut

Senior technical reviewer for a climate risk investigation of the Town of Iqaluit's water supply. A Goldsim model was developed for the lake-based water supply. Various scenarios were investigated to assess the vulnerability of the supply to climate change.

BHP Billiton
Elliot Lake, Ontario

Technical advisor for applying climate change projections to extreme precipitation events used to assess potential climate change implications for tailings storage facilities and water management ponds. This work was completed as a part of the Dam Safety Surveillance and Management program at BHP Billiton's closed Canadian and U.S. sites.

PROJECT EXPERIENCE – SOURCE WATER PROTECTION

Source Water Protection: Midland and Penetanguishene Tier 3
Midland, Ontario

Surface water lead for the Midland and Penetanguishene Tier 3 water budget and water quantity risk level assessment. This study involved implementation of a combined surface and groundwater model using MIKE-SHE. The modelled recharge distribution was applied to a groundwater model developed by Golder using FEFLOW in order to further refine drawdown effects in close proximity to wells and surface water features. The study area included the whole of the Midland Peninsula and areas of provincially significant wetlands in close proximity to municipal wells with GUDI designation. Groundwater and surface water interactions, both recharge and discharge areas were significant in spatial scale and an important part of this project.

Source Water Protection: Peer Reviewer York Region Tier 3
York Region, Ontario

Peer reviewer for the surface water components of the ongoing York Region Tier 3 water budget and water quantity risk level assessment for the area between and surrounding Aurora and Stouffville. The project team is proposing to use GSFLOW to model both the surface and groundwater systems. GSFLOW is an integrated surface and groundwater hydrology model developed by the US Geological Survey, based on MODFLOW and PRMS components. The study area is complex as it includes the southern flank of the Oak Ridges Moraine and straddles the divide between Lake Ontario and Lake Simcoe. Stouffville is in the headwaters of the Rouge River watershed.

Source Water Protection: Peer Reviewer Halton Hills Tier 3
Halton, Ontario

Peer reviewer for the surface water components of the ongoing Halton Region Tier 3 water budget and water quantity risk level assessment for the Georgetown and Acton areas. The project team used MIKE-SHE to model surface and groundwater hydrology and applied the modelled recharge distribution to FEFLOW to provide further discretization around key areas of interest including wells and surface water features. The study area is complex as it includes the Niagara Escarpment, the Acton re-entrant valley and several buried bedrock valleys which are believed to play and important role in delivering groundwater to the area. The study area also straddles the divide between the Grand River and Credit River watersheds.

Source Water Protection: Peer Reviewer Orangeville Tier 3
Orangeville, Ontario

Peer reviewer for the surface water components of the ongoing Orangeville, Mono and Amaranth Pilot Tier 3 water budget and water quantity risk level assessment. The project team is using HSPF and MODFLOW to model surface and groundwater hydrology respectively. The study area is complex as it includes the Niagara Escarpment and the Oak Ridges Moraine. The study area also straddles the divides between the Grand River, Credit River and Nottawasaga River watersheds.

Source Water Protection: Peer Reviewer CTC Tier 1 and Tier 2
Southern Ontario

Peer reviewer for the surface water components of the Tier 1 and Tier 2 water quantity stress assessments for the CTC Source Protection Region, which includes the Credit River (CVC), Toronto Region (TRCA) and Central Lake Ontario (CLOCA) watersheds. Data availability and modelling approaches used by the different conservation authorities and their consultants varied across the CTC region.

Source Water Protection: Lower Speed River (Guelph) Tier 3
Guelph, Ontario

Golder Associates teamed with AquaResource to complete a Tier 3 water budget and water quantity risk level assessment for the Lower Speed River watershed. The study area includes the City of Guelph, part of Cambridge and contributing drainage and recharge areas located north and east of Guelph. An extensive baseflow survey was conducted across the study. Baseflow was measured at thirty-two locations during the spring, summer and autumn of 2008. This information was used to estimate varying groundwater discharge and recharge rates to support definition of boundary conditions for the groundwater model.

Source Water Protection: Nickel District CA Valley East Tier 3
Sudbury, Ontario

Senior technical advisor for the Valley East Tier 2 and Tier 3 water quantity stress assessment. The City of Sudbury draws drinking water from several wells located in the Valley East area. Worked with project team to identify a modelling approach that would make the best use of, sometimes limited, existing data. The Tier 2 results led to the initiation of the Tier 3 Local Area Water Budget for the groundwater supply in Valley East.

Source Water Protection: Ramsay Lake Tier 1 and Tier 2
Sudbury, Ontario

Senior technical advisor for the Ramsay Lake Tier 3 water budget and water quantity risk level assessment. The City of Sudbury draws water directly from Ramsay Lake for part of its drinking water supply. Ramsay Lake and its contributing drainage areas are being modelled using HEC-HMS (Hydraulic Engineering Corps – Hydrological Modelling System). Based on existing information, it appears that the hydrology of Ramsay Lake is dominated by surface water inputs and as such, there is no plan to include groundwater modelling at this time. HEC-HMS will be used to complete the risk level assessments. Additional field data collection has been initiated to fill existing data gaps regarding key inflows to the lake and the outflow adjacent to Science North.

Source Water Protection: Bronte Creek
Halton, Ontario

Golder Associates were commissioned to undertake a Threats Assessment of a potential intake at Bronte Creek. Mr. MacKenzie directed the project for Golder. The intake, intended to deliver surface water to a small water treatment plant, was identified as one potential alternative for providing a drinking water supply to nearby residential properties possibly affected through the construction of an adjacent quarry. The Threats Assessment identified eleven water quality issues at the potential intake location, attributing causes to a number of likely contaminant sources throughout the watershed. In accordance with MOE Draft Guidance Modules, the work undertaken as part of this assessment included stakeholder liaison, hydraulic modelling, IPZ delineation, vulnerability analysis, the compilation of issues and threats inventories and a description of data knowledge gaps. Should surface water abstraction from Bronte Creek be identified as the preferred alternative for providing long-term drinking water supply, this Threats Assessment report will provide the basis for the Tier 2 assessment.

Source Water Protection: Timmins IPZ Study
Timmins, Ontario

An Intake Protection Zone (IPZ) and the vulnerability scores for the City of Timmins drinking water treatment plant on the Mattagami River were assessed. The delineation of the IPZ included the consideration of river flow conditions, influences of dam operation, location of significant potential upstream sources of contamination, local transportation routes, storm sewer drainage patterns and the behaviour of spills in the river. The project also included the collection of site-specific data through a field program. The field program used non-conventional methods to measure travel time due to restrictions on the use of dye tracers in the river because of the presence of private drinking water intakes. The field program collected detailed velocity data that was used to estimate dispersion and to calibrate a HEC-RAS model that was used to predict the travel time under various flow conditions.

PROJECT EXPERIENCE – WASTE MANAGEMENT

Barrie Landfill Reclamation
Barrie, Ontario

Technical advisor for stormwater management modelling and conceptual stormwater infrastructure design. The project included a significant removal and replacement of historic municipal waste. Daily and permanent cover design required new stormwater management strategies and facility design. Interacted with groundwater modellers to develop representative and conservative boundary conditions for modelling.

Nexcycle
Southern Ontario

Technical advisor in support of the ECA (Sewage) application package for a glass recycling facility. The project included conceptual design of Best Management Practices and source controls to improve stormwater quality.

Eagleson Landfill Brookside Creek Channel Design
Northumberland, Ontario

Ongoing support regarding a channel remediation design/assessment for the County of Northumberland on a reach of Brookside Creek located downstream of the closed Eagleson Landfill to reroute unaffected surface water flows away from a zone of leachate influenced groundwater.

Edgewood Landfill Monitoring
Flamborough, Ontario

Designed and implemented a flow and water quality monitoring programme to assess potential historic effects of watercourses surrounding the closed Edgewood Landfill site in Flamborough Ontario. This work was completed as part of an inventory and assessment of historic landfill operations in the City of Hamilton.

Bath CKD Landfill Design and Monitoring
Kingston, Ontario

Monitored existing water quality and flows associated with an existing Cement Kiln Dust landfill. Designed stormwater control measures for design of a new landfill cover for the existing landfill as well as four new cells to increase the capacity of the landfill.

Brow Landfill Storm-water Management Plan
Flamborough, Ontario

Developed a storm-water management plan to address drainage requirements for the site and mitigation measures required to control potential impacts as part of the closure process. Designed drainage channels, a stormwater management pond, hydraulic flow control structures and a drop structure to safely convey stormwater over the edge of the Niagara Escarpment into a purpose designed plunge pool.

Adams Mine Landfill
Kirkland Lake, Ontario

Completed a baseline hydrology assessment including flow and water quality monitoring as part of an investigation into the feasibility of a proposed land-filling operation at Adams Mine. Monitoring included flow measurements from boats in medium to large rivers.

PROFESSIONAL AFFILIATIONS

Professional Engineers Ontario

Engineers Nova Scotia

PUBLICATIONS AND PRESENTATIONS

Other

Rose, G. T and **MacKenzie, K. M**. (2013). Water Quality Forecasting and Infrastructure Optimization System. Meeting #68 of the Atlantic Coastal Zone Information Steering Committee (ACZISC). Bedford Institute of Oceanography, Halifax, Nova Scotia, January 16-17, 2013.

S. I. Ahmed, **K. MacKenzie**, B. Gharabaghi, R.P. Rudra, W.T. Dickinson. (2011). Within-storm rainfall distribution effect on soil erosion rate. ISELE Paper Number 11000. International Symposium on Erosion and Landscape Evolution. Anchorage, Alaska September 18-21, 2011.

Bell, J., **K. MacKenzie** and J. Southwood. (2011). Down Under Up North - Could an Australian water- sensitive urban design project work in the Canadian context? Water Canada July/August 2011.

DeVito, C. and **MacKenzie K**. (2011). Critical Shear Velocity Estimates Improved with In-Situ Flume. 20th Canadian Hydrotechnical Conference, Ottawa Ontario June 14th to 17th 2011.

Davidson C. and **MacKenzie K**. (2011). Golder Daily Climate Record Generator. 20th Canadian Hydrotechnical Conference, Ottawa Ontario June 14th to 17th 2011.

MacKenzie, Kevin. (2009). Industrial Wastewater Approvals. Canadian Environmental Compliance Conference and Trade Show (CANECT). Metro Toronto Convention Centre, April 2009.

MacKenzie, Kevin. (2007). Industrial Wastewater Approvals. Canadian Environmental Compliance Conference and Trade Show (CANECT). Metro Toronto Convention Centre, April 2007.

Mackenzie, K.M., R.P. Rudra and W.T. Dickinson. (1996). Modelling the inter-rill detachment process: Some considerations for improving model results. ASAE Paper No. NABEC96-94, Amer. Soc. Agr. Engr., St. Joseph, MI.

MacKenzie, K.M., R.P. Rudra and W.T. Dickinson. (1995). The effect of temporal distribution of rainfall on inter-rill detachment. ASAE Paper No. 95-2378, Amer Soc. Agr. Engr., St. Joseph, MI.

Education

M.Sc. Geology, University of Windsor, Windsor, Ontario, 1988

B.Sc. Geology, Honours, University of Windsor, Windsor, Ontario, 1986

Certifications

Registered Professional Geoscientist, 2002

Languages

English – Fluent

Golder Associates Ltd. – Ottawa

Employment History

Golder Associates Ltd. – Ottawa, Ontario
Principal/Senior Hydrogeologist (1997 to Present)

Mr. Kris A. Marentette, M.Sc., P.Geo., is a Principal and Senior Hydrogeologist in the Ottawa office of Golder and has 20 years of broad experience in the fields of water supply development, physical hydrogeological characterization studies, regional scale groundwater studies, aggregate resource evaluations and the licensing and permitting of quarry development and expansion projects, waste management and contaminated sites assessment /remediation. Kris is responsible for business development, project management, and senior technical review of hydrogeology, quarry and sand and gravel pit development and expansion, golf course irrigation, site assessment and remediation projects, and waste facility siting, design, operation and environmental compliance monitoring assignments from the Ottawa office.

Kris has been the Golder Project Manager on a number of Ministry of Natural Resources quarry and pit licensing projects for both new operations and expansions to existing operations and has extensive experience in managing these complex, multi-disciplinary projects. Participated in comprehensive aggregate resource evaluations of Paleozoic sedimentary sequences (limestone) and Precambrian marble deposits at quarries in eastern Ottawa for the purpose of developing preferred site development plans to maximize the production of high quality aggregate products. The aggregate resource evaluations have typically included borehole coring, geological core logging, geophysical evaluations and comprehensive laboratory testing programs.

Golder Associates Ltd. – Ottawa, Ontario
Hydrogeologist/Senior Hydrogeologist (1988 to 1997)

Responsible for business development and the initiation, implementation and direction of hydrogeological investigations from the Ottawa office. Projects have included test well drilling programs for private services developments; subsurface investigations as related to the installation of subsurface sewage disposal systems; communal water supply investigations; and, regional hydrogeological studies to assist in establishing planning policies for future private services developments and to develop standards for water well construction.

Project manager for numerous hydrogeological studies of existing/proposed landfill sites including the assessment of impacts on water resources and developing and implementing monitoring programs and contingency and remedial action plans. Participated in hydrogeological aspects of waste management studies, preparation and submission of documentation to obtain Emergency Certificates of Approval and Site Interim Expansions of landfill sites under both the Environmental Assessment Act and Environmental Protection Act. Projects have included preparation of landfill site development and operations plans including evaluations of landfill final cover design options. Expert testimony at hearings before the Environmental Assessment Board.

Also responsible for investigation, design and implementation of soil and groundwater remediation programs at hydrocarbons, metals, solvents, and PAH contaminated sites including the risk assessment approach to site management. Projects have included third party peer review of site remediation programs.

Conducted hydrogeological assessments of quarry developments/expansions and pre-acquisition environmental site audits.

PROJECT EXPERIENCE – AGGREGATE INDUSTRY

Stittsville Quarry
Township of Goulbourn (Ottawa), Ontario, Canada

Project Manager and Project Hydrogeologist retained by R.W. Tomlinson Limited to provide geoscience and engineering services and to co-ordinate a multi-disciplinary study team in the preparation of the supporting documents, for a submission to the Ontario Ministry of Natural Resources, in support of an application for a Category 2, Class "A" license for a 44 million tonne quarry which intends to extract limestone from below the established groundwater table. Assignment also included preparation and submission of applications to the Ontario Ministry of Environment for approval under Section 34 (Permit to Take Water) and Section 53 (Industrial Sewage Works) of the Ontario Water Resources Act. All required approvals were obtained and the quarry became operational in September 2002. Kris continues to be involved as Project Director on all environmental compliance monitoring requirements associated with the Ministry of Natural Resources aggregate license and the Ministry of Environment approvals under Section 34 and 53 on the Ontario Water Resources Act.

Rideau Road Quarries
City of Gloucester (Ottawa), Ontario, Canada

In 2003, Golder Associates was retained by R.W. Tomlinson Limited to provide geoscience and engineering services and to co-ordinate a multi-disciplinary study team in the preparation of the supporting documents, for a submission to the Ontario Ministry of Natural Resources, in support of an application for a Category 2, Class "A" license for a 40 hectare parcel of land adjacent to Tomlinson's existing quarry operations. The quarry was designed to extract limestone from below the established groundwater table for the production of high quality aggregate suitable for all types of asphalt pavements. Kris was Project Director and Project Hydrogeologist for this assignment and Golder Associates' primary responsibilities included preparation of Level 1 and Level 2 Hydrogeological studies and Natural Environment evaluations of the property. Of particular significant for this project was the innovative approach develop by Golder Associates (in consultation with the Ministry of Natural Resources) for the purpose of addressing the presence of the American ginseng plant species and butternut trees on the property. The aggregate license was issued by the Ministry of Natural Resources in 2006.

Tatlock Quarry
Township of Lanark Highlands, Ontario, Canada

Project Director and Project Hydrogeologist retained in 2002 by Omya Canada Inc. to conduct Level 1 and Level 2 hydrogeological studies in support of an application to the Ministry of Natural Resources for a Category 2, Class “A” license for the extraction of calcitic marble (crystalline limestone) at the Omya Tatlock Quarry located northwest of Perth, Ontario. Golder Associates was also responsible for the preparation of an application for an industrial sewage works approval under Section 53 of the Ontario Water Resources Act. The quarry license application was issued by the Ministry of Natural Resources in April 2006 and the industrial sewage works approval was issued by the Ministry of Environment in March 2006. Kris continues to advise Omya Canada Inc. on matters related to environmental compliance monitoring and other issues pertaining to Ministry of Natural Resources aggregate license and the Ministry of Environment approvals under Section 34 and 53 on the Ontario Water Resources Act.

Dunvegan Quarry
Township of North Glengarry, Ontario, Canada

Project Hydrogeologist retained by the Township of North Glengarry to conducted a peer review of the hydrogeological aspects of the Cornwall Gravel Company Ltd. Dunvegan Quarry license application. The peer review focused on developing an opinion as to whether the Hydrogeological Assessment Report addressed the various components specified as part of a Hydrogeological Level 1 study and Hydrogeological Level 2 study in the context of a Category 2, Class “A” Quarry Below Water.

Klock Quarry
Aylmer, Quebec, Canada

Golder Associates was retained by Lafarge Canada Inc. to conduct the hydrogeological and natural environment assessments associated with obtaining approval for the extraction of limestone from a property situated adjacent to the existing Klock Quarry. Kris is responsible for overall project co-ordination and direction of a multi-disciplinary team.

Brechin Quarry
City of Kawartha Lakes, Ontario, Canada

Project Manager and Project Hydrogeologist retained by R.W. Tomlinson Limited to complete the necessary hydrogeological, hydrological and ecological studies to support an application under the Aggregate Resources Act. The proposed Brechin Quarry is located in the former Township of Carden within the City of Kawartha Lakes, Ontario. The property covers an area of approximately 206 hectares and involves an aggregate resource of 70 million tonnes with an expected operational timeframe of over 70 years. The assignment involves a comprehensive assessment of the potential effects of quarry development on private water supply wells and an adjacent Provincially Significant Wetland and other natural environment (biological) features as well as consideration of the potential cumulative impacts associated with multiple quarry developments in the area of the proposed Tomlinson Brechin Quarry. This project involves extensive municipal and public consultation as well as interaction with representatives of the Ontario Ministry of Natural Resources and Ontario Ministry of Environment. The aggregate license was issued by the Ministry of Natural Resources in 2009.

TRAINING

Ministry of Environment Approvals Reform and Air Emission Summary and Dispersion Modelling Report Workshop
Ministry of the Environment, 1998

Site Specific Risk Assessment Seminar
Ottawa, 1998

Contaminated and Hazardous Waste Site Management
1997

Occupational Health and Safety Course
1989, 1995

Groundwater Protection in Ontario Conference
Toronto, 1991

Short Course in Dense, Immiscible Phase Liquid Contaminants (DNAPLs) in Porous and Fractured Media
Waterloo Centre for Groundwater Research, 1990

PROFESSIONAL AFFILIATIONS

Associate Member, Ontario Stone Sand and Gravel Association (OSSGA)

Member, Association of Groundwater Scientists and Engineers (N.G.W.A.)

Member, International Association of Hydrogeologists

Member, Ottawa Geotechnical Group, The Canadian Geotechnical Society

Member, Ontario Water Well Association

GOLDER

golder.com